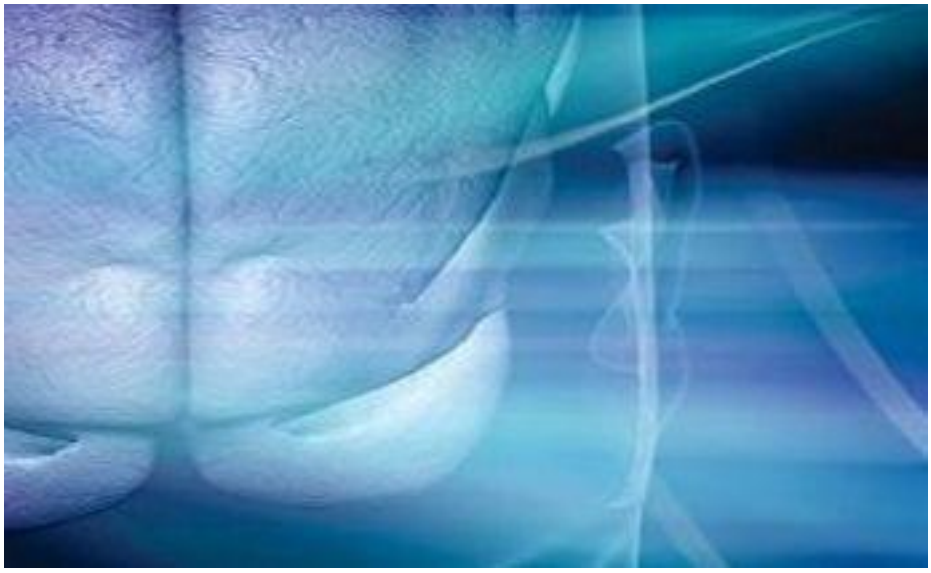

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VOLUME 1, 2001

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Acquired Posterior Fossa Arachnoid Cyst Following Cervical Laminectomy for Neurofibroma: Case Report

Jerrel H. Boyer, D.O., Philadelphia College of Osteopathic Medicine, Philadelphia, Pennsylvania

ABSTRACT

Arachnoid cysts are pathologic intra-arachnoidfluid collections, the majority of which are presumed congenital. Acquired subarachnoid cysts following trauma or surgical procedures have been reported but are usually located at the site of the previous trauma. We present a case of an acquired posterior fossa arachnoid cyst following cervical laminectomy and resection of intradural nerve root tumor. The arachnoid cyst caused obstructive hydrocephalus secondary to compression of the fourth ventricle and was successfully treated with cysto-peritoneal shunting. This article presents the case with radiographic evidence for the acquired nature of the cyst as well as speculation as the mechanism of the cyst formation.

INTRODUCTION

Arachnoid cysts have been diagnosed more easily since the advent of CT and MRI imaging. Congenital arachnoid cysts collections of fluid within the arachnoid layer consisting of an inner and outer layer of arachnoid. Arachnoid cysts are benign and usually asymptomatic. Some may cause symptoms related to compression of adjacent structures, alteration of CSF flow, hydrocephalus or increased intracranial pressure. Seventy-five percent of symptomatic arachnoid cysts present in early childhood. Most arachnoid cysts are thought to be congenital resulting from CSF forces upon the developing arachnoid (1,2). There is a subgroup however, of acquired arachnoid cyst. These usually follow some event that either causes alteration in CSF flow or disruption in the normal arachnoid plane such as surgical procedures, meningeal puncture or trauma. These acquired cysts have been located at the site of the previous insult or in the same anatomic compartment. We present a case of formation of an arachnoid cyst remote (posterior fossa) from the site of anatomic disruption (cervical spine).

CASE REPORT

In April 1998 an 18 year old male was referred to the neurosurgical service for a presumed diagnosis of cervical neurofibroma. The patient was born with numerous café-au-lait spots his trunk and had developed multiple cutaneous nodules consistent with neurofibromas. Genetic testing had confirmed the diagnosis of neurofibromatosis type I. The patient had developed bilateral upper extremity radicular pain which prompted MRI imaging of his cervical spine revealing multiple enhancing masses involving the nerve roots at multiple cervical levels. The largest mass was involving the right C2 nerve root and was causing canal compromise with significant spinal cord compression. At he time of referral to the neurosurgical service all radicular symptoms had resolved. Physical examination revealed multiple cutaneous neurofibromas. No focal motor or sensory deficits were elicited and reflexes were symmetrical and within normal limits. No myelopathic signs were elicited. In addition to spinal imaging a MRI of the brain was preformed prior to the surgical procedure. This study revealed no intracranial abnormalities.

Because of the spinal cord compression cause by the lesion at C2, surgery was recommended and the patient subsequently underwent a C2 laminectomy and resection of his tumor. After laminectomy and durotomy, an intradural extra medullary lesion was found encompassing the C2 nerve root and displacing the spinal cord from right to left. Tumor resection was uncomplicated and the dura was closed in a watertight fashion as was the muscular, fascial and cutaneous layers. No extrathecal CSF diversionary devices were utilized. The patient had an uncomplicated post-operative course and was discharged on the third post-operative day. Pathologic examination confirmed the lesion to be a plexiform neurofibroma.

The patient did well after discharge until 5 weeks postoperatively when he presented to an outside institution with a syncopal episode. The following day he again presented to another institution with nausea and vomiting and subsequently had a grand mal seizure. A CT scan performed at that time showed an extra axial fluid collection compressing the left cerebellar

hemisphere and fourth ventricle resulting in obstructive hydrocephalus. The patient was subsequently transferred to our institution where MRI of the brain and cervical spine was performed. This study demonstrated the presence of a left sided retrocerebellar and supracerebellar arachnoid cyst with mass effect and obstructive hydrocephalus. A pseudomeningoceole was present from Cl to C5, which was not contiguous with the posterior fossa cyst.

Cysto-peritoneal shunting was performed which resulted in complete resolution of the cyst and obstructive hydrocephalus. CSF analysis at the time of the shunting revealed xanthochromia, 80 WBC's, 60 % lymphocytes, 35% monocytes; 1225 RBC's, protein 107 and glucose 44. The gram stain revealed no organisms and CSF culture was negative. The patient returned 3 weeks post discharge with recurrent nausea and vomiting. Repeat CT scanning revealed re-accumulation of the arachnoid cyst in the same location and obstructive hydrocephalus. A proximal shunt obstruction was found and revised. A post-operative head CT revealed complete resolution of the cyst and hydrocephalus. The patient has remained asymptomatic since this revision.

DISCUSSION:

The majority of arachnoid cysts are assumed to be congenital. These cysts form within the arachnoid layer during its development creating an outer and inner membrane. A few cases of acquired arachnoid cysts have been documented as well. Although no pathologic series are available, the non-congenital nature of these cysts makes it unlikely that the formation occurs within the arachnoid layer. A more likely hypothesis is that these are loculated collections within the subarachnoid space. Only one other case report of an acquired arachnoid cyst remote from the surgical site or trauma could be located. This involved the development of a cyst in the posterior fossa after surgery in the cerebellopontine angle on the contralateral side. We believe this to be the first case report of an intracranial arachnoid cyst developing following spinal surgery. The normal brain MRI preceding the cervical laminectomy clearly demonstrates the acquired nature of this particular lesion.

The exact mechanism of non-congenital leptomeningeal cyst development has not been demonstrated. Cyst development usually is preceded by leptomeningeal irritation or disruption (3,4). One proposed mechanism of cyst development following surgery or trauma involves the development of subarachnoid hemorrhage and arachnoiditis. Arachnoiditis has been found in a few cases treated surgically (4). The presence of elevated protein, mild leukocytosis and xanthochromia in the CSF in this case helps support that mechanism. It is possible that blood products may reflux through the foramen magnum during the intradural procedure resulting in localized arachnoiditis. Subsequent formation of arachnoid adhesions may result in loculation of CSF and disruption of normal flow. This fluid sequestration could enlarge via a ball valve effect. Arachnoid adhesions at the location of the intradural procedure may also limit the normal flow of CSF through the foramen magnum, which may contribute to the formation of the posterior fossa cyst.

CONCLUSION:

Arachnoid cysts can be grouped according to etiology, congenital or traumatic. The majority of symptomatic arachnoid cysts are thought to be congenital. The occurrence of acquired arachnoid cysts are usually related to changes in normal arachnoid. Cysts may be formed by local arachnoiditis, adhesions and loculation however this remains unproven. This case demonstrates that cyst formation is possible in response to spatially remote events.

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Pituitary Apoplexy Following Craniotomy: Case Report And Review Of The Literature

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ABSTRACT

Bleibtreau first documented acute hemorrhagic necrosis of a pituitary adenoma in a young patient with acromegaly as a pathological entity in 1905 (1). While this so called "pituitary apoplexy syndrome" has been widely described (2,3,4,5), the incidence of association of pituitary apoplexy with intracranial surgery or other surgical procedures, and the precise mechanisms of pituitary tumor injury is unknown. There are hundreds of case reports of pituitary apoplexy in the literature; however, the role of cranial surgery as a precipitant factor for pituitary apoplexy has not been described. The authors present a case of a patient that developed pituitary apoplexy following the resection of a frontal, parasagittal meningioma. The role of intracranial surgery as a potential precipitating factor for apoplexy is hypothesized.

CASE REPORT

A seventy year old, Native American male, presented with a three-week history of headaches and left-sided hemiparesis. His headaches were confined to the right parietal area, were constant, and they occasionally felt stabbing in nature. They did not radiate to other parts of the head, and he did get some relief with the use of Tylenol. He denied complaints of nausea, vomiting, altered mental status, seizure activity, visual changes, or numbness and tingling in the arms or legs.

On physical exam, his appearance was of appropriate weight for his height. He was awake, alert, and oriented to his location, age, name, time, president, and current events. There was no evidence of dementia or altered mental status. His face was symmetric with good facial expression. His cranial nerves two through twelve were intact grossly. Detailed motor exam revealed strength at five out of five on the right side in the arm and leg, however, the left side revealed four out of five in both the arm and the leg. A detailed sensory exam revealed decreased sensation to pinprick and light touch on the left face, arm and leg. His cerebellar testing revealed no dysmetria or dysdiadokinesia. A right frontal contrast-enhancing mass with surrounding vasogenic edema was identified. There was no evidence of herniation, however a slight effacement of the right lateral ventricle was evident. An incidental small sellar mass was noted and thought to be a pituitary adenoma.

After review of the CT, the most likely etiology in the differential diagnosis was a meningioma causing the patients symptoms. The sellar mass was felt to be an incidental finding and not relating to the patient's symptoms. The patient agreed to a craniotomy for resection of the right frontal tumor. The surgical procedure was uneventful, as the tumor was excised in a gross total fashion. The patient was transferred to the recovery room post-operatively immediately after the surgery was complete. A physical exam at that time revealed that the patient had a new third and fourth cranial nerve palsy on the left side. No new motor or sensory signs were evident on physical exam. An immediate postoperative CT scan without contrast was performed which suggested a hyperintense density in the suprasellar region. A magnetic resonance image (MRI) was then obtained, which showed a sellar mass, predominantly hypointense on T-1 weighted images, with a hyperintense suprasellar component extending asymmetrically to the left parasellar region. The lesion was hyperintense on T-2 weighted images and enhanced after the administration of Gadolinium contrast.

Since those finding were consistent with pituitary apoplexy, and symptomatically the patient had new cranial nerve palsies, the patient was brought back to the operating room. The patient underwent a transsphenoidal approach for a resection of the sellar lesion. The pathology was consistent with a pituitary adenoma, containing large areas of necrosis. Immunohistochemical stains revealed a mild immunoreactivity for prolactin within the cytoplasm of the tumor cells. There was no immunoreactivity for growth hormone, thyroid stimulating hormone, lutienizing hormone, follicule stimulating hormone, or adrenocorticotropic hormone. Incidentally, the pathology of the initial tumor was meningioma with malignant features.

Following the resection of the pituitary tumor the patient remained neurologically stable, and was discharged home. On a follow-up examination thirty days later, the patient had returned to a normal cranial nerve, motor, and sensory examination.

DISCUSSION

In a review of nine thousand seven hundred and thirty-seven autopsies of patients not suspected of having pituitary disease, Molitch and Rusell identified pituitary adenomas in almost eleven percent (6). The vast majority of these were microadenomas, which is defined as less than ten millimeters in diameter. The tumors were distributed equally throughout the age groups and between the sexes (6). The sudden catastrophic bland or hemorrhagic infarction of a normal or neoplastic pituitary gland may cause compression of structures adjacent to the sella, presenting with severe headaches, sudden loss of visual acuity, a visual field defect, occulomotor palsy, decreased sensorium, and hypopituitarism (7,8). This phenomenon called pituitary apoplexy by Brohan et.al. in 1950 can occur de novo, without any identifiable precipitating factor, or following a variety of potential insults (9). Instances of pituitary apoplexy have been associated with pregnancy (10), head injury (11,12), chronic coughing and sneezing (13), administration of isorbide (14), or anticoagulant drugs (15). It has also been seen in endocrinologic manipulations (10,16,17), such as estrogen administration (18) or bromocriptine medication. (2,19,20) It has also been seen in radiation therapy to a pituitary tumor (21), as well as following cerebral angiography (22). It has been hypothesized that during cerebral angiography, the injection of contrast may increase the intravascular pressure, leading to hemorrhage in the pituitary (23).

Relatively few cases of pituitary apoplexy have been reported in association with surgical procedures. Most of these cases have been reported in patients undergoing cardiopulmonary bypass. (24,25,26) In addition, pituitary apoplexy has been reported following thyroidectomy (27), and spinal anesthesia for a hip replacement (28). Possible mechanisms of pituitary apoplexy during these surgical procedures include edema secondary to hemodilution from large amounts of crystalloid priming of the cardiopulmonary bypass tubing, inadequate superior vena cava drainage, episodes of hypotension, or from drug or blood-products inducing histamine release (24).

The authors were unable to find any case of pituitary apoplexy precipitated by intracranial surgery in an extensive Medline computer search of the English language articles. Holnes et al reported a case of apoplexy producing chiasmal compression following minor traumatic brain injury (29). Uchiyama reported two similar cases (30). The mechanism is thought that the intrasellar portion of the tumor is fixed by the bony structures forming the sella, and the suprasellar portion is free to move. A hypothesis is that during head trauma, rotational force acting on the occipital region on one side can create a shearing strain between the intra- and suprasellar portions of the tumor, which causes the apoplexy (12).

In many patients, like the present case, pituitary apoplexy represents the first definitive indication that either a pituitary tumor or an endocrinopathy is present. The present case showed an asymptotic pituitary adenoma, which was evident on the admission CT.

In this patient, it is likely that the surgical manipulation of the meningioma can produce effects similar to that seen in the three reported cases of apoplexy following head trauma. (12,29) Another theory is that a circulatory disturbance is created in the venous system of the tumor by occlusion, of the portal vessels (29). A combination of brain manipulation during the tumor resection as well as shifting of the brain after debulking the meningioma can produce a disruption of the portal vessels resulting in the apoplexy seen.

CONCLUSION

Pituitary apoplexy is a relatively rare clinical entity, although Wakai, et.al, saw it in almost seventeen percent of pituitary adenomas. (31) Patients most commonly present with headache, vomiting, ocular paresis, and visual loss (32). In patients who present in a conscious state with some useful vision, surgical decompression should be performed as soon as possible in an effort to restore neurological function (28,33).

Surgical procedures have been associated with pituitary apoplexy in a few cases, most of which are cardiac procedures. Although not previously described in the literature, pituitary apoplexy can be precipitated by intracranial surgery. This case report should alert the clinician to the possibility of apoplexy from the manipulation of the intracranial contents. The authors believe this case of apoplexy has a similar etiology as that seen in head trauma.

In patients with an incidental pituitary adenoma, who are undergoing a craniotomy for some intracranial pathology, the clinician should be alert for any acute deterioration. This deterioration should include pituitary apoplexy in the differential diagnosis and should be diagnosed and managed in an efficient manner.

This case also bring up the question of which tumor should be treated first. Retrospectively, one might argue that the pituitary adenoma should have been surgically resected prior to resecting the meningioma, even though the meningioma was the symptomatic lesion. This question will likely have to be answered on a case-by-case basis for similar cases in the future.

Table 1: Reported cases of apoplexy following surgical procedures

	Age/ Sex	Presentation	Procedure	Treatment	Pathology	Outcome	Ref
1	F	Headache	Thyroidectomy		Not Reported		27
2	68 M	Headache Lethargy	AVR	Steroids	Not Reported	Improved	25
3	77 M	Ophthalmopl, Hemiparesis, Confusion	CABG	Steroids	Not Reported	Death	34
4	59 M	Headache, Ophthalmopl	CABG	Steroids Hormones TSSx	Necrosis	No Change	34
5	63 M	Ophthalmoplegia	CABG	Steroids TSSx	Necrosis	Resolved	24
6	62 M	Ophthalmoplegia	AVR MVR	Hormones TSSx	Hemorrhage	Resolved	24
7	55 M	Ophthalmoplegia	CABG	Steroids Hormones TS Sx	Adenoma No Hemorrhage or Necrosis	Resolved	24
8	62 M	Ophthalmoplegia Hemiparesis Field cut	CABG	Steroids TS Sx	Hemorrhage Necrosis	Residual Hemiparesis	35
10	60 F	Ophthalmoplegia	CABG	Steroids Hormones TSSx	Hemorrhage	Persist Ill Nerve Palsy	31
11	57 M	Ophthalmoplegia	CABG	Steroids IS Sx	Necrosis	Partial Ophthalm.	26
12	55 M	Ophthalmoplegia Hemiparesis	MVR	Steroids IS Sx	Hemorrhage	Improved	26
13	56 M	Ophthalmoplegia	MVR	TS Sx	Necrosis	Improved	36
14	64 M	Comatose	CABG	IS Sx	Necrosis	Resolved	37
15	51 M	Headache Visual loss	Hip Replaced	Craniotomy	Necrosis	Resolved	28
16	70 M	Ill, IV Cranial Nerve Palsy	Frontal Craniotomy	Steroids TS Sx	Necrosis	Resolved	C

Key to table 1: AVR: aortic valve replacement; CABG: coronary artery bypass graft; M: male; F: female; TS Sx: transsphenoidal surgery; Ophthalmopl: ophthalmoplegia; C: current article

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Neurosurgical Invention: Elastic Loaded Retractable Pin Device For Cranial Bone Attachment

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ABSTRACT

The present invention pertains to pin-type devices useful for securing bone flaps in position following their removal in craniotomy and other surgical techniques. More particularly, the present invention pertains to pin-type devices having a retractable shank portion which is elastically loaded such that the pin, upon compressing and positioning over a passage in the skull or bone flap adapted to receive a pin, regains a substantial part of its uncompressed length. The present invention also pertains to a surgical kit containing one or more of the subject pin-type devices, and a surgical procedure directed to the use thereof.

BACKGROUND OF THE INVENTION

In many surgical procedures involving the cranium, a section of the skull bone (cranium) must be removed to provide access to the brain or other underlying tissue. This section removed may be round, square, or other shape dictated by the nature of the operation, the equipment available, the training of the surgeon, and the like. Following the operation, the bone flap removed must be repositioned and maintained stably for a period of time sufficient to allow the bone to knit together.

In the past, two principle methods have been used to secure the bone flap, as illustrated by Figures la and lb. In figure la, a series of holes are drilled adjacent to each other along the mating peripheries of the skull and the bone flap. Wires are inserted through these holes and twisted or tied together to anchor the skull and bone flap in close proximity. The use of such wires causes several problems, which are well recognized. The protruding wire is apt to cause irritation due to either or both the normal motion of the scalp over the wires, or the palpation of the scalp over the wires. Moreover, the protrusion of the wires above the surface of the cranium causes an elevation of the scalp at these positions, which may become more noticeable as scar tissue caused by relative movement of wires and scalp builds over time. This problem is aesthetically displeasing when a portion of the bone flap removed is below the patient's hairline, or for balding patients, virtually anywhere. An improvement over the use of wires to maintain a bone flap in position is the use of screw-type devices as illustrated by Figure lb. However, these screw-type devices share some of the irritational and in large part, the disfiguring disadvantages of the use of wires.

In United States patent *5,669,912* are disclosed metal pins having two tapering shanks extending from a central protruding collar. One shank is pressed into the bone flap while the other shank is inserted into a hole in the skull positioned to receive the shank. The collar limits the degree of insertion into the bone flap. The device of the '912 patent is illustrated in Figure 2a, and an application of the device is illustrated in Figure 2b.

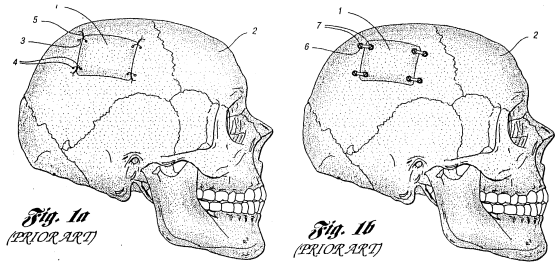


Figure 1a illustrates prior art wire-type fasteners used to position a skull flap. **Figure 1b** illustrates prior art screw-type fasteners used to position a skull flap.

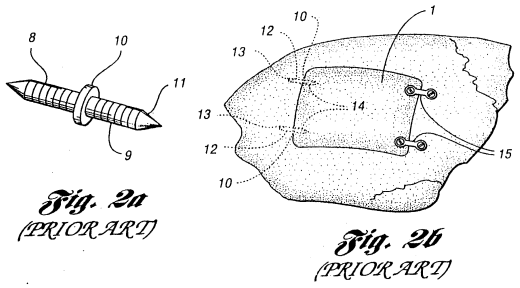


Figure 2a illustrates a prior art pin-type device used to position a skull flap. **Figure 2b** illustrates a skull flap positioned through use of two of the devices of Figure 2a and two screw-type fasteners.

As can be seen in Figure 2b, the use of

the pins of the '912 patent is partially helpful in alleviating irritation and disfigurement by eliminating a number of wires and/or screw-type devices. However, the pins must be positioned parallel to each other and located on the same side of the bone flap, or they will be unable to enter the holes in the skull drilled to receive them. Thus, while one side of the bone flap may be secured with such pins, the remaining sides must be fixed in position with traditional fasting devices such as wires or screw-type fasteners.

The elastic-loaded, retractable shank devices of the present invention are sized according to the needs of the patient and the location of the craniotomy, i.e. in particular, the thickness of the skull at the relevant areas. In general, the length of the device is from about 7 mm to about 1.5 cm, although shorter and longer devices can be employed where indicated. Diameter of the retractable shank may vary from 0.3 mm to about 1.0 mm, while the hollow shank need be of sufficient diameter to receive the retractable shank while being such wall thickness so as to provide the strength necessary to maintain stability of the skull/bone flap interface. A diameter which is larger than the diameter of the retractable shank by from about 0.4 mm to about 1 .0 mm is satisfactory, for example. The dimensions of the retractable shank and the hollow shank can be adjusted to higher or lower values depending upon the circumstances.

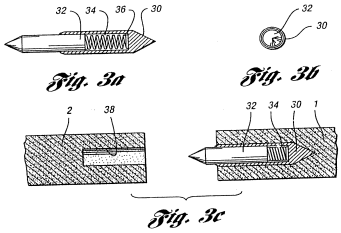
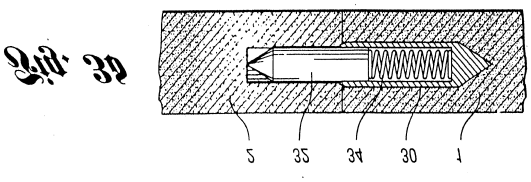


Figure 3a illustrates on embodiment of an elastically loaded, retractable shank pin according to the subject invention.
Figure 3b illustrates an end view of the device of Figure 3a, viewed from the retractable shank end.
Figure 3c illustrates a bone flap containing a retracted device of Figure 3a being positioned proximate a shank-receiving hole in the skull.

Figure 3d illustrates a bone flap secured in position by extension of the retracted shank portion, as illustrated by Figure 3c, into the skull bone.



The elastic loading means is preferably a coil spring. However, compressible elastomers, particularly highly compressible, biocompatible elastomer foams may be used as well. When such foams are used, it is highly desirable to use a foam with high elastic recovery, i.e. low compression set. Silicone and polyurethane foams may be used, for example.

The material of which the elastic-loaded, retractable shank devices are constructed can be of any material with sufficient tensile strength, compressive strength, and modulus to maintain a stable skull/bone flap position. Materials of fully dense ceramic, reinforced thermoplastic or thermosetting engineer polymers, and metals may be used, for example. The various elements of the elastic-loaded, retractable pin devices need not be made of the same material. For example, a retractable shank may be constructed of fully dense ceramic while the hollow shank may be made of metal.

Preferably, the material of the elastic-loaded, retractable shank device is one which has a magnetic moment of less than 2 EMU/g, more preferably less than I EMG/g. Devices constructed of these materials, particularly those with magnetic moments of less than 1 EMG/g, are considered safe for use in magnetic resonance imaging (MRI). Examples of suitable metals having low magnetic moments are various austenitic stainless steels, for example nickel chromium stainless steels. Methods for testing materials to determine their suitability for MRI sensitive applications and alloys suitable for use are contained in the article "Aneurysm Clips: Magnetic Quantification and Magnetic Resonance Imaging Safety", Manuel Dujovny, M.D. et al., Journal of Neurosurgery 87, pages 788-794, 1997, incorporated for this purpose by reference.

Conventional craniotomy surgery

techniques are used prior to insertion of the pins of the subject invention. Pin insertion can be accomplished by the methods disclosed in the United States patent *5,669,912,* which is herein incorporated by reference. In view of the variety of pin placements made available by the subject invention pins, the use of a boring guide is advisable in certain instances. A boring guide is a mechanical device, which ensures that holes bored in the skull to receive the retractable pins are proper location. The same device may be used to bore holes in the bone flap as well as the skull, assuring proper registration when pins are inserted.

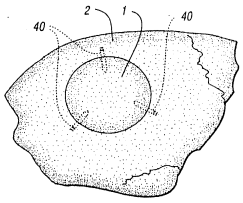


Fig. 4a

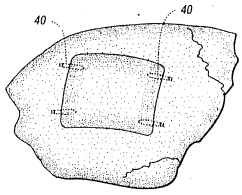


Fig. 4b

Figure 4a illustrates a bone flap positioned through use of three of the devices of Figure 3a.
Figure 4b illustrates a bone flap positioned though use of four of the devices of Figure 3a.

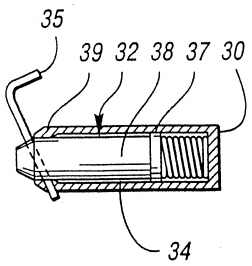


Fig. 5e

Figures 5e illustrates alternative embodiments of the elastically loaded retractable shank pin devices of the subject invention.

An example of a boring guide is illustrated in Figure 6, and consists of two stainless steel rings 60 and 62 with guide blocks 64 and 66 extending below the ring. Guide blocks 64 are inset from the outer circumference of ring 60 and have drill guide bushings 68 through which the drill bit will pass from the inside of the guide block outwards to bore the skull. The outer circumference of the ring is such that the plate will rest on the skull during drilling, while the inner diameter B is the diameter of the hole in the skull from which the bone flap has been removed. Boring guide ring 62 also has boring blocks 66 below it, but with the inner edges of the blocks lying along a circle with diameter B, i.e. a radius from the center of the boring guide of B/2. The inner circumference of the boring guide C is smaller than the bone flap outer diameter such that device may rest atop the bone flap. The top of ring 62 may be left solid. The depth of the drill guide bushings 68 below the bottom of rings 60 and 62 is determined by desired pin placement depth and bone thickness. The height and spatial position of these blocks may also be made variable, for example by use of guide blocks located in rings 60 and 62 by means of a dovetail slot and corresponding extension. Upward and downward movement may be facilitated by similar guides located in two part guide blocks, or by the use of guide blocks of different heights. Square ring~ or rings of other shape, or alternative devices may be used as well. For example, the pins may be first pressed into Place in the bone flap or located in holes drilled in the bone flap, and movable guide blocks adjusted to the proper positions, the pins retracted and the boring guide removed and placed on the skull to drill at the indicated positions.

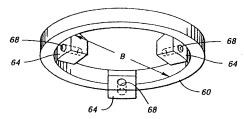


Fig. 6a

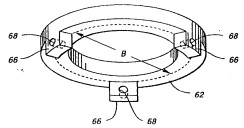


Fig. 6b

Figures 6a and 6b illustrate embodiments of boring guides suitable for use in craniotomy employing the subject invention pins.

The dimensions A and B may be standardized, and supplied in kit form with the necessary number of pins, or individual devices

may be constructed from a clay, wax or other replica of the particular part o f the cranium and a suitable boring guide prepared by stereolithography, lost wax, or other casting techniques. The boring guide may be made of robust thermoset or thermoplastic material or metal, the former preferably with metal drill bushing inserts.

By the terms "substantially enter" as used herein to meant that the retractable shank shall be capable of retraction into the hollow shank such that any remaining protrusion of the retractable shank outside the hollow shank will yet allow for correct positioning of the bone flap within the skull cavity without exertion of undue pressure. Preferably, this protrusion will be no more than 1.5 mm, more preferably no more than 1 mm, and most preferably less than 0.7 mm. By the term "positioned congruent" used herein is meant that drill guide positions are established which allow a retractable pin of a elastic-loaded, retractable pin device located in the corresponding mating bone of the bone surfaces to be located at a position to allow entry into the retracted pin receiving cavity.

Having now fully described the invention, it will be apparent to one of ordinary skill in the art that may changes and modifications can be made thereto without departing from the spirit or scope of the invention as set forth herein.

SUMMARY OF THE INVENTION

The present invention pertains to a retractable pin-type device which is elastically loaded such that the pin, in its retracted position, may be positioned for entry into a corresponding hole in the skull, following which the retraction pressure is released, causing the retracted shank of the pin to enter the hole in the skull. Due to the ability of the skull-extending portion of the shank to retract prior to entry into the skull, when a plurality of the present devices are used, they are not required to be positioned parallel to each other, but may be distributed around the periphery of the bone flap, thus not requiring any wires or screw-type fasteners. Without any protrusions, irritation and disfigurement are substantially dim mated.

CONCLUSION

Elastic-loaded, retractable shank surgical pins having a hollow shank adapted to received an elastic-loaded retractable shank can be inserted into the bone flap or into the walls of the skull cavity from which the bone flap has been removed, the retractable shank compressed against the elastic loading, and the bone flap placed into position in the skull cavity. The retractable shanks are allowed to expand outwards into corresponding holes positioned in the skull or bone flap, securing the latter in place without the necessity of protruding wires or other conventional locating devices. The pins need not be positioned parallel to each other, and may be spaced around the bone flap, preferably constituting the sole means of securing the bone flap in the skull cavity.

This invention is pending for The United States Patent. Foreign Filing License was granted on March 30, 1988, by The United States Department of Commerce, Patent and Trade Mark Office.

The next steps are 1) to test the prototype model in the animal and human cadavers, 2) to evaluate safety of the instrumentation 3) to formulate the recommended guidelines of the procedure, and 4) to obtain FDA approval to carry out the clinical phase trial.

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Neurosurgical Treatment Of Hypothalamic Hamartomas Producing Intractable Gelastic Seizures And Precocious Puberty

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ABSTRACT

Hypothalamic hamartoma is a rare intracranial neoplasm with a characteristic spectrum of signs and symptoms and radiographic appearance. There has been controversy regarding the effecacy of surgical treatment for the amelioration of gelastic seizures and precocious pubery. A three year old boy who was diagnosed with gelastic seizures and precocious puberty was reported to have a hypothalamic hamartoma after biopsy. The mass was later identified as a gangliocytoma. The patient's precocious puberty was adequately controlled medically. However the gelastic seizures became more frequent and severe with altered characteristics and significant deterioration of quality of life. A two stage procedure was utilized to achieve surgical extirpation of the mass which was histologically identified to be a gangliocytoma. The initial approach resulted in a decrease in seizure activity with resection of 40% of the mass. Following the second stage of the procedure no more seizure activity was reported by the staff or caretakers with approximately 95% of the mass removed. Post operatively the patient no longer required Lupron to treat his precocious puberty but remained on stress dose steroids and DDAVP. One year after surgery he has not displayed any seizure activity and sex hormone levels remain within a normal range. Surgical extirpation is a viable treatment modality that has the capacity to substantially increase the quality of a patients' life.

INTRODUCTION

It has been well documented that hypothalamic masses such as hypothalamic hamartomas, pituitary tumors, astrocytomas of the mammillary bodies and dysraphic conditions are associated with gelastic seizures and precocious puberty (1,4,13-19). There has been controversy regarding the efficacy of surgical management of gelastic seizures as well as surgical resection to treat precocious puberty. In 1993, Albright and Lee (5) reported a series of five children successfully treated surgically for precocious puberty secondary to hypothalamic hamartoma and a case report in 1994 by Romner et al (8) described similar results in a six year old girl. Alvarez-Garijo et al. (6) and Burton et al. (7) concluded that there was little role for surgery in the treatment of hypothalamic hamartomata.

Gelastic seizures associated with hypothalamic masses portend a poor prognosis. The seizure activity begins in infancy, usually refractory to medical treatment and can progress to other forms of epilepsy. There also can be progressive cognitive and mental deterioration. The precise mechanism of these seizures have not be elucidated however several theories have been proposed (4). There have been several studies to report decreased gelastic seizure activity following surgical resection of a hypothalamic hamartoma (9,11) Nishio et al have described decreased seizure activity as the result of surgical resection with concomitant normalization of endocrine abnormalities in a patient without the stigmata of precocious puberty (9,10). Kuzniecky et al. in 1997 (20) identified three patients with gelastic seizure and hypothalamic hamartoma with ablation of seizure activity in one patient after stereotactic radiofrequency lesioning, while surgical ablation of epileptogenic cortex associated with hypothalamic hamartomas did not decrease seizure activity (12). Cascino et al have reported that most patients who receive interventional treatment do not become seizure-free (12). Breningstall reported in 1985 that surgical intervention in seven out of ten patients was of little diagnostic or therapeutic benefit (17). This study reviews the current literature regarding surgical extirpation of hypothalamic masses and describes a case of successful treatment of gelastic seizures and precocious puberty by subtotal surgical extirpation of a mass identified as a gangliocytoma arising from the hypothalamus.

ILLUSTRATIVE CASE

A 3 year old boy with a history of gelastic seizures and precocious puberty was admitted to our service. He was born after a

normal pregnancy and unremarkable family history. At approximately 4 months of age he began to experience what his mother described as fits once a week. The fits were described as a brief episode of laughter without any loss of consciousness or post-ictal period. Between 4 and 6 months of age he did not attain his developmental milestones and was worked up for gastric esophageal reflux disease and gastroenteritis. His height and weight increased rapidly and at 8 months he was wearing clothing for a three year old. He soon thereafter developed enlarged external genitalia and pubic hair. He was then referred to an endocrinologist who recommended that imaging studies be performed. A suprasellar mass was biopsied in September 1996. Pathologic analysis revealed a mass consistent with hypothalamic hamartoma. His seizures activity continued in frequency to about 15-20 per day, lasted approximately 15 seconds and did not preclude him from interacting with his surroundings during the seizure activity. There was no loss of consciousness. The seizures consisted of unprovoked and uncontrollable laughter, which were poorly controlled with anti-seizure medication. Beginning in October 1998 the character of the seizures changed as did the mass. (see fig.1,2,3)

Fig. 1,2,3- Preoperative MRI depicting large isodense hypothalamic mass.

Fig 4. Intraoperative precocious puberty. photograph of patient. Note size and stigmata

The activity became more severe, prolonged in duration, associated with periods of apnea, tonic-clonic activity and a post-ictal period. He was taking Tegretol for seizure activity, Lupron, synthroid, cortisol and DDAVP. On physical exam he was large for his chronologic age with signs of precocious puberty. (see flg.4) He exhibited signs of restlessness and agitation but was consolable. He demonstrated verbal ability and motor skills of a child approximately half his age. He was otherwise without focal neurological deficit. He was scheduled for the first stage of a two stage debulking procedure of the suprasellar mass through a right pterional craniotomy. (see fig. *5)* The pontine and interpeduncular portions of the mass were resected which comprised about 40% of the total. (fig. 6,7)

Fig.5-Intraoperative photograph of proposed incision outlined by the part in the hair.

Fig. 6,7-Postoperative MRI reveals 40% of hypothalamic mass resected

Postoperatively there was a transient right oculomotor palsy, which resolved. The seizure activity decreased to 15 gelastic seizures per day, which represented the baseline activity

prior to the recent deterioration. The second stage was an interhemispheric transcallosal approach, which resulted in the resection of 95% of the original tumor. This resulted in total abolition of seizure activity immediately postoperatively. The patient was then weaned from his anti-epileptics (AED) six months after surgery. One year postoperatively the patient remains seizure free, continues on DDAVP for diabetes insipidus, stess dose hydrocortisone for fever and no longer requires Lupron for elevated LH and FSH or AED for seizure control.

Hypothalamic hamartoma results from aberrant differentiation producing a mass of disorganized but specialized cells indigenous to the hypothalamus. Its posterior location, lack of calcification and typical history differentiates hamartomas from other suprasellar masses. It was probably first reported case 1934 with 90 cases documented worldwide with 60 of those in past decades due improved imaging modalities. The majority were found on ventral surface from tuber cinereum to mammillary body, typically between the optic chiasm and the pons. The mass may be sessile or pedunculated. Most present with precocious puberty before age of 3 years. There are no racial, familial or sexual predilection and 74% of patients present with stigmata of precocious puberty.

Precocious puberty is associated with hypothalamic hamartomas and is defined as the premature development of secondary sexual characteristics. This syndrome includes virilization with spermatogenesis resulting from the activation of the hypothalamic-pituitary system. The list of etiologies include tumors, especially associated with hypothalamic hamartoma, central nervous system infections and other infections. Idiopathic precocious puberty is a diagnosis of exclusion. Precocious pseudopuberty refers to virilization without spermatogenesis. This results from leydig cell tumors, beta-HCG secreting tumors, tumors of the adrenal glands and congenital adrenal hyperplasia. There are two possible mechanisms for precocious puberty as the result of hypothalamic hamartoma, both of which lead to elevated levels of GnRH. A mechanical effect of the mass may compress normal inhibitory pathways or a neurosecretory mechanism of action from the mass could elevate serum levels of the hormone.

Males may have voice deepening, muscular development, pubic hair and enlarged testes or penis; females with breast development, menses and pubic hair. The patients have advanced bone age and are a large size for their age.

Precocious puberty is confirmed by elevated LH, FSH, estradial or testosterone. Levels of GH and TSH are usually normal. Satisfactory treatment has been attained for precocious puberty with the introduction of long-acting GnRH analogs. Gelastic seizures occur in 21% and mental retardation may be present. Gelastic is derived from the Greek “gelos” which signifies mirth. This seizure type was probably first described by Trousseau in 1877. It is described as episodes of involuntary laughter. It is the motor act of laughter without the subjective feeling of merriment or amusement. It has many etiologies but when associated with hypothalamic hamartoma it usually begins in infancy or childhood and begins as unprovoked laughter but usually progresses to other seizure types. The seizures usually last less than thirty seconds and can occur several times per day. They are usually refractory to anti-seizure medications. There can also be neurocognitive decline.

Ictal laughter has been found in four pathologic situations; complex partial seizures of temporal lobe origin, children with infantile seizures, pseudobulbar palsy and tumors of hypothalamic origin. The pathophysiology is at this time unknown and the exact location of the epileptogenic focus is still debated. There are three current theories proposed for gelastic seizures resulting from hypothalamic hamartoma. Mechanical stimulation has been proposed to produce increased electrical discharges within the limbic system.

An electrophysiologic origin may result from abnormal electrical activity within the mass. Thirdly, a paracrine effect from the release of epileptogenic peptide from the hypothalamic mass may result in seizure activity. Other findings include headache, visual disturbance or autonomic dysfunction such as hyperphagia, hyperactivity, or somnolence. Microscopically hypothalamic hamartomas are composed of mature neurons with glial cells. The neurons

may contain secretory granules, blood vessels and capillaries. Electron microscopy shows dense core granules.

Radiographically, a hypothalamic hamartoma is isodense and nonenhancing on CT. MRI characteristics show slightly hypointense mass, usually abuting the floor of the hypothalamus on T1. On T2 weighted images the mass is usually isointense to adjacent grey matter and it does not enhance with the administration of gadolinium. The typical imaging characteristics and location usually suggest the diagnosis of hypothalamic hamartoma. Other considerations in the differential diagnosis include neoplasms such as: craniopharyngioma, rathke's cleft cyst, meningioma, germ cell tumor, epidermoid/ demoid, chiasmatic/hypothalamic glioma, chordoma, choristoma and metastasis. Other tumor-like masses include: arachnoid cyst and eosinophilic granulomatosis. Inflammatory, vascular or ischemic lesions could also present in this region.

DISCUSSION

It is well established that hypothalamic hamartomas are associated with gelastic seizures and precocious puberty. Precocious puberty has also been reported to be caused by hypothalamic hamartomas and gangliogliomas (13). Precocity has been treated with success with medical and surgical treatment. Long acting GnRH analogs have proven to be an efficacious method of controlling the abnormal secretion of FH and LH. There are also many reports of surgical resection of the hypothalamic hamartoma for treatment of precocity (5,10,21,26).

Gelastic is derived from the Greek "gelos" signifying mirth and was probably first described by Trousseau in 1877 (29). Gelastic seizures have been associated with hypothalamic hamartomas as well as other suprasellar masses such as pituitary tumors, astrocytomas ofthe mammillary bodies and dysraphic conditions (27). This seizure type has devastating effect on the patient's quality of life and can progress to different seizure types refractory to medical management as well as being associated with behavioral problems and cognitive decline. There is however controversy regarding the efficacy of surgical extirpation for the treatment of gelastic seizures. These mixed results may be attributed to the location of the seizure generator. In the case of the actual hamartoma being responsible for the epileptic activity a cure of the seizure activity would be seen with surgical extirpation directed at the mass. Munari et al. demonstrated electrical discharges using depth electrodes from within the hamartoma (30). There have been studies showing increased activity in the hypothalamus using SPECT by Donley et al. and Kuzniecky et al (31,32). Successful treatment of seizure activity has been reported by Nishio et al (25), Muchado et al (11), Sato et al (28). Kuzniecky et al have demonstrated seizure activity arising from the hypothalamic hamartoma with ablation of seizure activity following radiofrequency lesioning (20).

In cases where the seizure activity arises from abnormal electrical discharges originating in areas remote from the hypothalamic mass or due to multiple areas of independent generators, there will be little seizure reduction after resection of the hypothalamic mass. Focal cerebral dysgenesis such as seen in hypothalamic hamartomas are often associated with occult cerebral structural change (26). It has been proposed that the poor outcome following focal surgical resection may be due to structural changes not seen on routine MRI and not on the hypothalamic hamartoma itself (17,22,23,24). It is unproven whether or not these structural changes are foci of the epileptic activity. There has been little success with seizure control following resection of the proposed cortical generators (12,23). Sisodiya et al. advocate the use of quantitative MRI to identify possible seizure generators before surgery is undertaken (22,24). Our case has illustrated an ablation of intractable seizure activity after subtotal surgical excision of the hypothalamic mass. This would lend further support to the presence of the seizure generator within the disorganized mass of cells comprising the mass. This would conclude that surgical extirpation of the mass would be a viable treatment for intractable seizure activity and precocious puberty.

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Chondroblastoma Of The Temporal Bone Case Report Of An Unusual Bone Tumor In A Rare Location & Review Of The Literature

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CASE REPORT

A 35 year old male presented with hearing loss in the right ear for eight years. Physical examination revealed a normally developed black male, alert and oriented. Aside from complete conductive hearing loss in the right ear, the remainder of the neurological exam was unremarkable.

CT scan was obtained and revealed an extensive destructive lesion involving the right temporal bone and temporomandibular joint (TMJ). MRI showed the mass to involve predominantly the petrous and mastoid portions of the temporal bone with extension into the infratemporal fossa extending medially toward the pharynx. Patchy enhancement was seen. Temporal bone CT with coronal reconstruction was obtained for surgical planning. This study showed destruction of the glenoid and posterior mandibular condyle and ramus. The tegmen tympani was also obliterated. Calcification was seen within the soft tissue mass in the infratemporal fossa. The ossicles and inner ear structures were seen to be intact. Sclerosis of the temporal bone suggested a longstanding process.

Prior to surgical intervention the patient underwent and failed balloon test occlusion of the right internal carotid artery. A combined one-stage neurosurgical and maxillofacial approach was utilized. The patient underwent a right infratemporal craniotomy via a transzygomatic transmandibular approach with near-total excision of the mass. Frozen section was not diagnostic. Histiocytic-appearing cells, cartilage components, and hemosiderin pigment were seen on permanent sections. This was consistent with chrondroblastoma of the temporal bone. The patient's postoperative course was unremarkable.

Chondroblastomas (CB) involving the temporal bone are rare lesions, with approximately 50 cases reported. Comprising approximately one percent of all bone tumors, chondroblastoma usually arises in the epiphyses of long bones in children and adolescents (1). Bones commonly involved include the femur, humerus, and tibia (2). The bones of the calvarium are uncommon sites of occurrence, representing less than two percent of all cranial bone tumors.

Reports suggest chondroblastoma occurring in the temporal bone may be more aggressive and tend to occur in older patients than the adolescent and young adult populations commonly affected in long bones (3,4,5). The mean age of occurrence in the temporal bone is 43 years (1,2). Males are more commonly affected than females in a ratio approximately 2:1. Cranial bones involved, aside from the temporal bones, include the mandible, maxilla, parietal, and occiput (6,7).

The origin of chondroblastoma in the temporal bones is uncertain. Several theories have been hypothesized. Bloem et al suggest that the temporal bone, especially the petrous portion, may be affected more frequently than other skull bones because it contains sites of membranous and endochondral ossification. These sites of primary or secondary enchondral ossification may be the origin for these tumors. Controversy exists regarding whether these tumors arise from rests of fetal cartilage or represent adult cartilage exposed to and altered by an unnatural environment. Tumors, which arise in the squama of parietal bones, cast doubt on these theories of development from fetal or adult cartilage because they do not normally contain cartilage. Consideration must then be given to the possibility of an "ectopic" location of cartilage developing neoplasia at these sites (2,6). Spahr et al report one case of CB arising from articular hyaline (nonepiphyseal) cartilage of the TMJ.

PRESENTING SYMPTOMS

Hearing loss is the most common presentation of CB in the temporal bone. Other presenting symptoms include otalgia, tinnitus, plugged sensation in the ear, sensation of an ear mass, vertigo, dizziness, and cephalgia. Other less commonly reported signs and symptoms include facial nerve palsy, increased intracranial pressure, coma, temporomandibular joint dysfunction, otorrhea, external auditory canal

obstruction, and facial numbness (10-12).

RADIOLOGICAL EVALUATION

CT allows visualization of the destruction and erosion of temporal bone lesions (2). It allows the density of the mass to be assessed and calcifications to be seen if large (3). Coronal views allow involvement of the temporomandibular joint to be seen (5). Midline shift and brain edema, although not commonly seen with CB, is also visible on CT when present (13).

MRI allows the interface between tumor and dura to be visualized. It is not uncommon for extension into the dura to occur (14). Muntane et al hypothesized that isointensity to gray matter seen on T1-weighted images is most likely from the highly vascular fibrous stroma and high cellularity seen in CB.

Differential diagnosis of expansive lesions of the temporal bone include neurinoma of fifth nerve, neurinoma of seventh nerve, osteoma, chondroma, giant cell tumor, aneurysmal bone cyst, fibrous dysplasia, metastases, chondroblastoma, pigmented villonodular tenosynovitis, enchondroma, and infectious process.

Cerebral angiography may be useful if the internal carotid artery is involved. Balloon test occlusion may be useful to determine if sacrifice of the ICA is a surgical option. Review of the literature revealed that angiography is often negative because CB is commonly an avascular mass that displaces or compresses the carotid rather than invades it (2).

Histological diagnosis of CB can be extremely difficult as this tumor has features shared with many other tumors occurring in bone. Specimens from our case contained cells demonstrating chondroid differentiation with large amounts of hemosiderin pigment. Histiocytic-appearing giant cells were present in abundance. The histologic slides were reviewed by John M. Lee (Loyola University), Andrew E. Rosenberg (Harvard University), and K. Unni (Mayo Clinic). The tumor most closely mimicked pigmented villonodular synovitis (PVS) as it contained hemosiderin and invaded the temporomandibular joint, synovium, and meniscus. PVS, however, does not contain cartilage as a component. Abundance of hemosiderin is common in CB of the temporal bone.

Pathologic examination of CB reveals moderate-sized polyhedral cells (chondroblasts), which can be tightly packed or loosely arranged nodules interspersed with acid mucopolysaccharide ground substance (6). This interstitial material often contains a “lattice-like” or “chicken-wire” network of calcium (5). Presence of calcium in the stroma near areas of hemorrhage and necrosis is common in CB (6) and has been termed “calcification necrosis” by Feely et al.

Intracellular calcium is also sometimes present. Cytoplasmic hemosiderin granules as seen in our case are common and can cause difficulty in differentiating CB from PVS (15).

The cellularity may vary from abundant to sparse and can hinder correct diagnosis. Those tumors with high cellularity may be confused with chondrosarcoma or giant cell tumor (13). Cells contain one centrally-located nucleus and only rare mitotic figures are seen. Anim et al report one case in which frequent mitoses were seen. Multinucleated giant cells are present in varying numbers and are usually located near sites of necrosis (3,5). Occasional areas of reactive bone formation may be seen within CB (10). The presence of a variety of features can make it extremely difficult to differentiate CB from giant cell tumor, chondrosarcoma, aneurysmal bone cyst, PVS, and other pathologic conditions (11).

Immunohistochemistry evaluation is sometimes helpful in differentiating CB from other lesions of the temporal bone. Monda et al found the stromal cells in 7 of 9 CB were S-100 positive. They concluded that S-100 immunostaining may be helpful in differentiating CB from many other bone lesions including giant cell tumor, fibrous dysplasia, giant cell reparative granuloma, chondroid myxoid fibroma, and aneurysmal bone cyst but not from clear cell chondrosarcoma.

The diagnosis of CB is dependent upon the presence of chondroid differentiation within the tumor (17). Temporal bone tumors of this type sometimes prove to be extremely challenging to diagnose because they often demonstrate subtle chondroid differentiation when compared to long bones (18).

TREATMENT AND PROGNOSIS

Surgical excision is the mainstay of treatment for chrondroblastoma. Lesions, which cannot be completely excised, are often treated with adjunctive radiation therapy. Recurrence is not uncommon in chondroblastoma of the temporal bone. Surgical re-operation is often performed for recurrence and then radiation therapy is performed.

The occasional transformation after radiation treatment into malignancy such as chondrosarcoma or fibrosarcoma treatment has been reported at other sites. Cases have also been reported in which a histologically benign CB metastasized to the lungs, causing death (12). Jambhekar et al recommend early and regular evaluation of pulmonary status in patients with benign CB. Recurrence rates of temporal bone CB vary but the largest series reports a recurrence rate of fifty percent after curettage (1,12). CB at other sites show a much lower recurrence rate of fourteen to sixteen percent (8).

The high rate of recurrence in the temporal region is likely multifactorial. Anatomy of the temporal bone precludes aggressive surgical curettage to preserve vital structures in some patients. The behavior of CB at this site proves to be more aggressive, occur in older patients, and demonstrate higher rates of cellular derangement (12).

Hearing loss is a common complaint in elderly patients, however, in young adults both intracranial and facial pathology must be ruled out. Pathological diagnosis of these rare lesions can be difficult and tissue slides should be examined by bone pathology experts whenever possible. This is extremely important to avoid mistaking a malignant chondrosarcoma or osteosarcoma for a benign CB (19).

Surgical treatment should be performed via a team approach to maximize the initial resection of any tumor in the temporal region. Often neurosurgeons, maxillofacial surgeons, otolaryngologists, and plastic surgeons must work together for the best result possible. Close follow-up with radiation oncologists and surgeons is necessary as most recurrences occur in the first two years but have been reported much later (12).

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Treating Glioblastoma Mollecular Targets

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ABSTRACT

Primary brain tumors affect 12 per 100,000 individuals annually in the United States. There are approximately 29,000 primary brain tumors and 100,000 to 125,000 metastatic brain tumors. Although, brain tumors account for only 2% of cancer deaths they are responsible for 7% of years of life lost. The risk of brain cancer peaks at the age of two years old, declines, start to rise at 10 years old and then doubles after 40, continuing to rise until 70 years of age. Throughout the world the risk of malignant brain tumors are highest in males living in Israel, born in Europe or America; followed by those living in New Zealand, Sweden and Los Angeles. It is lowest in males from Osaka, Japan, Hawaii, Bombay, India or Miyagi Japan. For woman the highest incidence of malignant brain tumors are found in Israelis born in Israel followed by women living in Iceland, Sweden, new Zealand and lowest for those women living in Osaka, Japan, Miyagi, Japan and Bombay India. In the United States the risk is highest in Caucasian males. The standards of treatment have been with surgery possibly accompanied by radiation therapy and chemotherapy. Multiple studies since the late 1970s demonstrate that the average length of survival in weeks is approximately four weeks with no therapy, 19-24 weeks with chemotherapy, 36 weeks with radiation therapy, 53 weeks with surgical therapy; followed by a slightly better outcome with surgery, radiation and chemotherapy. Life expectancy is better in younger individuals, the extent of surgery, and the quality of life prior to surgical intervention. We do not know at this time the exact cause for primary brain tumors. There is a 15% family history of brain tumors. Brain tumors may be associated with occupations, food groups, medications, and viruses. Until we understand the etiology our treatment will be complex, incomplete and temporary.

The molecular nature of primary brain tumors has been studied with viral derived molecular probes. It is only the advances in biology, genetics, and immunology that will lead to an improved treatment. The process of tumor formation can be broken down into four different steps.

PRESENTATION

Initially a stimulus is presented to the astrocyte or other cell surface. This will stimulate the epidermal growth factor receptor or other growth factor receptors. The stimulus could be tissue growth factor alpha (TGF-a) or epidermal growth factor (EGR) or other molecules. Once the receptor is stimulated it is internalized and this initiates a cascade resulting in genetic expression. It has been shown that the initial stimulation is on the cell surface by an oncogene. The cell surface receptor, e.g. the epidermal growth factor receptor (EGFR) may then lead to a secondary step of protein kinase-C activation (PKC). Protein Kinase-C may also be activated independent of the growth factors and it is also the normal response after injury. In tumor genesis even though the cell surface receptor is stimulated and internalized it is not recognized as a foreign reaction. There is no immunological reaction to this cascade.

The lack of immunological reaction may be due to several reasons. The internalized molecule may not be cleaved and returned to the surface, it may be that the reaction is inhibited by transforming growth factor beta (TGF-b) or it may be that there is a defect in the T cell. Transforming grown factor beta is what is responsible for inhibiting interferon gamma, which leads to an immunological reaction. Interferon gamma is usually stimulated by monocyte chemoattractive protein (MCP), macrophage inflammatory protein 1-alpha (MIP-1a), macrophage inflammatory protein- 1-beta (MIP-1b), or tumor necrosis factor alpha (TNF-a). Interferon is also secreted by T lymphocytes. We know that interferon gamma is inhibited by transforming growth factor beta. Transforming growth factor beta also decreases the proliferation of T-cells, decreases interleukin receptor expression, decreases the proliferation of these cells, decreases the secretion of IgG and IgM, and increases the secretion of IgA. Transforming growth factor beta (TGFB) will also decrease the activation of NK cells, LAK cells, and CTL cells. Transforming growth

factor beta decreases the production of tissue necrosis factor alpha, tissue necrosis factor beta, interleukin II. It leads to macrophage chemotaxis and the decrease release of oxygen radicals and nitric oxide. TGF beta is stimulated by RAS and by p53 deletion. The stimulation of TGF beta essentially inhibits the immunological reaction. If there is no immunological reaction there is no T-cell mediated cell death.

Other glioblastoma tumor cell changes include increased PGE2, which suppresses interleukin II production as well as suppressing CTL cell, NK cell and B cell activation. It decreases cell mediated cytotoxicity and decreases the expression of MCL class II molecules. Over production of interleukin V leads to the inhibition of interleukin I, interleukin gamma, tissue necrosis factor and interleukin VI. Interleukin V works with TGF beta to inhibit macrophage cytotoxicity.

CELLULAR CHANGES

One of the earliest changes in tumor growth is the inhibition of tumor suppressive gene p53. When p53 is disabled cyclin dependent kinase 4 (CDK4) forms and active complex with cyclin Dl cross-phosphorylating the retinal blastoma protein thereby stimulating cell growth. The formation of the cyclin D1-CDK4 active complex is stimulated by the lack of p16, p15 and p21. The cyclin Dl -CDK4 complex is stimulated by MDM2 and RAS. This results in unchecked cell growth.

CLONAL GROWTH

The abnormal mutated glioblastoma cells begin to proliferate. An autocrine loop is established as well as a paracrine loop which leads to changes in neighboring normal cells. The glioblastoma cells are then the most fit to compete in their manipulated environment. The tumor cells survive in low oxygen, low pH, and high calcium concentrations. The cells will further change their environment by affecting the extra cellular milieu.

EXTRA CELLULAR MILIEU

The tumor cells will migrate over the glial limitans. It is unusual to violate the glial limitans externa and for this reason glioblastomas usually do not invade the cisterns or subarachnoid space. The tumor cells increase the secretion of chondroitin, hyaluronan, gelatinase, protease, cathepsin and urokinase plasminogen activator as well as bFGF, TF, VEGF and angiogenin. This leads to angiogenesis. Angiogenesis is essential for tumor growth beyond a few millimeters and is an adaptation to hypoxia. During angiogenesis new vessels are formed form existing vessels as well as endothelial cells migrating to form new vessels. Angiogenesis is stimulated by TGF and inhibited by interferon gamma, endostatin, thrombospondin I and tissue inhibitor of metalloproteinase III (TIMP-3). These inhibitors of angiogenesis are themselves inhibited by methylation.

It is clear from the preceding discussion that the major protein alterations in glioblastoma are the stimulation of the EGFR and inactivation of the p53 protein and stimulation of TGF. Other factors may be inhibition of p16, p15, PTEN and stimulation of RAS, CDK4, and MDM2

CURRENT TREATMENTS

SURGERY: Surgery has advanced over the century. We know the pitfalls of biopsy and subtotal resection and even though we have additional advanced technology, which allows a gross total resection, we are still not able to prevent the reoccurrence of a glioblastoma with surgery.

RADIATION: Conventional radiation, focus beam radiation, brachytherapy, boron neutron capture therapy, proton beam therapy, hyperthermia and hypothermia are all applications of types of radiation. The glioblastoma cells are resistant to radiation, as they are resistant to hypoxia. Radiation does indeed induce DNA damage, however the mutated cells have the ability to fix some of the damage of DNA.

CHEMOTHERAPY: Future chemotherapy will eventually lead to the eradication of glioblastomas. Currently chemotherapy can be delivered orally, intravenous, intra-arterial or implanted into the tumor resection cavity. The implanted chemotherapy can be by BCNU wafers, by photodynamic means as a form of immunotherapy and as a form of genetic therapy. Current chemotherapy such as

alkylating agents, depend on cells entering the cell cycle. The tumor cells can often repair the single or double stranded breaks induced by the alkylating agents. Other more specific chemotherapies look to inhibit protein kinase-C, inhibit cyclin dependent kinase, inhibitor tumor angiogenesis, inhibit growth factor inhibition, inhibit tumor invasion or stimulate cell deafferentation. These cells are currently being tried. The most promising chemotherapy appears to be gene therapy.

CONCLUSION

At this point, with all of our technology and advances in medicine we can only stretch out the survival of individuals with glioblastoma. Not only must we look for a tumor cocktail to fix the genetic alterations of p53, p16, p15, PTEN but also EGFR, MDM2, CDK4, RAS and TGF. At the same time we are treating these alternations we must keep in mind that there may be one initiating factor that affects p53, EGFR, and TGF.

Anterior Decompression of Upper Cervical Spine Via a Transmandibular Approach in a Patient with Ossification of the Posterior Longitudinal Ligament A Case Study and Review of the Literature

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ABSTRACT

Key first described the pathologic ossification of the posterior longitudinal ligament in 1838. However, the term ossification of the posterior longitudinal ligament (OPLL) was coined by Terayamer in 1964 (2), thus setting it apart from other hyperostosing processes and osteoarthritis. The incidence of OPLL was thought to be much higher in the Japanese, effecting twenty-two percent of the population. More recent studies have found the rate of OPLL as a cause of myelopathy in North Americans to approach that of the Japanese, being twenty, and twenty-seven percent respectively. We present the case of a fifty-four-year-old obese white male with a ten-year history of symptoms resulting in progressive myelopathy secondary to OPLL of the upper cervical spine.

CASE PRESENTATION

Over ten years ago our patient began experiencing neck pain with paresthesias of his upper extremities bilaterally. This progressed to weakness and an ataxic gait. Approximately five years ago he underwent posterior cervical decompression at C3-C7 for severe cervical stenosis. Post-operatively he did recover some strength and gait stability. This improvement lasted two to three years. He then took a downward turn, which was progressive leaving him only to ambulate with assistance and severe weakness of his upper and lower extremities. At the "University Hospital" he was told that nothing could be done due the extent of the disease and mal-alignment of his cervical spine. Upon first presentation his neurological exam was a myelopathic picture, motor exam 3/5 in the upper extremities and 4-/5 in all major muscle groups of the lower extremities. The patient was walking with a walker and had a severely spastic gait with sustained clonus bilaterally. The MRI scan of the cervical spine revealed extensive continuous ossification of the posterior longitudinal ligament at C2-C5 with a kyphotic deformity of approximately ten degrees. A myelogram was performed via C1-2 puncture to better evaluate the degree and extent of the stenosis. The patient was offered anterior surgical decompression via a modified mandibular approach, with a corpectomy at C3-C5, fibular strut graft and anterior plate.

DISCUSSION

Anatomy

The PLL extends from the basiocciput to the sacrum. It attaches to the disc annulus and adjacent vertebral body cortex, but is free at the mid-body level secondary to a venous plexus. The PLL is uniformly broad and flat in the cervical region, but at lower levels becomes narrow behind the vertebral bodies and expands laterally at the disc. OPLL can occur at any level, with the cervical, thoracic and lumbar regions accounting for seventy-five, fifteen and ten percent of the cases respectively. Symptomatic disease preferentially affects the cervical spine ninety-five percent of the time (1).

Etiology

The etiology of OPLL is not known. Research into possible causes has revealed an association with other diseases, and a possible hereditary link. Idiopathic skeletal hyperostosis (DISH); is present in up to fifty percent of patients (7) with OPLL. Ankylosing spondylitis is present in two percent and ossification if the ligamentum flavum in nearly seven percent (1). Spondylotic changes accompanied OPLL in about thirty-seven percent of cases (1). Diabetes mellitus, hormonal imbalance, trauma, irradiation and dietary factors (6) have also been implicated. Siblings of patients with OPLL have been found to have a fifteen times greater chance of acquiring the disorder, with recent research revealing a possible autosomal dominant and recessive inheritance pattern. Antigen BW40 and SA5 are more prevalent in OPLL as is increased fibrorectin plasma levels.

Pathology

The basic pathologic process of OPLL is similar to heterotopic bone formation in response to mechanical stress in other tissues (2).

However, OPLL occurs independent of spondylotic changes such as intervertebral disc space narrowing, posterior osteophyte formation or appreciable facet arthropathy (1). OPLL also often exceeds the anatomic limits of the PLL with the formation of bone outside the annular attachments with dural invasion. It commonly involves the higher cervical levels not normally affected by spondylotic changes (1,2). Four morphologic types of OPLL have been described. Segmental, where ossification occurs dorsal to each vertebral body (thirty-nine percent), continuous, where ossification spans vertebral body segments (twenty-seven percent), mixed, where a combination of segmental and continuous ossification exists (twenty-nine percent), and localized, where ossification is focal over the intervertebral space (1). Three basic shapes have also been described as viewed on axial CT scan, round, cubical and mushroom shaped (4). Quantitative evaluation of the cross sectional spinal canal diameter with proposed prognostic value has been formulated. The compression ratios, as defined by CT, (OPLL width/A-P diameter of the spinal canal) of greater than thirty percent were observed to lead to severe myelopathy (5). Other studies have advocated the use of absolute canal diameter with a critical value of 9-10 mm resulting in myelopathy (3,7). Dynamic factors related to decreased cord motility secondary to tethering with resultant alterations in microvascular perfusion leading to venous stasis and ischemia is thought to be responsible for decreased amounts of neural tissue found on autopsy studies (16).

Radiology

Plain cervical spine radiographs have a low yield in diagnosing OPLL Myelogram and post-myelogram CT scan are the most sensitive studies for diagnosing OPLL but have the disadvantage of being invasive and exposing the patient to radiation. MRI is less sensitive with only fifty percent of lesion being identified up to 9mm thick. However, MRI is quite useful in ruling out other diagnoses and evaluating the integrity of the spinal cord parenchyma (1,2,13).

The average age of onset of symptomatic OPLL is fifty with a slight male predomination. Patients most commonly present with neck pain, followed by upper extremity paresthesia slowly progressing to myelopathy with weakness and a spastic quadraparesis (1,2). The average duration of symptoms prior to presentation is seven-and-a-half to twenty-two months with some cases presenting up to five years after the onset of symptoms. Many patients were diagnosed after a minor trauma at which time they presented acutely myelopathic.

Treatment

Surgical indications include failed conservative management, severe radiculopathy, myelopathy; regardless of age, and very severe stenosis. In the past there has been considerable debate as to anterior versus posterior decompression. With improved microsurgical techniques in the last ten to fifteen years it has become evident that the anterior approach has provided better initial improvement with less long-term deterioration than the posterior approach (8,9,10,11). Anterior decompression via corpectomy with excision of the ossified mass addresses the pathology directly. This alleviates progression of the disease and displacement of the spinal cord with its resultant stretching of nerve roots and microvascular compromise. Spinal alignment is maintained and neurological decline secondary to trauma decreased. Goto in his series of 115 cases comparing anterior versus posterior approaches spanning twenty-five years with a mean follow-up of 7 to 8.7 years, found that with improved anterior techniques consisting of corpectomy with fibular graft fusion the most severe cases had the “best recovery rate”, maintained the highest level of recovery the longest and had the least amount of neurological deterioration compared to laminectomy or laminoplasty (l0). Epstein also found that patients with the most severe pre-operative deficits had the best post-operative results when treated with corpectomy (8,13). However, it should be noted that her study only spanned three years with an average follow-up of 20.3 months, and information was biased toward an anterior approach.

The most common complications that occur when performing the anterior approach include cord damage and CSF fistula. Early on Goto experienced three cases of quadriplegia resulting from anterior decompression that was attempted on patients with less than a 3mm canal A-P diameter. He also experienced four cases of

CSF fistula (10). Factors associated with poor outcome include insufficient removal of the ossification mass, post-operative kyphotic angulation and an extremely narrow spinal canal, as mentioned before an A-P diameter of less than 3mm. Factors associated with a favorable outcome, by compensating for the negative factors include, ankylosed vertebrae with ossification of the anterior longitudinal ligament, a wide developmental spinal canal and excellent cervical alignment (l0). There are several factors which effect surgical outcome regardless of surgical approach, these include; severe disability, myelopathy of greater than two years duration, kyphotic curvature, age over sixty-five years and post-traumatic onset of neurological decline (1,2,11,12,13). Posterior decompression via laminectomy or laminoplasty is associated with postoperative OPLL progression in seventy percent of patients and with those with a kyphotic deformity in forty-seven percent. In a retrospective review Yasiyi concluded these factors had little effect on neurological decline (12). However, the incidence of acute quadriplegia secondary to minor trauma was high. Thus, his study recommends laminoplasty over laminectomy in hopes of increasing stability at non-ossified levels affording the spinal cord protection from excessive motion. In this case study concern arose regarding adequate exposure due to the patients large, short neck and his kyphotic deformity. It was believed that a typical transcervical approach would not provide adequate superior exposure. Therefore, a transmandibular approach was performed as described by Krespi (14) and later expanded upon by Ammirati (15). The incision was then carried distally along the anterior border of the stenocleidomastoid muscle exposing down to C7. A C3-C5 corpectomy was performed with undercutting of the body of C2. The OPLL had invaded the dura, which then needed to be taken off with the bone in multiple areas. Small muscle grafts were used to close the dural defects. Fibrin glue and a lumbar drain were used to help prevent a CSF fistula. A fibular graft was fashioned from C2-C6 and held in place with an anterior plate.

During the procedure SSEP's were monitored without any changes. Finally a halo was placed and the patient was transferred to the ICU where he remained flat for seven days with CSF drainage and no development of a fistula. Post-operative x-rays demonstrated good graft alignment. The patient was ambulatory ten days post-operatively with much less spasticity. Dysphagia, a common complication, was developed by the patient and necessitated peg tube insertion for nutritional supplementation. Over the course of two months the patient's symptoms improved and the peg tube was discontinued. The patient underwent outpatient rehabilitation and serial x-rays to monitor his disease progression and cervical alignment. At six months post-operative the patient is ambulating unassisted with minimal spasticity, his dysphagia completely resolved, and he has had no progression of his disease. The graft alignment is excellent with evidence of fusion.

CONCLUSION

Once thought to be a Japanese disease OPLL has been found to be a much more prevalent cause of myelopathy in the North American population. Although the etiology is unclear, new research has implicated multiple factors, including a hereditary link. Post myelogram and CT scanning is the diagnostic tool of choice with anterior decompression giving the best results with the least amount of neurological deterioration. With greater awareness of OPLL as a discrete entity as a cause of myelopathy better treatment strategies will be adopted.

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Outcome Analysis of Microsurgery of the Anterior Cervical Spine in a Community Hospital Population

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ABSTRACT

Cervical radiculopathy is most commonly caused by compression and irritation of a nerve root by a bony spur or soft disc herniation. Disc degeneration is a normal occurrence of the cervical spine that generally advances with aging. This process initiates further changes in vertebrae, including facet arthritis, osteophyte formation along the vertebral body edges, ligamentum flavum thickening, and uncovertebral joint degeneration. Degenerative changes at the facet or uncovertebral joint can produce nerve root impingement as well.

Until the 1950s a posterior approach was the only procedure described for patients with cervical radiculopathy who had failed non-operative treatment The primary problem with this approach is the technically difficulty encountered in attempting to expose and remove compressive structures located anterior to the spinal cord and nerve roots. The chosen surgical approach must address the cause of nerve root impingement and prevent further deterioration. The need for easier access to anterior compressive structures led to the development of the anterior surgical approach to the cervical spine.

The anterior approaches to the cervical spine originated to explore the tuberculous spine1. Spine surgeons used the anterolateral approach to reach the site of the tuberculous lesion in the vertebral bodies and discs. This approach was then applied to cervical disc disease associated with radiculopathy and myelopathy, beginning with the reports in 1952. Bailey and Badgely (31) performed an anterior cervical stabilization utilizing an onlay iliac crest strut graft combined with cancellous strips packed into the disc space. Smith and Robinson in 1955 24 described an operative technique for stabilizing a pathologic cervical segment utilizing a tri-coritcal horseshoe shaped iliac crest graft placed into the intervertebral space. This technique was first used in 1954 (32) by Smith and Robinson. They employed curettes and pituitary rongeurs and did not attempt to remove the posterior osteophytes, hypothesizing that following joint stabilization the osteophytic spurs would spontaneously resolve (3).

The advantages to the anterior approach with fusion include 1) the prevention of further osteophyte formation, 2) existing posterior osteophytes would remodel and regress after solid arthrodesis, 3) distraction of the disc space would reduce buckling of the ligamentum flavum and enlarge the neuroforaminal volume with consequent nerve root decompression (4). All of these factors result in direct and indirect nerve root decompression. Since the 1960s, the operation has become a standard part of the neurosurgical armamentarium (2). The predominant changes associated with cervical spondylosis are situated ventral to neurovasular structures within the spine. The anterolateral approach allows these structures to be decompressed directly.

INTRODUCTION

The various graft configurations for anterior cervical fusion after discectomy have been described. These include the horseshoe-shaped graft of Smith and Robinson (24,31), the dowel graft developed by Cloward (33) the iliac strut graft by Baily and Badgley (32), and the keystone graft of Simmons (34). White and Hirsch (35) biomechanically studied the various graft configurations and concluded that the Robinson horseshoe shaped graft is the strongest. It was much more resistant to compressive forces than other graft shapes.

The objectives of anterior cervical spine discectomy are decompresson of neural elements, fusion, restoration of stability, and maintenance of physiological alignment. Numerous refinements have been made in the anterior cervical fusion technique, including variations in configuration of the bone graft and the source of the graft material. The use of operative magnification and improved illumination has allowed better visualization of neural structures so that compressive lesions can be easily identified and removed quickly and safely. These techniques continue to be some of the most common surgical procedures for the treatment of spondylosis, tumors, and degenerative disc

disease affecting the cervical spine.

This current study was undertaken to reflect these overall advancements in the patient and surgical outcomes of the anterior cervical microdiscectomy for cervical spondylosis and herniated discs with the assistance of the operating microscope in an Ohio community population. Patient profiles, clinical status and radiographic presentations are evaluated as well as the surgical experience and complications. The outcomes of these patients are then compared to the past and current surgical literature. This moderate sized study of 656 patients reveals comparable re-operation rates with surgical and post-operative outcomes.

CLINICAL MATERIAL AND METHODS

This is a retrospective study that includes all patients whom underwent an anterior cervical microdiscectomy, foramenotomies, decompression of neural elements, interbody fusion with auto/allograft, with or without anterior instrumentation (plate and screws) utilizing the operating microscope. These patients were admitted to the neurosurgical service at Doctor's Hospital, a community hospital in Columbus, Ohio, over a four-year period. The patient's hospital, office and computer-based medical records were reviewed for all patients in this category from March 15, 1995 to March 9, 1999. A total of 656 patients were selected and evaluated by primary analysis for patient presentation, operation experience, hospital stay, and patient outcome. All patients underwent diagnostic roentgenography including MRI, CAT scan with or without myelography, and/or EMG. Two neurosurgeons performed all the cervical operations. The senior neurosurgeon performed sixty-six percent of the operations in this series. A single independent physician analyzed all the data.

The inclusion criteria were patients with the presence of a cervical herniated disc with or without midline or lateral spondylotic stenosis. The patients underwent anterior cervical microdiscectomy, interbody fusion, with or without anterior instrumentation. The patients also included were those with primarily bony spondylotic stenosis or lateral recess stenosis with resultant nerve entrapment. Cervical laminectomies for herniated discs were not included.

A comprehensive medical evaluation was taken from each patient. A categorical file of data was organized on a spreadsheet from the patient's records, EMG reports, radiological x-rays and interpretations. Distribution of the patients profiles including sex, age, presenting occupational condition, cigarette consumption, previous surgery, work-related injury and workmen's compensation were all compiled. Patient's clinical status regarding weight distribution, provocative maneuvers, pain, reflex and motor activity were obtained.

The ideal body weight was approximated as follows:

Women: 100 lbs. For the first 5 feet of height + 5 lbs. for each inch over 5 feet.

Men: 106 lbs. For the first5 feet of height + 6 lbs. for each inch over 5 feet Subtract 2 lbs. For each inch less than 5 feet. IBW range will be + I - 10% of above calculation.

The radiographic evaluation of the disc pathology by MRI, CT and or a myelogram was obtained. EMG results were examined to evaluate whether they were related to the surgical and radiographic pathology. Surgical and radiographic levels were recorded including the individual single or multiple level cases and the presenting pathology. Complications were analyzed including failures of patient's to conservative therapy. The distribution of patients who underwent re-operation for recurrent disc herniation and their location were examined. The operative experience, specifically the blood loss, operative time and length of hospital stay were gathered.

All patients in this series were evaluated by computed axial tomography (CAT), magnetic resonance imaging (MRI), and/or myelography/CAT prior to surgery. The use of the routine myelography has diminished largely because of greater reliance on MIRI. On the basis of surgical morphology and radiological evaluations, intervertebral disc and spinal canal pathology was divided into seven categories: 1) contained disc extrusion, 2) non-contained disc

extrusion, 3) disc sequestration, 4) midline osteophytic canal stenosis, 5) lateral recess and or foraminal stenosis, 6) disc extrusion or sequestration in association with significant osteophytic midline, lateral recess, or foraminal stenosis, 7) spinal cord compression.

Cervical disc extrusions involved a significant herniation of firm annular and/or soft nuclear material beyond the confines of the intervertebral space. Contained extrusions were covered by all of the layers of posterior longitudinal ligament, whereas non-contained extrusions formed a partial or full fenestration through the ligament. Extrusions were in a midline, paracentral, or lateral location compressing the cervical spinal contents. Sequestered discs involved the passage of free nuclear material through the annulus and posterior longitudinal ligament with migration of fragments away from the disc space into the epidural space and/or foramen.

Midline spondylosis involved the protrusion into the spinal canal by a centrally located ridge or osteophytic bar. Lateral recess spondylosis involved spondylotic compression in the lateral recess of the spinal canal, whereas foraminal stenosis involved the actual narrowing of the foramen by osteophytes protruding from the uncovertebral or facet joints.

The patient's clinical status was the most important factor in determining the role and timing of surgical intervention. Those patients without radicular pain or positive radiologic findings were treated with at least two months of conservative treatment before operative intervention was even considered. Patients with radicular pain, but no neurologic findings, generally underwent at least a month of physical therapy, stretching and mild exercise, spinal manipulation, and epidural steroid injections in combination with medical treatment. A course of oral systemic steroids were given to patients with acute cervical radiculopathy. Those individuals with marked radicular or mild myelopathic symptomatology and appropriate neurological deficits were considered for surgery after only a brief period of therapy lasting two to four weeks. Finally, patients with severe arm pain and marked neurological findings, or those with severe or progressive myelopathy underwent surgery without delay.

Intraoperative evoked spinal cord monitoring and EMG was utilized in patients with severe cervical stenosis and clinical myelopathy by the junior neurosurgeon. Also, in the patient with significant instability, stenosis and/or spinal deformity, awake intubation was preferred. Intraoperative hypotension can be disastrous in this patient population and it was important to confirm that the anesthesiologist if fully cognizant of this association. The junior neurosurgeon encouraged anesthesia to place a small endotracheal tube, ideally less than or equal to a 6.5, to allow less mass effect in the operative field.

The surgical procedure followed was substantially similar in all patients, with minor variations. Pre-procedure medication including prophylactic antibiotics, one gram of cefazolin I.V. and eight milligrams of dexamethasone acetate I.V. were given. Under general endotracheal anesthesia, all patients were positioned in the supine position and arms were placed at their side. The junior neurosurgeon placed a roll under the patient's neck and between the shoulder blades. The head was positioned in a neutral manner on a foam head rest. The neck was turned slightly to the left exposing the right side of the neck. A roll was placed under the left hip to prominate its position facilitating the harvesting of the iliac crest. A 2-3 cm. Incision was marked over a horizontal medial border of the sternocleidomastoid on the right side. Left iliac crest incision was marked three fingerbreadths posterolateral to the anterior superior iliac spine. After betadine preparation and infiltration of 0.25% marcaine with 1:200,000 epinephrine hemostatic agent was completed in both incision areas. Betadine prep, sterile towels and drapes were applied.

A transverse cervical incision was completed with a #10 scalpel on the right side of the neck at the appropriate level. Careful hemostasis was controlled with bipolar coagulation. Sharp Metzenbaum's scissors and blunt digital dissection was taken through the platysma along the medial border of the sternocleidomastoid along the plane between the carotid sheath and esophagus. The anterior spine was exposed and Cloward retractors were inserted. The longus coli muscles were cauterized along the medial insertions and elevated with a

#1 Penfleld. Caspar self-retaining retractor blades were placed beneath the longus coli muscles and secured. Intraoperative x-ray is obtained to localize the level(s) of concern after the spinal needle is placed into the interspace.

While the microscope was being sterilely draped the left iliac incision was begun with a #10 scalpel, electrocautery incised the subcutaneous tissue and periosteum over the crest. Periosteal elevator exposed the iliac crest, and the sagittal saw and osteotomes removed the cortical cancellous biltricortical block of bone with hemostasis achieved with thrombin spray, gelfoam and irrigation with copious amounts of normal saline. The incision was then closed in layers and infiltrated with 0.5% Marcaine for analgesia post-op.

Under direct microscopy the cervical procedure was initiated with the disc incised at the anterior longitudinal ligament with disc curetted and removed meticulously down to the level of the posterior longitudinal ligament. The Cloward interbody spreader was then placed to open the disc space further and allow improved visualization. The blunt nerve hook tented up the posterior longitudinal ligament and incised with a #15 scalpel. High speed drill was utilized for partial decortication and graft site preparation for the Smith and Robinson graft. Exploration into each foramen with a fine nerve hook to identify and remove the associated pathology was then performed. The discs and spurs were removed with curettes, Kerrisons and nerve hooks. At this point a sizing instrument is used to measure the height, width and depth of the disc space to be filled with the graft. The cortical cancellous block of bone was shaped, measured, gently inserted and locked into place with the removal of the intervertebral disc distracter. Soft tissue was then removed off the anterior vertebral bodies. The anterior cervical plate was screwed and locked into place. Irrigation, careful hemostasis, and examination of the vital structures are observed with placement of a Penrose drain. Layer closure of skin and intra-op x-rays are taken to examine placement of the graft, plate and screws.

The patient outcome was categorized into excellent (no problem at all), very good (fully functional, but occasional pain, no restrictions), good (function with some restrictions to strenuous activities), fair (restrictions to daily activity, chronic pain medication required), disabled (moderate to severe restrictions to daily activity, unable to work).

The Functional-Economic Outcome Scale of Prolo measured the outcome as well. (see Table 1.) The Prolo scale consists of two sub scales: the economic and the functional. The reviewing physician on the basis of chart review assigned outcome scores. The subscale scores were summed to obtain an overall score. Total scores of five or less were designated as poor outcomes; score of six to seven were considered to be moderate outcomes; and scores between eight and ten were reflected as good outcomes. The functional scale as reported by Prolo gives an economic grade expressing the patients' capacity for gainful employment and a function grade expressing the effects of pain on daily activity. The scale was modified for outcomes in cervical disc pathology.

Table 1.
Functional-Economic Outcome Rating Scale

Economic Status	
El	Complete Invalid
E2	No gainful occupation including inability to do house work or continue retirement activities
E3	Able to work at previous occupation part-time or limited status
E4	Working at previous occupation part-time or limited status
E5	Able to work at previous occupation with no restrictions of any kind
Functional Status	
Fl	Total incapacity (or worse than before operation)
F2	Mild-to-moderate level of neck pain and/or radiculopathy (able to perform all tasks of living)
F3	Low level of pain and able to perform all activities except sports
F4	No pain, but patient has had one or recurrent episodes of neck pain or radiculopathy
F5	Complete recovery, no recurrent episodes of neck pain or radiculopathy, able to perform all previous sports

RESULTS

Patient Profiles (see Table 2.)

Males were slightly more common than females requiring cervical surgery. There were also a higher percentage of men working in labor positions. The patients ranged from nineteen to eighty-seven years old, but forty-six percent were between thirty-five and forty-nine years of age. The mean age was forty-two for males and females. Cervical disc herniation occurred in men at an average age of forty to forty-six years of

age. The occupational profiles showed that the overwhelming majority of patients were laborers (strenuous, blue collar) with thirty percent of the patients functioning as office workers (non-strenuous).

Over fifty percent of the patients stated that this a work-related injury and forty-one percent of these work-related injured patients claimed workmen's compensation. A small portion of the patients had a previous surgery at the same level as the prior cervical discectomy/fusion. Over two-thirds of the patients used nicotine products by either smoking or chewing.

Table 2.

Patient Profiles		#	%
Sex	Male	349	53
	Female	307	47
	TOTAL	656	
Age	<20 yrs old	1	<1
	20-34	118	18
	35-49	300	46
	50-70	217	33
	>70	20	3
Occupation			
	Retired	66	10
	Unemployed	20	3
	Office Worker	197	30
	Laborer	373	67
Workers Compensation		151	23
Work-related Injury		367	56
Previous Surgery		40	6
Cigarette Consumption		440	67
Motor Vehicle Accident		39	6

PATIENT CLINICAL STATUS

The patient's clinical status is reviewed in Table 3. Just over one-third of the patients in this series were normal weight. Two-thirds of the patients selected for surgery were overweight. One-third of the patients were in excess of forty pounds overweight.

Eighty-nine percent of the patients presented with neurological finding on physical examination. These included a motor loss, a sensory change, radicular numbness, and/or a reflex loss in either the biceps, triceps or brachioradialis. Provocative measures such as the Spurling's Sign were commonly present. Myelopathic signs such as Hoffman's, clonus, and Babinski's were present in almost twenty percent of the patients with soft disc cervical herniation. The most sensitive test was the presence of a sensory change, unfortunately it is not specific and reliable for a specific radicular pattern. All patients complained of neck or arm pain or paresthesias in a radicular distribution. Almost all of the patients presented with both neck and arm pain of varying proportions. A small portion of the patients complained of only neck or arm pain independently.

Table 3.

	Patient Clinical Status	%	#
Weight	Obese (>40lb.)	34%	223
	Overweight (<40lb.)	33%	217
	Normal	33%	216
Pain	Neck and Arm	82%	535
	Neck Only	9%	60
	Arm Only	8%	52
	No Significant Arm and Leg Pain* lnterscapular Pain	1% 19%	9 124
	*lndication for surgery was significant neuro deficit		
Neurologic Abnormalities	Motor Loss	58%	381
	Sensory Change	89%	584
	Radicular Numbness	56%	367
	Reflex loss	73%	479
	Hoffman's Sign Present	16%	105
	Spurling's Present	56%	367
	Myelopathic Signs	19%	125

CAUSE OF INJURY

Lifting accidents were found to cause the highest incidence of ruptured disc in this series (Table 4.). The contributing factors to herniated discs in descending distribution were repetitive use, motor vehicle accidents, falls, sports or exercise injuries, and coughing or sneezing. No definite cause could be determined in seventeen percent of the cases. Smoking, advancing age, lack of physical fitness, obesity, and improper ergonomics were all statistically significant risk factors in predisposing patients to cervical herniated discs and or spondylosis.

Table 4.

Pathology	%	#
Lifting	41%	269
Repetitive Use	19%	125
Falls	9%	59
Sport or Exercise Injury	2%	13
Motor Vehicle Accident	11%	72

Coughing/Sneezing	1%	7
No Definite Cause	17%	111

FAILED CONSERVATIVE THERAPY

All patients underwent conservative therapy of some form, see Table 5. Ninety-one percent of the presenting patients had symptoms for at least three months before surgery. Seventy-six percent of the patients had at least two weeks of bed rest or significantly decreased amount of activities. Narcotics, NSAIDs, and oral steroids were the medications of choice that failed in the majority of the cases. Greater than three-quarters of the patients failed either or both systemic (oral) or epidural steroids. Patients who responded to epidural steroids at least briefly were positive indicators of a good surgical outcome. Almost three-quarters of patients attempted muscle relaxants. Eighty-seven percent of the patients failed physical therapy, exercise, stretching, electrical stimulation, heat, cooling, traction or ultrasound therapy. Osteopathic or Chiropractor cervical manipulation was attempted and failed in less than one-quarter of the cases. As long as the patients were not myelopathic, manipulation was not considered a contraindication to therapy for herniated discs as many primary care providers assume.

Table 5.

Failed Conservative Therapy	Percent	Number
Narcotics	95%	623
NSAIDS	93%	610
Epidural Steroids	19%	125
Physical Therapy	87%	138
Manipulation	21%	571
Muscle Relaxants	72%	472
Systemic Steroids	77%	505

RADIOGRAPHIC EVALUATION AND SURGICAL PATHOLOGY (see Table 6.)

Magnetic resonance imaging was obtained in almost all cervical patients. If the MRI and/or EMG results were equivocal or did not correlate with the patient findings a cervical myelogram with CAT scan was obtained to evaluate the patient further. The majority of EMG and MRI findings obtained were positive on the selected surgical patients.

The majority of the cases presented with non-contained extrusions, followed by sequestration and contained extrusions. Frequently, disc extrusions were associated with prominent osteophytic spurs either anteriorly, posteriorly, or both. Sequestered discs were found to migrate into the epidural space rostrally or caudally behind the rostral or caudal vertebral body, or laterally into the foramen, anterior, posterior, or rostral to the nerve root. With time, sequestered discs were usually covered by a glistening white fibrotic capsule, which was often densely adherent to the surrounding dura.

At least some evidence of midline spondylosis was identified in over two-thirds of the patients in this series at either a single or multiple levels. Lateral recess or foraminal spondylosis was identified in just less than two-thirds of the patients in this series either unilaterally or bilaterally at one or more levels. A combination of disc extrusion or sequestration, and either midline or foraminal stenosis was identified in greater than fifty percent of the patient population. Spinal cord compression was present in over fifty percent of the patients.

RADIOGRAPH		%	#
CT/Myelogram	Obtained, Positive	13	85
MRI	Obtained, Positive	91	596
EMG	Obtained, Positive	95	623
Total Discs			2719
Bone/Disc Pathology			
Extrusion (contained)		3	84
Extrusion (non-contained)		39	1060
Sequestration		21	571
Midline Spondylosis		69	1876
Lateral Spondylosis		61	1659
Extrusion/Sequestration & Spondylosis		51	1387
Spinal Cord Compression		15	407

SURGICAL AND RADIOGRAPHIC LEVELS

The anterior approach was utilized in all patients. Single level herniation was common at the C5-6 level, followed by C6-7, C4-5, C3-4, and C7-T1 in this series of patients (Table 7.). C5-6, C6-7 multiple level procedure was the most common procedure even though the single level operations were more frequent. The senior neurosurgeon placed a Penrose drain in all of his anterior cervicals. The junior neurosurgeon did not elect to place any drains. Bone grafts, either iliac crest autograft (61%) or freeze-dried allograft (39%) were used in all of the patients.

Nine percent of the patients wore a Philadelphia collar and forty-three percent wore a soft cervical collar. All but thirty-nine (seven percent) of the patients received anterior cervical instrumentation with fusions. A multitude of plates were used including Acromed, Spinal Concepts-Accufix, Codman, Synthes, Atlantis and Orion anterior cervical titanium plates. The operating microscope was utilized in all of the cases.

The senior neurosurgeon utilized the iliac crest autograft in the majority of the cases performed, while the junior neurosurgeon used freeze-dried bank bone allograft in all his cases. The senior neurosurgeon selectively used anterior cervical plating and the junior neurosurgeon used plates in all of his cases.

Table 7.
Surgical and Radiographic Levels

	Level(s)	Percent	Patient Number
	1	56%	365
	2	36%	235
	3	8%	50
	4	1%	6
Single	C3-4	2%	12
	C4-5	6%	40
	C5-6	26%	168
	C6-7	21%	135
	C7-T1	<1%	4
Multipl	C3-4, C4-5	1%	7
	C4-5, C5-6	8%	50
	C5-6, C6-7	27%	175
	C3-4, C4-5, C5-6	1%	6
	C4-5, C5-6, C6-7	6%	42
	C3-4, C4-5, C5-6, C6-7	1%	6
	C5-6, C6-7, C7-T1	<1%	2
	C6-7, C7-T1	<1%	3

COMPLICATIONS

Sixty-eight patients (ten percent) in this series developed complications related to their surgical experience (see Table 8.). The most frequent postoperative complications were persistent or recurrent neck pain and/or persistent or recurrent arm pain. Dysphagia was the second most common complication. In these patients, the pain was severe enough to interfere with the patient's ability to return and perform rigorous or strenuous physical activity. In four percent, twenty-six of the patients, the pain was significant enough to proceed with additional diagnostic tests (MRI and/or myelography). Clinically significant recurrent pain in patients who had become asymptomatic post operatively occurred in a total of three percent (20) of the patients. No patient suffered a cerebrospinal fluid leak post operatively.

Eight patients in this series had a subcutaneous postoperative infection. Two patients required surgical debridement of wound dehiscence. The other patients cleared their infections with a short course of oral antibiotics. Infections were most prominent in obese and diabetic patients. No patient experienced a disc space infection.

Seven patients developed acute hematomas in the immediate postoperative period. One patient developed a soft tissue clot that required emergent evacuation for acute airway obstruction. This patient did not have a drain placed intraoperatively.

Thirteen patients complained of dysphagia lasting two weeks, but in all cases resolved before one month. Twelve patients complained of hoarseness lasting four weeks, and in one of these patients the hoarseness was permanent requiring ENT evaluation and treatment.

Eight patients suffered clinically significant postoperative subluxation, and pseudoarthrosis, requiring long-term immobilization and/or repeat surgery. No significant neurological deficits were noted post operatively, including paralysis and root avulsions. No deaths were recorded in the immediate post-operative period. No esophageal perforations were identified. No major vessel injuries occurred including the vertebral and carotid arteries and the internal jugular vein.

Table 8.
Complications

Persistent Neck Pain	8%	52
Recurrent Neck Pain	4%	26
Persistent Arm Pain	5%	32
Recurrent Arm Pain	3%	19
Dysphagia (> 2 weeks)	2%	13
Hoarseness (> 4 weeks)	2%	12
Homers Syndrome	<1%	3
Subcutaneous Infection	1%	8
Disc Space Infection	0	0
CSF Leak	0	0
Subcutaneous Hematoma	1%	7
Subcutaneous Hematoma with Airway Obstruction	<1%	1
Epidural Hematoma	0%	0
Subluxation (Pseudoarthrosis-Symptomatic)	1%	8
Root Injury	<1%	1

Subcutaneous Neuroma	0%	0
Repeat Surgery	3%	18
Disability (Permanent)	1%	6
Death	0	0
Esophageal Perforation	0	0
MajorVessel Injury	0	0
Recurrent Laryngeal Nerve Injury	<1%	3
Deep Vein Thrombosis	<1%	1

RE-OPERATION FOR RECURRENT DISC HERNIATION/PSEUDOARTHROSIS (see Table 9.)

There were eighteen patients in this series who required an additional surgery at either a different level or at the same level. Adjacent level disc disease was the most common etiology for re-operation. Pseudoarthroses with postoperative instability and recurrent pain were the second most common reasons for repeat surgeries.

Table 9.

Second Surgery at Different Level	2%
At Same Level (repeat procedure)	<1%

BLOOD LOSS AND OPERATIVE TIME

Ninety-eight percent of the patients experienced less than one hundred ml of blood loss (see Table 10.). Only multi-level cases, experienced blood losses greater than one-hundred ml. No complications resulted from patient blood loss and no patient required a transfusion secondary to the operation.

Table 10.

Blood Loss (mL)	Percent	Patient Number
0-50	94%	618
>50-1 00	4%	24
>100-200	2%	12
>200-300	<1%	2
>300	<1%	1

The operative time for the anterior cervical discectomy with interbody fusion and plating for a single level averaged one to one and half hours. Each additional level added an average of thirty minutes to the operative time (see Table 11).

Table 11.

Operative Time	SingleLevel	Multi-level
<45min	22/ 6%	
<60min	72/ 20%	13/ 4%
1-1.5 hrs	178 /49%	89/ 31%
1.5-2 hrs	56/ 15%	119 /49%
2-2.5 hrs	23/ 6%	36/ 12%
2.5-3 hrs	12/ 3%	23/ 9%
>3hrs	1/ 1%	11/ 4%

Hospital Stay

Ninety-nine percent of the patients ambulated on the day of surgery with remaining patients ambulating on the first post-operative day (see Table 12.). All the patients hospitalized greater than post-operative day number one were elderly and myelopathic individuals with pre-operative ambulation difficulties and or extensive medical issues. These individuals generally required physical therapy prior to discharge. One patient developed a deep vein thrombosis and another a post-operative hematoma requiring surgical intervention after they were discharged to home on an outpatient basis. Ninety-eight percent of the patients were discharged before 23 hours, and ninety-nine percent before the second post operative day.

Table 12.

Stay	%	#
Outpatient	7%	43
POD #1	91%	600
POD#2	2%	11
POD#3or>	<1%	2

PATIENT OUTCOME

The outcome classification in Table 13 was modified from Caspar. Eighty-five percent of the patients had resumed full home activity by two weeks and ninety-five percent by one month. Postoperatively, most patients returned to work comparatively early; two to four weeks for a desk job and one to three months plus for light physical work. Thirty-nine percent of the patients returned to work before the end of the fourth week. Early resumption of employment did compromise interbody fusions without instrumentation in eight individuals whom developed a pseudoarthrosis. Eighty-three percent of the patients were able to return before two months, and ninety-three percent by the third post-operative month. Less than one percent of the operated patients who had previously worked,

were unable to work after surgery and requested permanent disability. Ninety-five percent of the patients were grade from excellent to good outcomes. The one percent of the patients categorized as disabled were already moderately to severely restricted in their daily activities of living prior to the operation.

Non-industrial patients had a ninety-seven percent excellent or good rating compared with eighty-one percent of industrial accident patients. Professional, level of education, and self-employment led to better outcomes regardless of legal concerns or industrial insurance.

Table 13.

Patient Outcomes	Percent	#
Excellent (No problem at all)	52%	344
Very Good (Fully functional, but occasional pain, no restrictions)	32%	209
Good (Function with some restrictions to strenuous activities)	11%	71
Fair (Restrictions to daily activity, chronic pain medication required)	4%	26
Disabled (Moderate to severe restrictions to daily activity, unable to work)	1%	6

The overall outcomes are summarized in Table 14.

Table 14.

Patient Outcome	Percent	Patient Number
Satisfactory		
No or Some Neck/Arm Pain	96%	630
No or Minimal Medication Requirements	99%	649
Return to Work or Normal Activity	97%	636
Unsatisfactory		
Continuous Neck/Arm Pain	4%	26
Narcotic Medication Required	1%	6
Decreased Function and No Return to Work	1%	6

Table 14. continued

E1		0
E2	1%	5
E3	5%	30
E4	47%	47
E5	88%	574
Functional Scale		
F2	4%	24
F3	9%	56
F4	14%	89
F5	74%	487
Total		
Tl		
T2		
T3		
T4	0.20%	
T5	1.10%	
T6	2.30%	
T7	3.30%	
T8	7.60%	
T9	20.20%	
Tl0	67.60%	

DISCUSSION

The pathological process of cervical spondylosis is a circumferential degeneration of multiple structures surrounding the cervical spinal canal, including the ligamentum flava, laminae, zygapophyseal (facet) joints, uncovertebral joints, anterior and posterior longitudinal ligaments, cartilaginous endplates, vertebral body and intervertebral discs (nucleus pulposus and annulus fibrosis).

Risk factors for the initiation and propagation of the degenerative process include advancing age, cigarette smoking, excessive weight, sedentary lifestyle, prior infectious process, massive or repeated injuries, excessive or strenuous repetitive wear and tear, inflammatory joint disease, congenital abnormalities (motion-segment anomalies), positive family history, and atherosclerosis. These spondylotic changes affecting spinal column supporting structures cumulatively result in a circumferential narrowing of the spinal canal diameter and/or intervertebral foraminal dimensions. The spondylotic changes, though primarily affecting spinal column motion segments and their ligamentous supporting tissues, secondarily affect neurovascular elements by narrowing the diameter of the spinal canal, decreasing the dimensions of the intervertebral foramen, and on occasion compromising the integrity of the foramina transversalis. This reduction in space produces neurologic symptoms by compressing the enclosed spinal cord, spinal roots, and vertebral artery and/or its radicular branches. Although the spondylotic spine itself may be asymptomatic (except for minor axial pain syndromes), secondary compression of these structures frequently results in significant neurological symptoms that often lead the patient to seek medical attention.

The anterior approach for soft disc protrusions, extrusions, and sequestration was developed in the late 1950s as an alternative to the classical laminectomy approaches (24). The difficulty and danger encountered when extracting disc fragments situated to the spinal cord or nerve roots from a posterior approach spurred the development of more accessible and safer anterior approaches.

The objectives of anterior cervical spine discectomy are decompresson of neural elements, fusion, restoration of stability, and maintenance of physiological alignment. The advantages for the anterior approach are the ease of positioning the patient and the minimal trauma to the muscle. The major disadvantage is the potential for injury to the soft tissue structures of the neck, including the carotid artery, the recurrent laryngeal nerves, the trachea and the esophagus.

The overall reported results for both posterior and anterior approaches in treating root compression due to a bony spur are closely comparable (12,13,29,30). For spondylotic radiculopathy, long-term success using the anterior approach can be expected in an average of seventy-six percent of patients, whereas the posterior approach is successful in around sixty-eight percent. There is no statistical difference between these results, suggesting that the widely debated issue of the need for osteophyte removal versus a simple nerve root will remain a controversial point of discussion depending on the surgeon's personal perspective. In addition, overall there is a ninety percent chance that an individual patient will receive at least a satisfactory outcome regardless of the approach, and only a two to five percent chance that the outcome will be less than satisfactory with either procedure (14,15,16).

For soft disc herniations (11,18,19,21), the anterior and posterior approaches yield similarly, good short-term results in seventy-four to one hundred percent of cases (average, 82%). Long-term good results (after one year) vary form 63% to 71% (average, 68%), with a recurrence rate of 10% to 18% (average, 14%) for the anterior approach, and of 0% to 11% (average, 6%) for the posterior approach. Generally, better results are obtained from either approach in patients undergoing surgery at one level only.

For spondylotic myelopathy (7,11,20,28) 40% to 84% of patients show significant improvement (average, 50%) using the anterior or posterior approach, with the duration and severity of myelopathy and the patient's age being the most important prognostic factors.

The Smith-Robinson tri-cortical iliac crest is believed to be the ideal choice for arthrodesis after anterior cervical discectomy (3,4,9). Autologous bone heals better and has better long-term results (8,22,25). The grafts are very strong and will only very rarely collapse, especially when supported with an anterior plate. The disadvantages of autologous grafts are the morbidity associated with harvesting including persistent iliac crest pain, hematoma, infection, hernia, pelvic fracture, injury to deep vessels and paresthesias. This pain may be due to irritation of the adjacent nerves, including the lateral femoral cutaneous, ilioinguinal and genitofemoral nerves. Accurate assessment of the true incidence of graft donor complications is difficult (3,9). Donor site complications can be avoided by meticulous surgical preparation and draping, making the skin incision one to two cm below the iliac crest, and taking the graft two to three cm behind the anterior superior iliac spine. This service also uses the sagittal saw instead of osteotomes to harvest the graft, practicing thorough hemostasis and copious irrigation. Drains were not routinely used with the cases for the hip. The use of freeze dried allograft increases the time to bony fusion and prolongs the period of patient immobilization (2,10,17).

Advanced age, long duration of symptoms, smoking, and increased severity of stenosis may be associated with poorer clinical outcome (23,26). Advanced age or severe presenting functional disability should not be contraindications to surgical treatment (27).

Infection occurs in less than one percent of operated patients (37). Meticulous skin preparation, prophylactic antibiotics, and careful operative technique remain the foundation of any policy to avoid infection. No deep or disc space infection in this patient population.

Hematoma formation is a potentially disastrous complication that can cause respiratory compromise. It is avoidable with meticulous attention to hemostasis at the end of the procedure, with bipolar cautery and use of

hemostatic agents, this can be avoided. The use of a drain gives added insurance without increased risk. Rarely one can injury the vertebral artery, most commonly when the surgeon becomes disoriented as to position. No vertebral artery injuries occurred in this series. The one airway compromising hematoma that occurred in this series could have possibly been prevented with a drain. This patient was also sent home on an outpatient basis. Overnight observation with a drain to evaluate the patient's progress would be prudent postoperative care.

Esophageal injury is a rare but serious complication of anterior cervical spine surgery, occurring in approximately 1 in 500 procedures (36). The perforation is usually not recognized until the patient develops an abscess, tracheoesophageal fistula or mediastiitis in the postoperative period. No perforations occurred in this clinical series.

Hoarseness or sore throat after anterior cervical surgery may be due to edema or endotracheal intubation and can occur in up to one half of patients in some series (5). In a small number of patients recurrent laryngeal nerve palsy can be the etiology of persistent hoarseness (6). Damage to the recurrent laryngeal nerve is the most common major risk of the anterior exposure. The reported incidence is nearly one percent, but one report claimed an incidence as high as eleven percent (5,8). Damage to the superior laryngeal nerve can occasionally result in hoarseness, but more often produces only minor symptoms such as easy voice fatiguability (6). Injury to these nerves was prevented in this series by placing the self-retaining retractors only in the horizontal fashion, not in the rostral-caudal direction.

Graft extrusion usually occurs anteriorly away from the spinal cord and can be associated with dysphagia, tracheal obstruction, kyphotic deformity and neurological symptoms. The incidence is reported to a range from one to thirteen percent (16-18). Graft collapse is another complication. Graft extrusion can be prevented anteriorly by placing anterior instrumentation. The most common presentation in graft extrusion was noncompliance of the patient to wear their cervical collar and limit flexion and extension of the neck.

Spinal cord injury is the most dreaded of all complications and, fortunately, is extremely rare and did not occur in this patient population. Various authors have reported incidences averaging less than 0.5% (19,20,37). Most spinal cord or nerve root injuries are associated with technical misfortunes (19). Plunging into the spinal cord has been reported with many of the various anterior cervical procedures (5). Bone graft insertion is also associated with direct spinal cord injury (13,14). Vascular compromise of the spinal cord is associated with significant morbidity. The cord is at particular risk in the cervical region because of lack of collateral circulation, and the dependence on three or four contributing vessels. However, some people have a single vessel supplying blood to the spinal cord. Loss of radicular vessels can result in severe spinal cord ischemia. Pre-existing pressure is probably the most common etiology, positioning can be poorly tolerated, and intraoperative hypotension has been associated with spinal cord ischemia. This patient series did not have and major spinal cord or nerve root injuries.

Techniques such as the Smith-Robinson fusions utilized by this staff have been widely accepted and successful for degenerative conditions. These bone graft techniques rely on the stability of the construct between the bone graft and host bone, and successful fusion can be accomplished in the majority of cases. However, these techniques when applied to a more unstable cervical spine, may not offer sufficient stability and may result in complications such as bone graft dislodgment, collapse, and nonunion. Biomechanical studies support the use of anterior plates except in severe flexion-distraction injuries (19,20). There have been several reports of good clinical results with the use of anterior plates for the unstable cervical spine (21-24). The incidence of nonunion is higher among patients who received allografts, patients who smoke, and patients who underwent multiple fusions (23,26). Anterior cervical plating for augmentation of anterior bone grafting may improve the stability of the construct and fusion rate, particularly in multiple level fusion cases and in smokers (27).

Pseudoarthrosis is an established complication utilizing interbody fusions (5,6). With the interbody approach the incidence of pseudoarthrosis approaches ten percent in most reported series, but can range from 0 to 26

percent (28-30). The incidence of pseudoarthrosis is reported to be greater using the Cloward (10) technique. Multiple-level fusions have been associated with a higher rate of nonunion than single level fusions. Anterior re-operation to correct pseudoarthrosis is fraught with potential serious complication, including an increased risk of esophageal and carotid artery injury in the literature (9). Pseudoarthrosis was the highest concern in our patient population receiving freeze dried allograft without an anterior plate and who was a heavy smoker and non-compliant.

The results of multiple series of anterior cervical fusions have been satisfactory in over ninety percent of patients (21-24). Robinson (24) reported 55 patients who underwent anterior cervical discectomy and fusion with the tricortical horseshoe iliac crest graft; the results were inversely proportional to the number of levels fused. For a single level fusion, 94% had a satisfactory result, as opposed to 73% for two-level fusion and 50% for three-level fusion. Solid bony fusion was achieved in over 95% of cases and two percent achieved asymptomatic pseudoarthrosis or painless fibrous union. Symptomatic pseudoarthrosis was noted in less than three percent of cases. The reasons for the poor results which correlate with this service relate to two factors: the first is the greater severity of multilevel disease; and the second relates to the failure of fusion of the bone graft to the adjacent level vertebrae, which is inversely proportional to the number of levels fused.

Aronson (1) reported 88 cases of soft cervical disc herniation treated with anterior cervical discectomy and fusion. He noted an overall success rate of 100%, but the article did not define the criteria for success.

DePalma reported on 388 patients who failed to respond to non-operative treatment and were advised to have surgery: 281 considered surgical intervention and 107 declined. Of the non-operative group 46% obtained satisfactory results, 32% lost no time from work, and 68% overall were able to return to work with in 2 months of the onset of symptoms. Litigation affected the results of non-operative treatment, and except for patients with pending litigation, 61% obtained satisfactory results with non-operative treatment. Of the 281 operative patients, satisfactory results were obtained in 63%. The period of disability was greater for surgical patients than the non-surgical ones. Both subsets had similar failure to return to the original occupation. If a subset of patients with radicular symptoms was followed, the results of surgical management were superior to non-operative treatment: 65% of the patients with radicular symptoms obtained satisfactory results with surgical intervention, whereas only 33% obtained satisfactory results with non-operative treatment. This patient population predominately had anterior instrumentation placed. DePalma did not place in anterior instrumentation. Anterior plating decreased the pseudoarthrosis rate and certainly improved this series satisfactory outcomes.

Gore and Sepic (39) reviewed 146 patients who underwent an anterior cervical fusion with autologous bone graft. At follow up 97% believed they benefited from surgery, and there was a 97% fusion rate. More patients with cervical spondylosis developed problems with recurrent pain than did those with simple disc herniation. Twenty-five percent of the patients were classified as soft disc herniations, whereas the etiology in the remainder were spondylotic spurs causing nerve root compression. This patient series confirmed with Gore's study that the autograft fusion sustained higher patient satisfaction and fusion rates.

Cloward (5) reviewed his experience with over 2000 patients treated with anterior cervical discectomy and fusion. Overall, 94% had relief of their pain: the fusion rate was 97%. Connolly (6) demonstrated a pseudoarthrosis rate of 15% with one or two level fusions, and 46% for three level fusions with the Cloward graft. White et al.(26) Reported an 80% fusion rate for one level and 66% for multiple level fusions.

The Cervical Spine Research Society (40) study had 40 surgeons entered over 500 cases for a prospective cohort study of cervical spine problems. When these patients had an independent assessor perform a 1 year follow up (on cases which were mostly one and some two-level procedures) there was clear improvement in over 70%. The same patients reported to their doctor higher success rates: nearly 90%. So, the true number probably lies in between. The success has to be weighed against

the complication rate, which can approach 6% for these sort of cases. The good news is that the patients only remembers or appreciates less than half of these complications, approximately 2%. These studies did not demonstrate anterior instrumentation with fusion. The current studies are few and with a low volume of patients when patients are analyzed with anterior instrumentation.

The present series documents the benefits of the anterior approach in a variety of cervical spine degenerative conditions causing neck pain, radiculopathy and myelopathy. Good results combined with a minimum of complications make this approach a safe, effective means of dealing with neurologic disability as a result of cervical spondylosis.

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Autologous Trochanteric Graft for Anterior Cervical Discectomy and Fusion

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ABSTRACT

Patient A is a 38 year old right-handed morbidly obese white, female who presented to the neurosurgical service as an outpatient with complaints of left upper extremity lancinating pain that radiated from her neck into her forearm and hand in the C6-7 dermatomal distribution. She further described episodes of dropping objects with her left hand at home with numbness and paresthesias in the same distribution. Her symptoms began following a work-related injury approximately one year prior to consultation. Valsalva and repetitive movements at work aggravated symptoms. Conservative treatment including physical therapy, analgesics, and non-steroidals did not significantly alleviate her pain.

CASE REPORT

Plain radiographs of her cervical spine revealed disc space narrowing and spondylotic changes most prominently at C6-7. Subsequent MRI of the cervical spine and CT myelography revealed both osteophytic and discogenic compression of the thecal sac at that level, primarily on the left side. It was felt that this patient would benefit from anterior cervical discectomy with bony fusion. All findings and proposed surgical intervention were discussed with her and she agreed to proceed.

After being placed supine in the operative suite, the patient was noted to have a large panniculus, which required manual retraction and taping to facilitate exposure of the iliac crest. The patient was prepped, draped, and surgery was begun. As she had been referred to neurosurgery by orthopedics, autologous iliac crest graft was to be obtained by the orthopedic surgeon. Exposure of the anterior vertebral bodies of the cervical spine and discectomy at C6-7 proceeded in normal fashion. Tricorticate iliac crest graft procurement proved to be both labor intensive and time consuming because of the patient's size. Eventually, autograft was obtained, but it lacked the typical appearance of tricorticate iliac crest. The graft was tapped into the C 6-7 disc interspace and both incisions were closed. She was transported to the recovery room in stable condition and eventually to the surgical floor for post-operative care.

As expected, the patient complained of some right hip and neck pain on post-operative day one but appeared to be progressing satisfactorily. Post-operative cervical spine radiographs revealed adequate placement of the intervertebral graft. On day two, she complained of moderate to severe hip pain and some difficulty with standing. Physical examination of the lower extremities revealed the right lower extremity to be externally rotated with significant pain in all ranges of motion. She was also unable to weight-bear on her right leg. Urgent pelvic and right hip radiographs revealed her greater trochanter and femur neck to be fractured. Further inspection of both iliac crests revealed no evidence of graft harvesting.

The orthopedic surgeon brought the patient back to the operative suite in an attempt to stabilize her right femur with compression screws. She recovered slowly and was eventually placed into the Rehabililation department. Although her cervical fusion was healing appropriately several weeks after discharge from the Rehab unit, the hip construct failed and she required total hip replacement. While this may be an extreme example of morbidity associated with autologous graft harvesting, the potential does exist.

DISCUSSION

Since the early seventies, anterior cervical discectomy with bony fusion has gone through many revisions in determining the ideal construct for facilitating fusion. Both Robinson and Cloward separately introduced autologous iliac crest bone graft for cervical fusion (2). Since its introduction, the autograft has remained the most frequently used option for many different scenarios despite the development of alternative fusion grafts (9).

Fusion of one vertebra to another is felt to be mediated by several principles.

Osteogenesis, or new bone formation, and ultimately fusion, is directly determined by osteoinduction and osteoconduction (12). Osteoinduction refers to the ability of the graft to induce surrounding mesenchymal cells to facilitate callus formation and is dependent upon graft-derived factors (7). Fusion grafts with abundant cancellous bone and inductive factors hypothetically induce bone formation better than primarily cortical grafts (9). Osteoconduction describes the cascade of events, which includes vascular proliferation into the graft and migration of osteoprogenitor cells from the host into the graft. In fresh corticocancellous autograft, osteoconduction results from active bone formation and osteoinducfion whereas, passive osteoconduction occurs with allograft (12). Both processes serve to stimulate incorporation of the graft material into the construct and to facilitate interbody fusion.

Physical factors also strongly determine the incidence and speed of union between bone grafts and adjacent host bone. Stability of the construct strongly precipitates fusion, as has been shown in both autogenic and allogenic models. Contact between host-graft interface is absolutely necessary for fusion to occur. In animal models where host-graft interfaces were well approximated and stabilized, fusion occurred irregardless of the type of graft. Without host-graft contact, fusion did not occur despite stablization of the construct (12).

With these aforementioned principles defined, it is apparent why a variety of fusion materials have been developed. Each type of construct utilizes elements of these principles to facilitate fusion. The physical principles of stability and contact are universal for all constructs; fusion is unlikely to occur in an unstable construct that is not well approximated (12). Dependent on the nature of the fusion material, osteoinduction and osteoconduction may also contribute significantly to the speed and effectiveness of the fusion construct.

Biologically inert materials have been developed as an alternative for interbody fusion. As would be expected, metal interbody fusion devices provide adequate support and physical contact but are not osteoinductive. These cages are produced in a variety of sizes, making them convenient for many different applications without harvest site morbidity. When these cages have been packed with autologous bone chips, fusion rates of 96 % have been reported (9). Packing the cages with autologous bone allows osteoinduciion to occur. The cage provides mechanical stability and contact for the construct while the morcellized host graft induces fusion. As these cages may be utilized for single level fusions, they are optimally suited for multilevel constructs in combination with anterior cervical plating.

Allogenic cortical bone is the most common substitute for autologous graft and is considered highly osteoconductive and weakly osteoinductive (7). Since 1958 with Cloward's dowel fusion, the allograft has been successfully utilized for cervical fusion. As with the metal implants, allograft spares donor site morbidity (2) and is available in a variety of sizes, making it suitable for single and multi-level fusions. Unlike the metal implants the cortical bone provides a natural substrate for osteoconduction (9). A criticism of allogenic graft material is that a higher rate of non-union or collapse has been found primarily in multilevel constructs (7). This may be attributed to an increased number of surface contacts requiring bone consolidation that are required to fuse in a multilevel discectomy (9). It may also be directly dependent upon the preparation and storage of the allogenic graft. While fresh frozen allogenic bone maintains its structural integrity, freeze-dried cortical bone has been processed and dehydrated. leading to structural weakness (13). Most studies conclude that allograft fusion in single level discectomy has a similar fusion rate as that for autologous fusion (9). In multilevel discectomy, allograft fusion has been associated with a greater incidence of structural failure and may be more effectively treated via corpectomy with a single long strut (8). Despite the small potential for non-union or collapse with allograft fusion, donor site morbidity is avoided.

Demineralized bone matrix (DBM) has been recently developed for primary use and as an adjunct to allogenic and autogenic fusion. It promotes new bone formation through osteoinductive and osteoconductive mechanisms (2). The osteoinductive activity of DBM is secondary to low-molecular-weight glycoproteins contained within the extracellular

bone matrix, termed bone morphogemc proteins (9). Since its description by Urist, demineralized bone matrix has been widely used as a supplement to allograft fusion. It provides osteoinductive properties to the allogenic graft (2), making it similar to autologous bone.

Autologous corticocancellous graft material provides the fusion construct strength and inductive factors (10) with the potential morbidity associated with graft harvesting (11). Despite the development of alternative fusion materials, autologous corticocancellous bone remains the most popular choice for the majority of surgeons. As it maintains the ability to induce fusion through host and graft properties, it has provided superior results in the majority of comparative studies (2). Unlike the alternative graft substitutes, autologous bone harvesting confers potential graft site morbidity upon the patient (10). Beyond increasing hospital stay, common harvest site complications include unsatisfactory cosmesis, post-operatve pain and infection, wound hematoma/dehiscence, iliac crest fractures (4) with nerve injuries, and bowel injuries (10). Although these complications are commonly associated with iliac crest graft harvest, the incidence is low. Aside from harvest site post-operative pain, most patients tolerate graft harvesting without complications. Morbidity associated with autologous iliac crest harvesting has been increased in obese patients and those at risk for poor healing (11).

The unfortunate harvest site complication of femur neck and trochanter fracture has not been previously described in the literature. While Patient A was morbidly obese, she did not have other risk factors associated with poor healing. The iliac crests were intact, revealing that autologous graft was obtained from her right femur neck and trochanter. Post-operatively, Patient A obtained complete relief from her initial radicular complaints with cervical spine radiograph revealing adequate placement of the intervertebral graft. Follow-up imaging revealed her fusion to be stable with slight anterior extrusion of the graft. Despite this potential for harvest site morbidity as exemplified by Patient A, autologous bone graft for anterior cervical discectomy remains the most popular technique.

CONCLUSION

As suggested by proponents of allograft, donor site morbidity can change a routine elective surgery into a protracted hospitalization. To minimize graft site morbidity, identification of those patients with increased risk of complications is imperative. This subset of patients may benefit from allograft fusion in combination with demineralized bone matrix (11). In doing so, graft site harvest morbidity may be further decreased. As fusion technology continues to advance with the development of better alternative materials with similar fusion results, autologous harvesting may become less desirable. Until that point, judicious patient selection will facilitate optimal fusion results and outcomes. With autologous corticocancellous graft as the most reportedly successful fusion material at present, it should be the first choice for single and multilevel discectomy in thin patients. As illustrated by this case, in morbidly obese patients with single level disease, strong consideration should be given to utilizing allogenic graft in conjunction with demineralized bone matrix (11) in order to avoid potentially catastrophic morbidity.

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Cervical Spondylotic Myelopathy: Laminectomy With Instrumented Fusion A Four Year Analysis For Prevention Of Deformity Progression

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ABSTRACT

Surgical approaches for cervical spondylotic myelopathy (CSM) have long been debated by the Neurosurgery and Orthopedic communities. Among those approaches are anterior cervical subtotal corpectomy, anterior cervical corpectomy with strut grafting, microsurgical foraminotomy, multilevel oblique corpectomy, open-door laminoplasty, laminectomy, wide laminectomy, laminectomy with posterior fusion, suspension laminotomy, and laminectomy with instrumented fusion (2,4,5,6,7,8,9,10,11,13,14,15,16,18,19,20,21,23,25).

Anterior approaches have been advocated in the patient who presents with cervical disc herniation, kyphotic deformity or S-shaped cervical spine, cervical spine instability, need for aggressive foraminotomy, or simply the surgeon's preference and experience with a particular surgical technique (2,3,4,5,6,7,8,9,16,20,25). Posterior approaches are recommended for patients in whom significant stenosis is present over multiple levels (usually three or more), those with previous anterior cervical fusion with subsequent spinal cord compression at fused levels, those patients with a congenital spinal canal stenosis, ossification of the posterior longitudinal ligament, or the surgeon's preference based on patient presentation (1,3,5,10,11,13,14,15,18,19,21,23,25).

The pathogenesis of CSM involves a degenerative process of the cervical spine with subsequent compression of the neural elements. This compression eventually causes myelopathy- abnormal function of the spinal cord.

Although a few studies have addressed the issue of laminectomy with instrumented fusion to prevent kyphotic deformity, the patient population has been limited in number making it difficult to project data to larger patient groups with the same disease entity. Laminectomy appears to be the procedure of choice in patients who exhibit spinal canal stenosis which may benefit from its enlargement (1,5,10,11,18). This procedure while effective at decompression, may destabilize the cervical spine causing kyphosis or S-shaped deformity. As most surgeons are more familiar with posterior approaches to the spine, laminectomy with instrumented fusion can usually be done in less time than anterior discectomy or corpectomy while stabilizing the cervical spine to prevent deformity progression.

MATERIALS AND METHODS

Between 1994 and 1998, two hundred and seventy-one patients diagnosed with CSM underwent operative intervention. Of this population, one hundred and twenty-five patients were managed from a posterior approach alone. The remaining one hundred and forty-six patients were treated with an anterior approach. We prospectively studied progression of cervical spine deformity in two different patient groups. Posterior decompression with lateral mass fusion and instrumentation was performed in Group I (n=90) patients. In Group II (n=35) patients, posterior decompression alone was accomplished.

Decompression was not carried above C2 or below C7 in any patient. Patients requiring more extensive decompression or combined anterior/posterior approaches were excluded from this study. Trauma patients were also excluded. Instrumentation was not carried across intact or non-involved vertebral segments. Lateral mass screws were placed in 67 patients and facet wires were utilized in 23 cases. The majority of patients were male (n=103); however, there was an equal number of females in the two groups. Patients undergoing decompression suffered from a multitude of arthridities yet, there was no predominance of one type in either group. All patients were placed in a Philadelphia or Miami-J cervical orthosis postoperatively. Patients continued to wear the orthosis for at least 3 months until radiographic evidence of bony fusion was present. Follow-up ranged from three

months to 4 years.

Patients in Group I were further subdivided into Group Ia (n=70) in whom cervical lordosis was present on radiographs preoperatively. Group lb patients (n=20) were classified as having the presence of straightening of the cervical spine or kyphosis prior to surgery. All but one patient in Group II exhibited cervical lordosis preoperatively.

RESULTS

In Group Ia, no patient showed progression to deformity, and 59 patients exhibited radiographic evidence of fusion on postoperative films at their follow-up visits (Table I). Of the patients in Group lb. one patient revealed clinical and radiographic signs of adjacent level disease. Four patients in Group lb were found to have difficulties with construct integrity. Screw backout at the superior segment of the construct was seen in three cases and a lateral mass fracture was seen in one additional case. Despite the problems in Group lb. there was only one case, which demonstrated deformity progression. No long term problems were seen in patients undergoing facet wiring. Radiographic evidence of fusion was present and judged to be adequate by the attending neurosurgeon in 12 patients from Group lb. In the Group II patients, straightening of the cervical spine was seen in 5 patients and kyphotic deformity was seen in an additional 4 cases. One patient in Group II developed deformity prior to one year.

Table 1
Summary of Preop Condition and Postop Outcomes 1994-1998

					#Xray
	Preop	**Preop**	**Postop**	**Postop**	
	Lordosis	**Straight or**	**Lordosis**	**Straight or**	**Fuse**
		Kyphosis		**Kyphosis**	
Grp Ia	70		70		59
Grp lb		20	19	1	12
Grp ll	19	1	11	9	0

DISCUSSION

Cervical spondylotic myelopathy is a condition, which very seriously affects neurologic function to varying degrees from mild dysesthesias to severe and debilitating plegia. CSM patients typically present to the clinician's office with spastic and wide based gait, weakness in one or both hands-especially the intrinsic hand muscles as they often exhibit difficulty buttoning shirts or manipulating zippers, and proximal muscle weakness in the lower extremities. As dorsal column disease progresses, patients may show imbalance and unsteadiness. Paresthesias and dysesthesias may also be part of the clinical picture (3). Quite often there is decreased range of motion in the cervical spine due to attempts to autofuse adjacent vertebrae by degenerative processes. These vertebral bodies lose height while elongating and forming osteophytic spurs that may then press against nerve roots or the spinal cord. Patients suffering from this condition may go untreated for quite some time while being misdiagnosed as stroke, ALS, multiple sclerosis, neuroendocrine disorders, or any other neurologic dysfunctional syndrome.

Examination of the CSM patient may reveal upper motor neuron signs and symptoms in the lower extremity (below the level of the lesion) and upper motor neuron signs at or above the level of compression. The lower extremities may exhibit clonus or abnormal plantar responses. The upper extremities may show positive Hoffman's signs with weak interphalangeal muscles to strength testing (3,4,5,7,13,19,24). Lhermittes sign may certainly be observed clinically.

CSM occurs due to progressive degenerative processes of the cervical spine. As degeneration usually starts with the bony and soft tissue elements, these eventually begin to encroach on neural tissue, which is much less compliant than surrounding structures. Eventually this encroachment causes damage either by direct compression, arterial compression with ensuing vascular embarrassment, or possible venous occlusion again causing poor blood flow around the compressed cord and subsequent anterior horn cell loss (3,4). Histopathologically, gliosis and neuronophagia are commonly noted in the anterior horns of the gray matter. Atrophy of the dorsal nerve fibers may also be present. Demyelination and neuronal loss with axonal degeneration may be found in later stages (3,4).

The timing of surgery has been controversial as well as the type of operative approach to undertake for these patients.

However, most surgeons are in agreement that the technical aspects of surgical intervention outweigh the potential outcomes as this disease process is most often progressive. It has been advocated in the past for non-surgical intervention, yet this philosophy is probably not in keeping with the current medicolegal system in which medicine today functions (3,4,5,7,11,17,18,19,23,25). Some authors note substantial improvement in their patient outcomes, yet almost all agree that there is a point at which the patient will no longer improve due to the chronic and persistent compression of the spinal cord which causes irreversible degeneration of axons and dysfunctional neural tissue (2,4,5,6,7,8,9,10,11,14,16,17,19,25). That irreversible point appears to be slightly different in each study but is inevitably disclosed in the final analysis.

The anterior approach to the cervical spine has been performed with regularity for many years since it's introduction. Due to its ease and relatively low morbidity, many surgeons are most comfortable with anterior surgery for a majority of disease entities in the cervical spine. Indeed, from our study, one hundred and forty-six patients underwent anterior approaches for CSM. The advantages of the anterior approach include ease of operation, direct decompression of spondylotic bars, simplicity of osteophytectomy and foraminotomy, restoration directly of lordotic curvature, and correction of excessive spinal hypermobility (3,4,5,7). There are few complications to anterior cervical surgery in the hands of a skilled surgeon but may include graft avulsion, dysphagia or dysphonia, instrumentation failure, airway edema due to excessive retraction, cervical hematoma, or multiple other potential difficulties inherent to the surrounding anatomical structures. Laminectomy is advocated throughout the literature as the procedure of choice in CSM probably by surgeons who have a preference for this surgical approach due to either experience, surgical comfort, operative time, training, or other reasoning. It is generally agreed however, that laminectomy alone may allow the cervical spine to become unstable due to loss of the posterior bony and ligamentous structures (1,3,5,10,11,14,18,19,21,23,25). It is for this reason we undertook this study to determine the benefit of laminectomy supplemented with posterior fusion and instrumentation. This study should help delineate the potential progression for cervical spine straightening or kyphotic angulation when laminectomy alone is performed versus laminectomy in conjunction with fusion or instrumentation in order to avert a painful outcome for patients while obviating the need for an additional surgical procedure should they develop instability.

Deformity after cervical laminectomy may occur in up to 26% of cases as is evidenced in our study. Development of neurological deficits does not necessarily correlate with the degree of deformity patients exhibit. In the face of cervical spine straightening and/or kyphosis, cervical plating should be considered as a first line therapy once decompression is deemed necessary. Adjacent level disease as seen with anterior fusions, may occur with posterior instrumentation and is most likely due to stress shielding across the superior unfused segment. Whether or not to add instrumentation to any fusion is a difficult decision for surgeons. Unfortunately, the practice of surgery in today's medicolegal environment only adds to the conundrum, which the surgeon faces. With an increasingly difficult climate in which we practice, loss of ability to choose instrumentation type, decreasing reimbursement, increasing malpractice litigation, global fees and cost containment have bound the hands of surgeons forcing us to operate faster, perform more cases, and return the employee to the work force as soon as possible. Surgeons understand that the benefits must always outweigh the risks in any procedure we elect to perform. We strive to give our patients the optimal outcome by the least invasive means necessary. In the case of laminectomy versus laminectomy with instrumentated fusion, we believe the dilemma solves itself by preventing potential complications, insuring stability, and limiting the vast majority of patients to a single operative procedure.

Cervical Microendoscopic Discectomy Excision in 50 Patients

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ABSTRACT

BACKGROUND: Microendoscopic discectomy (M.E.D.) was initially developed for the treatment of lumbar disc disease. We have found this technique very useful, providing us with results similar to or better than the standard microdiscectomy. After much success with the treatment of lumbar disc disease we applied the microendoscopic system to the treatment of cervical radiculopathy. We will present our experience with the first 50 patients.

PATIENTS AND METHODS: Fifty patients with unilateral cervical radiculopathy refactory to conservative therapy were treated surgically. The operations were performed using a posterior approach with the Sofamor-Danek M.E.D. retractor system and endoscope (Memphis, TN). This series included patients with lateral soft herniated discs and/or spondylotic foraminal stenosis. The mean age was 44.5 years.

RESULTS: Forty-one of fifty patients were discharged two to four hours post-op. Nine of fifty patients had late afternoon cases or long travel time and were observed overnight. Patients were discharged with Darvocet N100. Follow-up was 1-16 months. Forty-six of the fifty patients (92%) were off all narcotic pain medication before three weeks. Ten patients returned to work or usual activities symptom free by one week. The majority returned to work one to four weeks post-op. Four patients returned to work after ten weeks, two of these cases involved Workman's Compensation.

CONCLUSION: The M.E.D. system can be used for discectomy and decompression of cervical nerve roots, relieving pain and neurological symptoms with results comparable to the traditional open laminoforaminotomy. This technique is without increased complications. The muscle splitting technique is associated with much less post-op pain and therefore a quicker return to work and normal activity.

INTRODUCTION

The treatment of patients with cervical disc disease and or cervical spondylosis involves a significant portion of a neurosurgical practice. Although, most patients can be treated nonoperatively, many patients fail conservative therapy and require operative intervention. The choice of operative procedure and surgical approach depends on the clinical diagnosis and pathology noted on the imaging studies (1). The surgeon should be able to approach the cervical spine both anteriorly and posteriorly to provide the patient with the best possible outcome. Prior to Cloward reporting his technique of anterior discectomy in the late 1950's, the routine approach to herniated cervical discs and spondylosis was posterior (1,2,3,4). Cloward's anterior approach, and modification there of, became widely accepted as the treatment of choice for all operative degenerative disease of the cervical spine (1,4). We now know that anterior discectomy with or without fusion can be complicated by spinal instability and pseudoarthrosis. The anterior approach also leads to adjacent level disease, often requiring an operation at these levels (3,5,6,9,10). We know from years of experience that a posterior laminoforaminotomy does not lead to instability or adjacent level disease. Therefore, to assure the best outcome each patient must be individualized with the operative approach based on the clinical diagnosis and pathology.

Patients with radicular symptoms secondary to lateral soft disc herniation or spondylotic foraminal stenosis are successfully treated via a posterior cervical laminoforaminotomy with or without removal of the offending disc or osteophyte (1,2,8). This article presents the technique and results of 50 patients treated for refactory cervical radiculopathy via a posterior microendoscopic approach. Patients with radiculopathy secondary to a large central or broad based disc bulge, and those with anterior medial spondylosis are best treated with an anterior approach to the pathology.

PATIENTS AND METHODS

Fifty patients with unilateral cervical radiculopathy refactory to conservative therapy

were treated surgically. A posterior approach using the Sofamor-Danek M.E.D. retractor system and endoscope was used. The levels involved ranged from C4-5 to C7-T1 with C6-7 being most common. All patients underwent this operation for the first time.

This series includes patients with lateral soft disc herniations and/or spondylotic foraminal stenosis. The population consists of 32 males and 18 females. Their ages ranged from 20 to 66 years, with a mean of 44.5 years.

The operative procedure is essentially a dorsal laminoforaminotomy (1,2,6). The patient is placed under general anesthesia and the head secured in the Mayfleld-Kees head holder. The patient is then positioned sitting with the neck slightly flexed. Fluoroscopy is used to localize the surgical level. After a 16 mm paramedian skin incision is performed, the Sofamor-Danek M.E.D. retractor system is placed with minimal muscle splitting. The retractor provides direct exposure to the operative level. The system is secured to the bed and the endoscope is used to visualize the lateral margins of the lamina and the medial facet. The laminoforaminotomy is performed with a drill and Kerrison rongeurs. Approximately one-third of the upper and lower laminae are removed. Laterally one-third to one-half of the medial facet is resected. The ligamentum flavum is removed sharply exposing the nerve root and the lateral thecal sac. By simply freeing the nerve root the majority of patients are cleared of their symptoms (1,8). However, if anterior pathology exists such as a disc fragment, access to the disc space can be obtained through the axilla of the nerve root. In greater than 95% of the cases the disc fragment is removed inferior to the nerve through the axilla (1,2). The wound is closed in two layers and Dermabond (Ethicon, Somerville, NJ) is applied to the incision.

RESULTS

The patients were followed up for 1 to 16 months. Forty-one of the fifty patients were discharged two to four hours post-op. Nine of the fifty had late afternoon cases or long travel times and therefore observed overnight. Discharge medications included Darvocet N100 or a narcotic of comparable strength. Forty-six of the fifty patients were off all narcotic medicines before three weeks. Ten returned to work or usual activities symptom free by one week. Four patients returned to work after ten weeks, two of these cases involved Workmen's Compensation. Forty-two (84%) of the patients in our series returned to work or their pre-morbid lifestyle one to four weeks post-op. One patient with recurrent symptoms rated at 50% of their prior symptoms was felt to represent poor patient selection. A second patient had persistent pain but no weakness or numbness at seven weeks. A third patient in the series with left C6-7 surgery developed right C4-5 symptoms and underwent surgery with good results. A fourth patient with persistent thumb numbness was found to have carpal tunnel syndrome on nerve conduction studies.

There were three minor complications in our series. The first was a superficial wound infection, which was treated with antibiotics and resolved. The second and third complications involved two dural punctures, which did not damage neural tissue or require repair.

Cervical radiculopathy secondary to lateral disc herniations or spondylotic foraminal stenosis is often refractory to conservative therapy and frequently requires operative treatment. The goal of surgery is improvement of the patient's quality of life with resolution of the radicular symptoms. This goal can often be met by performing the classic posterior laminoforaminotomy or anterior cervical discectomy and fusion (1,2,3,4,5,6,7). Both procedures are capable of decompressing the cervical nerve root and removing the offending disc material.

The choice of operation performed depends on the patient's clinical symptoms and the pathology noted on imaging studies. Patients with radiculopathy secondary to lateral nerve root compression are successfully treated with a posterior cervical laminoforaminotomy. Studies have shown simply freeing the nerve root results in resolution of symptoms in 93 percent of patients (1,8). These results are higher if an offending disc or osteophyte is removed. Our experience using the Sofamor Danek M.E.D. retractor system and endoscope, to perform the posterior laminoforaminotomy for radiculopathy has been similar to the traditional open technique. However, use of the microendoscopic

system allows a much smaller incision and a muscle splitting approach to the cervical spine resulting in significantly less post-op pain. Therefore, patients have a shorter hospital stay (two to four hours post-op) and return to normal activities sooner (less than three weeks).

CONCLUSION

Cervical radiculopathy secondary to lateral nerve root compression is successfully treated with the microendoscopic approach, avoiding the risks of spinal instability and complications of fusion associated with anterior cervical discectomy. It has been argued that the posterior operation is associated with a risk of instability of the cervical spine. However, like other authors, we have not found evidence of instability resulting from this surgery in our series (8). When radiculopathy is secondary to central or broad based disc bulge the pathology can not be addressed via a posterior approach. In these cases, an anterior approach is more appropriate.

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Outcome Analysis of Microsurgery of the Lumbar Spine in a Community Hospital Population

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ABSTRACT

Surgical management of lumbar herniated discs is a relatively new art. In the past, only an occasional chondroma was removed by lumbar laminectomy. In 1934, Barr and Mixter (1) described the first procedure for the removal of a diseased lumbar disc and also described their transdural removal of a lumbar disc herniation. They were credited with establishing the link between disc herniation and sciatica by reporting their success of removing herniated disc material from patients. Major technical changes have been implemented to decrease the morbidity and hospital stay associated with this procedure including extensive laminectomy, laminotomy, and most recently, microlumbar discectomy.

Since Williams (6-10), Yasargil (11), and Caspar (4,5), first reported it in 1977, many researchers have described the usefulness of the microdiscectomy by an operating microscope for excision of a lumbar disc herniation. Most surgeons regard the operation to be less invasive, safer and more timely then more gross operative methods. Presently, microsurgery for lumbar disc herniation (LDH) is being done more frequently and numerous studies (4-11,13,15-17) have shown the results to be just as acceptable or superior to the standard (open) discectomy. Other procedures have been and are being proposed for the removal of LDH, but to date there is no scientific evidence to support their use, and in fact, some studies have questioned their usefulness (27,31,33,35,38). It is reasonable to state the gold standard for disc excision in LDH is open discectomy, which is greatly facilitated by the microscope with a reduced complication rate (10).

Surgeons have refined techniques and have gained a better understanding of the indications. Improved imaging techniques and accumulation of almost seventy years of experience with the basic procedure allow contemporary surgeons to select patients more accurately in who requires surgery. Many technical innovations, such as improved lighting and magnification via the operating microscope, adaptations of the operating room tables, specialized instruments and retractors, permit smaller incisions, less muscle dissection, less bone removal, less blood loss, and lower risk of nerve injury. Therefore, surgically treated patients have had less pain, shorter hospital stays, reduced needs for bracing and inactivity, and faster recovery.

To see better, surgeons have long recognized the value of magnification and illumination. In the field of spine surgery, the attempt to improve visualization has led many surgeons to use loupes and a headlight. Loupes require a skin incision and wound length of, which is no less than your interpupillary distance, 62 mm (42). To use the loupes and operate through a smaller incision is to give up stereopsis, three-dimensional viewing in the depth of the wound. The optics of the microscope reduces the wound dimension necessary to maintain 3D vision to between twenty-two and twenty-three mm (10,42). The use of the operating microscope is widespread in cranial neurosurgery, and neurosurgeons are opening to the idea of using the microscope for spine surgery. The operative maneuvers are magnified approximately six times, the surgical team, by reaction, becomes gentler with the neurological tissues. The brilliant illumination proved by the microscope is significantly better than anything else and displays tissue planes very well. As a result, the micro surgeon becomes safer and reveals pathology that would be missed by other approaches.

The ultimate beneficiary of these microscope advantages is the patient. The microscope has decreased operating room time, postoperative discomfort, and complications, while delivering results that are just as good if not better as standard discectomy. The operating microscope has resulted in most discectomy procedures being performed on an outpatient basis, reducing the cost of surgical care.

This current study was undertaken to reflect these overall advancements in the patient and surgical outcomes of the lumbar microlaminectomy for herniated discs with the assistance of the operating microscope in an Ohio community population. Patient profiles, clinical status and radiographic

presentations are evaluated as well as the surgical experience and complications. The outcomes of these patients are then compared to the past and current surgical literature. This moderate sized study of 626 patients reveals comparable re-herniation rates with superior surgical and postoperative outcomes.

CLINICAL MATERIAL AND METHODS

This a retrospective study that includes all patients who underwent a microsurgical laminectomy, medial facetectomy, excision of herniated nucleus pulposus and decompression of neural elements utilizing the operating microscope. These patients were admitted to the neurosurgical and orthopedic spine service at Doctor's Hospital, a community hospital in Columbus, Ohio, over a four-year period. The patient's hospital, office and computer-based medical records were reviewed for all patients in this category from March 15, 1996 to March 9, 1999. A total of 626 patients were selected and evaluated by primary analysis for patient presentation, operation experience, hospital stay and patient outcome. All patients underwent diagnostic roentgenography including MRI, CAT scan with or without myelography, and or EMG. Two neurosurgeons and one orthopedic spine surgeon performed the operations. The senior neurosurgeon performed fifty-five percent of the cases and the other two surgeons were evenly distributed in the total number of operations performed in this series. A single independent physician analyzed all data.

The inclusion criteria were the presence of a herniated lumbar disc that had been treated surgically under the operating microscope. The patients not included were those with primarily bony spinal stenosis or lateral recess stenosis with resultant nerve entrapment and those operated on without the assistance of the operating microscope. Patients who underwent lumbar fusions of any kind were also excluded.

A comprehensive medical evaluation was taken from each patient. A categorical file of data was organized on a spreadsheet from the patient records, EMG reports, radiological x-rays and interpretations. Distribution of the patients profiles including sex, age, presenting occupational condition, cigarette consumption, previous surgery, work-related injury and workmen's compensation were all compiled. Patients' clinical status regarding weight distribution, straight leg raising, pain, reflex and motor activity were obtained. The ideal body weight was approximated as follows:

> Women: 100 lbs. for the first 5 feet of height + *5* pounds for each inch over *5* feet
>
> Men: 106 lbs. for the first *5* feet of height + 6 pounds for each inch over 5 feet Subtract 2 lbs. for each inch less than 5 feet. IBW range will be +/- 10% of above calculation.

The radiographic evaluation of the disc pathology by MRI, CT and or a myelogram was obtained. EMG results were examined whether they related to the surgical and radiographic pathology. Surgical and radiographic levels were recorded including the individual single or multiple level cases, bilateral or unilateral procedure and the presenting pathology. Multitudes of complications were analyzed including failures of patient's conservative therapy. The distribution of patients who underwent re-operation for recurrent disc herniation and their location was examined. The operative experience, specifically the blood loss, operative time and length of hospital stay was gathered.

Magnetic resonance imaging (MRI), or computed tomography (CT) and/or CT myelography were obtained prior to surgery to evaluate all patients in this series. The use of the routine myelography has diminished largely because of greater reliance on MRI. On the basis of surgical pathology and radiological evaluations, seven categories were specifically created: bulge, contained protrusion, contained extrusion, noncontained extrusion, sequestration, stenosis and herniation, and scar.

The bulging disc was defined as a competent annulus that extends beyond the adjoining vertebral body confines of the interspace. There is generally a broad-based

extension without penetration of the nucleus outside of the annulus. A contained protrusion involves the protrusion of the nucleus pulposus, still contained within the annulus, beyond the adjoining vertebral body confines of the disc. The protrusion is most often focal, and its location can be lateral, paracentral, or central. The overlying annulus is still intact, even though it is often very thinned and weakened. A contained extrusion involves herniation of nucleus pulposus beyond the confines of some of the annulus but not beyond the posterior longitudinal ligament. The extrusion is often focal and rarely central; most often it is lateral or paracentral. A noncontained extrusion disc involves the extrusion of nuclear material through the annulus and beyond the confines of the posterior longitudinal ligament. The extruded material remains in continuity with the disc space. The free fragments have not broken loose and migrated into the epidural space. A sequestered disc fragment is a free nuclear or cartilaginous end plate fragment that has completely separated itself from any continuity with the disc space and migrated into the epidural space. Free fragments are capable of traveling a considerable distance from the disc space. Individuals with stenosis and herniation were also classified. The stenosis could be either central canal, foraminal, or subarticular. Patients with a previous excision of a herniated disc who developed a reoccurring enhancing focal lesion reproducing radicular symptoms shown by gadolinium enhancement on MRI were classified as scar.

The patient's clinical status was the most important determining factor in the role and timing of the surgical intervention. Patients were encouraged to attempt physical therapy, spinal manipulation, epidural spinal injection, and mild exercise in combination with anti-inflammatory, muscle relaxant, and analgesic medication. Intermittently patients were given a course of oral steroids. Those individuals with marked radicular symptoms and neurologic deficits were considered for surgery after a brief period of conservative care failure. In addition, patients with severe leg pain and significant neurologic findings in conjunction with positive straight leg test underwent surgery without delay.

The surgical procedure followed was substantially the same in all patients, with minor variations. Pre-procedure medication including a prophylactic antibiotic, one gram of cefazolin I.V. and eight milligrams of dexamethasone acetate I.V. were given. Under general anesthesia, all patients were positioned in prone position on laminectomy pads or a Wilson frame. The points of pressure were checked, while the head and shoulders were positioned by anesthesia. If laminectomy pads were utilized the table was slightly flexed. The back was shaved. A one to three cm skin scratch mark was created with an 18-guage needle over the lumbosacral area after palpation of surface anatomy landmarks and comparing them to pre-operative films. After betadine preparation, 0.5% bupivicaine with epinephrine was infiltrated into the subcutaneous fat and paraspinal muscles in the planned dissection plain for hemostatic and postoperative analgesia.

A #10 scapel incised the skin based on the previous mark. Unipolar Bovie electrocautery or a second #10 scapel incised the subcutaneous fat and fascia over the midline leading down the spinous process and the sloping lamina. Thrombin spray 10,000 units was instilled. Periosteal elevator completed the paraspinal muscle dissection and the McCullough retractor was inserted. Localization lateral x-rays were obtained to confirm the location with a #1 Penfield in the interlaminar space. A sterilely draped operating microscope was then used for the remaining surgical dissection. The interlaminar interval and a small amount of the lamina on rostral and caudal side were removed by various sized Kerrison rongeurs. The ligamentum flavum and medial facet was removed just far enough laterally to expose the lateral edge of the nerve root. Occasionally, segmental decompression was required for concurrent stenosis. The segmental decompression was defined as near complete or complete removal of the lamina for patients with concurrent sublaminar and/or subarticular stenosis.

The lateral edge of the nerve root and thecal sac was isolated with a #4 Penfield. The nerve root retractor carefully displaced the nerve root medially to expose the appropriate pathology. Bipolar cautery, thrombin spray, gelfoam and cottonoid pledgets were used for hemostasis as needed. The amount of discectomy

performed varied according to the pathology. Caution was taken to only remove the offending pathology to prevent future instability at that intervertebral segment and avoid vascular injury. Decompression of the neural elements with foramenotomies was used if foraminal stenosis existed either by disc or concurrent bony pathology. After a pillar dissector confirmed the removal of the offending pathology, an occasional free fat graft was placed covering the laminotomy site. The wound was then closed in a conventional manner using subcuticular sutures and steri-strips for the skin.

Patients were encouraged to ambulate as soon as they were awake and oriented, therefore postoperative deep vein thrombosis prophylaxis was not considered necessary. Postoperative medications including a prophylactic antibiotic, cefazolin one gram and dexamethasone four to six milligrams were given in at least one dose prior to patient discharge. All patients were given detailed written and oral instruction on postoperative care. Outpatients were allowed to be discharged to home if they were awake and oriented without intractable nausea and vomiting. Patients were also required to ambulate in the hallways, urinate and tolerate a diet without difficulty. No patients were administered a lumbar corset. Patients were allowed to return to normal sedentary activities until they were seen in follow-up four weeks from surgery.

Exceptions to outpatients being discharged on a patient basis are as follows: 1) completion of the operation in the evening; 2) the patient who is nauseated and vomiting from the anesthetic and surgical procedure; 3) the patient who experiences a local or general adverse reaction that necessitated continuing hospital stay; 4) elderly patients, who may wish more time to gain independent ambulation and to allow more time for observation of their medical state; and 5) patients with known guarded medical history, such as diabetes and moderate to severe heart and lung disease.

The patient outcome was categorized into excellent (no problem at all), very good (fully functional, but occasional pain, no restrictions), good (function with some restrictions to strenuous activities), fair (restrictions to daily activity, chronic pain medication required), disabled (moderate to severe restrictions to daily activity, unable to work).

The Functional-Economic Outcome Rating Scale of Prolo (43) measured the outcome as well. (see Table 1.) The Prolo scale consists of two subscales: the economic and the functional. The reviewing physician on the basis of chart review assigned outcome scores. The subscale scores were summed to obtain an overall score. Total scores of five or less were designated as poor outcomes; scores of six to seven were considered to be moderate outcomes; and scores between eight and ten were reflected as good outcomes. The functional scale as reported by Prolo (43) gives an economic grade expressing the patients' capacity for gainful employment and a function grade expressing the effects of pain on daily activity.

Table 1.

	Functional-Economic Outcome Rating Scale
Economic Status	
El	Complete Invalid
E2	No gainful occupation including inability to do house work or continue retirement activities
E3	Able to work at previous occupation part-time or limited status
E4	Working at previous occupation part-time or limited status
E5	Able to work at previous occupation with no restrictions of any kind
Functional Status	
Fl	Total incapacity (or worse than before operation)
F2	Mild-to-moderate level of lower back pain and/or sciatica (able to perform all tasks of living).
F3	Low level of pain and able to perform all activities except sports
F4	No pain, but patient has had one or recurrent episodes of lower back pain or sciatica
F5	Complete recovery, no recurrent episodes of lower back pain, able to perform all previous sports

Results

Patient Profiles (see Table 2.)

Men were slightly more common than women to require surgery. There were also a higher percentage of men working in labor positions. They ranged in age from sixteen to eighty-nine, but over two-thirds of the patients were between thirty and fifty years of age. The

mean age was forty-six years for males and females. LDH occurred in men at an average age of thirty-six to forty years and in women at an average age of forty to forty-six years of age. The occupational profiles showed that the overwhelming majority of patients were laborers strenuous, blue collar, with less than ten percent of the patients functioning as office workers, nonstrenuous. Almost two-thirds of the patients stated that this was a work-relate injury and forty-one percent of these work-related injured patient claimed workmen's compensation. A small portion of the patients had a previous surgery at the same level as the prior lumbar surgery including foramenotomy, discectomy or both for a herniated nucleus pulposus. Over 66% of the patients used nicotine products by either smoking or chewing. This suggests that patients who smoked could be higher risk for herniation of lumbar intervertebral disc.

Table 2.

Patient Profiles		Percent	#
Sex	Male	55%	342
	Female	45%	284
	TOTAL		626
Age	<20	2%	11
	20-29	7%	44
	30-39	29%	182
	40-49	33%	207
	50-59	11%	69
	60-69	10%	63
	70-79	5%	31
	>80	3%	19
Occupation	Retired	15%	94
	Unemployed	5%	31
	Office Worker	9%	56
	Laborer	55%	344
Worker's Compensation		41%	257
Work-related Injury		63%	394
Previous Surgery		16%	100
Cigarette Consumption		67%	419

Patient Clinical Status

The patient clinical status is reviewed in Table 3. Just over a quarter of the patients in this series were normal weight. The vast majority of the patients were overweight. Almost half of the patients were in an excess of forty pounds overweight.

Sixty-seven percent of the patients presented with neurological findings. These included an absent patellar reflex or quadriceps weakness, weakness of the extensor hallicus longus, and a diminished ankle jerk or gastrocnemius weakness. The most sensitive test of the patients in this series had a positive ipsilateral and/or contralateral straight leg-raising test. All patients complained of buttock or leg pain or paresthesias in a radicular distribution. Almost all of the patients presented with both back and leg pain of varying proportions. A small portion of the patients complained exclusively of leg pain and no one under surgery for back pain alone.

Table 3.

Patient Clinical Status			
		%	*#*
Weight	Obese (>40lb.)	48%	358
	Overweight (<40 lb.)	22%	137
	Normal	29%	131
Straight Leg Raising	Positive	73%	457
Pain	Back and Leg	91%	570
	Leg pain only	9%	56
	Back pain only		0
Reflex/ Motor	Patellar Reflex	24%	150
	Achilles Reflex	63%	398
	Extensor Hallicus Longus weakness	9%	56

CAUSE OF INJURY

Lifting accidents caused the highest incidence of ruptured disc in this series (see Table 4.). Contributing factors to herniated disc in descending distribution were repetitive use, falls, motor vehicle accidents, sports and exercise injuries. A few of the patients associated with disc ruptures caused by sneezing or coughing. No definite cause could be determined in seventeen percent of the cases.

Table 4.

Cause of Injury		
	#	#
Lifting	46%	288
Falls	12%	75
Repetitive Use	13%	81
Sport or exercise injury	4%	25
Motor vehicle accident	7%	44
Coughing/Sneezing	1%	6
No definite cause	17%	106

FAILED CONSERVATIVE THERAPY

All patients underwent conservative therapy of some form, see Table *5.* Ninety-two percent of the presenting patients had symptoms for at least three months before surgery. Eighty-one percent of the patients had at least

two weeks of bed rest, generally as an outpatient. Narcotics and NSAIDs were the medications of choice that failed in the majority of the cases. Greater than half of the patients failed either or both systemic or epidural steroids. Patients who responded to epidural steroids at least briefly were positive indicators of a good surgical outcome. Almost three-quarters of patients attempted muscle relaxants. Seventy percent of the patients failed physical therapy, exercise or stretching. Chiropractic or Osteopathic manipulation failed in sixty-seven percent of the cases. Manipulation was not considered a contraindication to therapy for herniated discs as many primary care providers assume.

Table 5.

Failed Conservative		
Percent	Therapy	Patient Number
96%	Narcotics	601
95%	NSAIDS	595
44%	Epidural Steroids	275
70%	Physical Therapy	438
67%	Manipulation	419
73%	Muscle Relaxants	457
58%	Systemic Steroids	363

RADIOGRAPHIC EVALUATION AND SURGICAL PATHOLOGY (see Table 6.)

Only six patients with a bulging disc required surgery in this series based on the persisting sciatica unresponsive to extensive conservative measures. The majority of the cases presented with contained extrusions, followed by non-contained extrusions, sequestered disc fragments and contained protrusions. After a previous laminectomy, protruding scar creating a mass effect and causing radicular signs and symptoms was not an uncommon finding. Magnetic resonance imaging was obtained in almost all patients. If the MIRI and/or EMG results were equivocal or did not correlate with the patient findings a lumbar myelogram with CAT scan was obtained to evaluate the patient further.

Table 6.

Radiographic evaluation			
Surgical Pathology		Percent	#
Disc Pathology	Bulge	1%	6
	Contained.Protrusion	13%	81
	Contained.Extrusion	40%	250
	Noncontained.Extrusion	32%	200
	Sequestration	16%	100
	Herniation.and.Stenosis	16%	101
	Scar	9%	56
MRI	Obtained, Positive	97%	607
CT/Myelogram	Obtained, Positive	9%	56
EMG	Obtained, Positive	73%	457

SURGICAL AND RADIOGRAPHIC LEVELS

In Table 7, single level herniation was most common at L5-S1 level, followed by L4-5, L3-4, L2-3, and L1-2 in this series. Single level operations dominated the multilevel operations. Unilateral operations were more common then bilateral operations. Simple microdiscectomies were utilized in the majority of the cases. Patients who required segmental decompression with their microdiscectomy had stenosis associated with their herniated disc(s).

Table 7 Surgical and Radiographic levels

	Level	Percent	#
Single level	L1-L2	<1%	3
	1.2-3	<1%	6
	L3-4	4%	22
	L4-5	24%	151
	L5-S1	58%	366
	TOTAL	86%	540
Multiple	L2-3,L3-4	6%	5
	L3-4,L4-5	23%	20
	L4-5,L5-S1	59%	51
	L3-4,L4-5,L5-S1	8%	7
	L2-3,L3-4,L4-5	2%	2
	L2-3, L3-4, L4-5, L5-S1	1%	1
	TOTAL	14%	86
Bilateral		14%	88
Unilateral		86%	538
Discectomy		89%	558
Discectomy and decomp		11%	68
Pathology	Disc	100%	626
	Spur	24%	150

COMPLICATIONS

Sixty-four patients (ten percent) in this series developed complications related to their surgical experience. (see Table 8.) Minor dural tears were the second most common

complication. The majority of the dural tears were minor (pinhole, arachnoid still intact, covered by intact bony structures) and required no corrective procedure. Primary suture repair with or without muscle/fat graft was used for larger tears utilizing micro surgical technique. The postoperative cerebral spinal fluid leak was sealed with either further wound suturing alone or this in conjunction with a blood patch. Only one patient needed a re-exploration with closure of a dural tear, initiated by an unnoticed spicule of bone projecting from a laminotomy site. Complications related to the positioning were the most common fmdings. Patients have suffered from orbital contusions and corneal abrasions to the eye. All recovered within a few days without sequelae. Supraorbital and supratrochlear nerve palsies have been more common since the anesthesia department started using plastic eye goggles. The plastic edge of the goggles pushes on the two nerves causing numbness and a tingling sensation in the forehead. These paresthesias can last for weeks. Ulnar, peroneal, radial and median neuropathy related to positioning has been shorter lived.

One postoperative hematoma on a multilevel elderly patient resulted in a delay in diagnosis and permanent foot drop. No patients suffered an episode of gastrointestinal hemorrhage, but gastritis and gastroesophageal reflux disease was not an uncommon finding. No major vascular injuries occurred in this series. Urinary retention was the third most common complication. Nearly all of these patients had preoperative symptoms related to benign prostatic hypertrophy and many of these patients then went on to further urologic care. No patients suffered disc space infections. The three patients who suffered a superficial wound infection cultured Staphylococcus aureus and all cleared with oral antibiotics. The fourth most common complication was significant perineural fibrosis as the cause of recurrent symptoms. Postoperative instability that developed new or worsening low back pain required further treatment and surgery in a small select group of patients.

Table 8.

Complications	%	#
Dural Tear (Minor)	3%	20
Dural Laceration (Requinng Suturing)	<1%	3
CSF Leak	<1%	3
Wrong Level Exploration (Unrecognized)		0
Missed Pathology	<1%	1
Post-op Hematoma		0
Hemorrhage Requiring Transfusion		0
Major Vessel Injury		0
Foreign Body Retention	<1%	1
Complications Secondary to Positioning		
Eye Pressure	<1%	6
Brachial Plexus Injury		0
Peripheral Neuropathy	<1%	5
Root Injury		0
Comeal Abrasion	4%	25
Cauda Equina Injury		0
Gastritis	<1%	2
Urinary Retention	2%	12
Pulmonary Embolus		0
Thrombophlebitis	<1%	1
Mortality		0
Superficial Wound Infection	<1%	3
Disc Space Infection		0
Post-op Perineural Fibrosis	1%	11
Post-op Instability	<1%	6
Acute Respiratory Distress	<1%	1
CHF (Acute)	<1%	1

Re-operation for Recurrent Disc Herniation

In this series, sixty-three (ten percent) of the patients required an additional operative procedure with half of the patients requiiug surgery at the same level and same site. (see Table 9.) Three percent of the population had recurrent discs operated on previously by the three surgeons evaluated in this study. A detailed analysis of the same level, same side recurrent discs showed a preponderance (sixty-seven percent) of the and fifty with average age being forty-seven years. This mean age is slightly older than the average of the overall groups, either men or women. Well over sixty percent of these patients were at least twenty pounds overweight. Fifty percent of the patients with reoccurrence of LHD developed symptoms within one year after the surgery.

Table 9.

63 Patients Underwent Re-operation for Recurrent Herniation		
Percent		#
Same Level, Same Site	48%	30
Same Level, Opposite Site	8%	5

Different Level	11%	7
Multiple Re-occurrences	16%	10
Recurrent Stenosis	17%	11
Total Recurrent Discs		63

BLOOD LOSS AND OPERATIVE TIME (See Table 10 and 11.)

The majority of single, bilateral and multi-level microdiscectomies cases lost less than fifty mls with a mean of 56.7 mls of blood loss. The mean operative time was less than sixty minutes for unilateral single level microdiscectomies. The bilateral and multilevel discectomies had a mean operative time of greater than 1.5 to 2 hours.

Table 10.

	Blood Loss (ml.)	
(ml.)	Percent	#
0-50	82%	538
>50-100	11%	69
>100-200	5%	31
>200-300	4%	25
>300	3%	19

Table 11.

	Operative Time	
Time	Unilateral Single Level	Bilateral or Multilevel
<30mm	8% /50	
<45mm	41% /257	
<60 mm	30% / 144	6% /5
1-1.5hrs	17% /106	44% /38
>1.5-2hrs	8% /50	19% /18
>2-2.5hrs	2% /13	16% /14
>2.5-3hrs		9% /8
>3hrs		6% /5

HOSPITAL STAY (see Table 12.)

Ninety-nine percent of the patients ambulated on the day of surgery with remaining patients ambulating on the first postoperative day. All the patients hospitalized longer than postoperative day number one were elderly individuals with preoperative ambulation difficulties and extensive medical problems. These individuals generally required physical therapy prior to discharge. No major complications were associated with outpatient surgery or early aggressive rehabilitation during this study.

Table 12.

	Hospital Stay	
	Percent	Patient Number
Outpatient	81%	506
POD#1	17%	105
POD#2	3%	19
POD#3or>	1%	9

Table 13.

Patient Outcome	%	#
Excellent (No problem at all)	51%	319
Very good (Fully functional, but occasional pain, no restriction)	34%	212
Good (Function with some restrictions to strenuous activities)	12%	75
Fair (Restrictions to daily activity, chronic pain medication required)	3%	19
Disabled (moderate to severe restrictions to daily activity, unable to work)	<1%	3

The outcome classification in Table 13 was modified from Caspar (4,5). Eighty-seven percent of the patients had resumed full home activity by two weeks and ninety-six percent by one month. Postoperatively, most patients returned to work comparatively early; zero to ten days for a desk job and one to four weeks plus for physical work. One-third of the patients returned to work before the end of the second week. Early resumption of employment did not compromise the long-term results of this study. Fifty-seven percent of patients were able to return to work before one month, and ninety-four percent by the third post-operative month. Less than one percent of the operated patients who had previously worked, were unable to work after surgery and requested permanent disability. Ninety-seven percent of the patients were graded from excellent to good outcome. The less than one percent of the patients categorized as disabled were already moderately to severely restricted in their daily activities of living prior to the operation. The three patients were elderly with substantial health issues.

Nonindustrial patients had a ninety-eight percent excellent or good rating compared with eighty-three percent of industrial accident patients. Professional, level of education, and self-employment led to better outcomes

regardless of legal concerns or industrial insurance.

Functional-Economic Outcome Rating Scale

The mean economic outcome score of all patients, as determined by the physician reviewer, was 4.8 out of five. The mean functional score was 4.6 out of *5,* with a total mean of 9.4 out of 10. The overall functional and economic outcome scores are reflected in Table 14. Outcome scores differed by physician. Scores improved with the seniority of the surgeon, but the difference was not statistically significant.

Table 14.

Outcome of Patients as Measured by the Functional-Economic Outcome Rating Scale

Economic Scale	%	#t	Function Scale	%	#t	Total	Percent
El		0	Fl	0		T1	
E2	0.9	6	F2	4.1	25	T2	
E3	4.4	27	F3	7.3	45	T3	
E4	7.2	45	F4	12.4	77	T4	0.4
E5	87.5	548	F5	76.2	479	T5	2.1
						T6	3.3
						T7	5.3
						T8	8.2
						T9	15.2
						T10	65.5

DISCUSSION

Although the scientific microscope has been around for centuries, its adaptation for surgery did not occur until the l920s when Swedish otolaryngologists used a bulky modification for laryngeal procedures. Thirty years later in 1953, Zeiss (42) introduced a surgical microscope. Since then, operative microsurgery has grown exponentially in the mid-sixties for anastamosis of nerves and blood vessels in the hand throughout the United States and for cerebrovascular and lumbar disc surgery as proposed by Yasargil (11) in 1970. Subsequent to that, Williams (6-10) and Caspar (4,5) have published there often quoted works on microsurgery for lumbar disc disease. Today, the microscope is being used extensively to augment the visual capabilities of surgeons in excisional surgery, such as brain and spinal cord tumors, and cervical and lumbar disc disease.

A review of the literature (11,42) reveals equal results for microdiscectomy with an operating microscope when compared to the standard discectomy with or without loupes. There are two prospective randomized controlled trials comparing microdiscectomy to standard discectomy. Lagarrique (44) and Tullberg's (45) randomized trials of eighty and sixty patients consecutively showed equal outcomes between the standard discectomy and microdiscectomy. In addition, there are eight nonrandomized trials comparing microdiscectomy to standard discectomy. Five of the trials revealed that the microdiscectomy was statistically superior to the standard discectomy (8,13,20,21,30). The other three trials reflected equal outcomes of microdiscectomy compared with standard discectomy (31,41,46). The research supports the opinion that microsurgical discectomy serves just as good an outcome as standard discectomy. The basis for recommending microdiscectomy is that it is an easier surgical procedure than standard discectomy, and it is gentler on the patient.

This study demonstrates that outcomes are comparable if not superior to previous research. The ninety-seven percent good or excellent outcome rating is comparable to Silver's (13) successful outcome of ninety-eight percent. Our series showed no discitis and patients were discharged on a out-patient basis to home much earlier than the mean of 3.7 days in Silver's study. Williams's results were also excellent, but nine percent of his patients required re-operations (6-10). Williams favored only minimal disc excision and no bipolar cautery for hemostasis. Like Wilson, Silvers and others who performed subtotal removal of the lumbar disc, only three percent of this series population required re-operation.

Surgical time was considerably shorter and intraoperative bleeding was much less by this series microsurgical technique. This was compared to the ten studies that compared microsurgical versus traditional laminotomy. Microsurgery also increased the chances of finding the offending herniated disc fragment and, therefore, decreasing the need for multiple level exploration.

The Functional-Economic Outcome Rating Scale or Prolo Scale (43) has received increased consideration by neurosurgeons. This simple ordinal rating scale is intended to provide surgeons with a common means by which to evaluate and express the outcome of lumbar spine

procedures and to compare economic and functional status of populations at the time of admission and after operations. The scale can also be used as a common standard to compare the status of populations undergoing different treatments to assess their relative effectiveness.

Pappas and Sonntag (12) had a mean economic outcome score (MEOS) of 4.5 and a mean functional outcome score (MFOS) of 4.08. The mean total functional and economic outcome score was 8.32. This is compared to this series with a MEOS of 4.8, and a MFOS of 4.6 and a total of 9.4 utilizing similar operative techniques and population sizes. Their mean length of stay was six days. In their study, seven percent of their patients developed wound infections and three patients developed discitis. One patient had a small bowel injury and two had major arterial injuries requiring surgical intervention in their series. One patient died secondary to the arterial injury. In this study there was a 0.5% infection rate with no major arterial or bowel injuries and no deaths.

This moderate series of microsurgical removal of lumbar herniated discs suggests excellent results with few complications and a minimal rate of recurrence can be obtained utilizing the operating microscope. The operative morbidity is minimal with comparable or better results with standard laminectomy and discectomy. One of the arguments against microdiscectomy is the potential for an increased infection rate reported in an old study (15,16). Recent experience has not demonstrated that higher infection rate. This probably related to the more frequent use of prophylactic antibiotics.

For the past several years, increasing national awareness of medical care costs and the need to restrain health care costs have resulted in broader application of outpatient surgery treatments. The financial benefit of outpatient versus inpatient surgery has been well documented for large numbers of procedures and does not require further discussion. Microlumbar discectomy is safe and economical when performed as an outpatient procedure. Almost all patients offered outpatient surgery elected to participate.

Advances in microsurgical technique and progressive understanding of lumbar anatomy through a keyhole presentation. have improved multiple areas of the patient's functional and economic outcome. Patients have shorter length of surgeries with less blood loss and anesthetic time. The post-operative mobilization, hospital-stay and postoperative recovery to gainful employment have significantly improved the patient's overall outcome and surgical experience. Surgical lumbar microdiscectomy in this series proved to be superior in both clinical results and cost effectiveness.

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MINUTES OF JOINT MEETING OF THE AMERICAN COLLEGE OF OSTEOPATHIC SURGEONS NEUROSURGICAL SECTION AND AMERICAN ORGANIZATION OF THE NEUROLOGICAL SECTIONS

Friday, September 22, 2000
7:30a.m.
73rd A.C.O.S. Meeting
Boston Marriott Copley Place
Boston, Massachusetts

I The annual business meeting of the American College of Osteopathic Surgeons, Neurosurgical Section and American Organization of Neurological Surgeons was called to order by its president, Dr. Timothy Detamore.

II The minutes from the 2000 meeting in Seattle, Washington were submitted and approved with grammatical changes.

III TREASURES REPORT.

The treasure's report was submitted by Dr. Dan Miulli. The amounts in the banking accounts were noted. The amounts were:
ACCT #1: $1,849.54;
ACCT #2: $2,988.25;
ACCT #3: $16,988.74.

There was one payout for the neurosurgical banner of $859.18. There are 75 members listed.

Dr. Detamore asked that all members submit their name, address, phone number, as well as E-mail addresses. He also asked that all residency program directors submit the names, phone numbers, addresses, E-mail addresses and year of residency for all the residents.

Dr. Miulli stated that this has been one of the worst years for members submitting dues. The following have NOT submitted their 2000 dues: Dr. Alapour, Dr. Blum, Dr.Boyer, Dr. Buster, Dr. Chen, Dr. Cohen, Dr. Decker, Dr. Dutcher, Dr. Goodall, Dr. Harron, Dr. Hayward, Dr. Heilman, Dr. Kattner, Dr. Kralick, Dr. Main, Dr. Mangano, Dr. Miller, Dr. Pham, Dr. Rodas, Dr. Schlifka, Dr. Siddiqi, Dr. Scott, Dr. Spight, Dr. Spitalieri, Dr. Spencer, Dr. Tartaglione, Dr. Thomas, Dr. Waterman, Dr. Warner and Dr. Yocum. Resident dues are $50 and attending dues are $100.

IV CORRESPONDENCE:

1. Coding and reimbursement panel.
2. Spinal surgical section correspondence.
3. Website correspondence.

Dr. Detamore stated that the above will be discussed in old business.

THE FUTURE PROGRAM CHAIRMAN

The program director for the year 2001 meeting in Palm Desert, California is Dr. Steve Hamm. The program director for the 2002 meeting in Orlando, Florida is Dr. Scott West. The program director for the year 2003 meeting in Chicago will be Dr. Robert Dixon. The program director for

the year 2004 meeting is still being sought and volunteers are being accepted.

Election of new members: All new members were elected by unanimous vote.

Dr. Richard Kanoff was elected for his third term to the American College of Osteopathic Surgeons Board or Governors by unanimous vote.

Dr. Keith Kattner was nominated and elected to Secretary Treasurer. The vote was unanimous.

Dr. Louis Jacobs becomes the President.

Dr. Dan Miulli becomes the President Elect.

V COMMITTEE REPORTS:

A. AOBS Committee Report - Dr. Eichart.

Dr. Eichart was at the board meeting and asked Dr. Jacobs to present the report. The American Board of Osteopathic Surgeons requests that all members submit questions for the written and oral boards. The questions must be submitted with one correct answer and several other choices. The questions must be referenced from a current textbook or if a journal is sited it must be less than two years old. No questions or answers can be based on anecdotal evidence or opinions of physicians in practice.

A questionnaire is being sent out to all members asking them to describe their practice. This information will be taken back to the American Board of Osteopathic Surgeons for consideration to weight the examinations according to the practice preferences of the current practicing neurological surgeon. Therefore the examines will not be generalized and well rounded in nature but focus more on present day neurological practices as determined by the members who respond to the questionnaire.

Dr. Decker asked that a formal letter be sent out to all members asking them to submit questions for the neurosurgical residency examination. The questions can be sent to Dr. Steven J. Eichart, 4415 South Harvard, Suite 201, Tulsa, Oklahoma, 74135. The Secretary-Treasurer should send this out in November 2000.

B. BOARD OF GOVERNOR - Dr. Richard Kanoff

The Board of Governors is asking that the Neurosurgical Section try to obtain more funding for the ACA annual program.

C. RESIDENT EVALUATION COMMIUEE REPORT:

The member of the resident evaluation committee was not in attendance. It was brought up during the meeting that the neurosurgical member on the resident evaluation committee may not be the best representative from the Neurosurgical Section. This was brought up to the Board of Governors. The committee of the Board of Governors had made a selection and they did not feel that it was appropriate for the neurosurgical membership to decide on a more appropriate Candidate for the member of the resident evaluation committee. The Neurosurgical Section asked that Dr. Kanoff take the recommendations of the Neurosurgical Section back to the Board of

Governors that either an additional member be appointed as determined by the Neurosurgical Section or that the current member be replaced. Dr. Rodney Routsong, previous member of the resident evaluation committee, volunteered to either assist on the committee or become the current member. Dr. Kanoff stated that the neurosurgical member to the resident evaluation committee is very important in deciding the direction of the residency programs. The current member has not attended any of the meetings this year. There was no mention of the doctor's name during this meeting. A suggestion was made that a letter is drafted to American College of Osteopathic Surgeons Board of Governors nominating a member to serve on the resident evaluation committee. This was discussed. Further recommendation was made that the residency program directors meet and elect a member from the Neurosurgical Section to serve on the resident evaluation committee. This was also discussed. Dr. Kanoff will take this information back to the Board of Governors for further discussion.

D. SCIENTIFIC COMMI TTEE REPORT: Dr. Robert Dixon

Dr. Dixon reported that over his three-year tenure as scientific committee chairman there have been improvements made in poster judging with strict judging criteria developed. One of the criteria for awarding points in judgment of a poster, is that an individual is present at the time of poster inspection. They get 10 points, not being there they get 0 points. This gave an individual possibly an unfair weighted amount of points. The members of the scientific committee have submitted a recommendation to the Board of Governors to change the weighting of the scoring system. Dr. Dixon asked that more members of the Neurosurgical Section especially the residents submit more posters. The poster presentation has been increasing but the Neurosurgical Section is still behind. Case reports do not score well in the judging. Original research tends to score better. Dr. Dixon suggested that the residents pull several charts and look as such things as the amount of blood loss when comparing neurosurgical operations to orthopedic operations, the use of Robaxin versus Flexeril to reduce spasms after fusion surgery, the affects of Toradol versus narcotics in back cases, he stated that if you perform a retrospectively study of 10 to 20 charts they usually receive favorable scoring during the poster presentations. Dr. Dixon also stated that companies are reluctant to donate money to a general ACOS fund. Companies are willing to donate money to the section itself to be used for scientific presentations. This can be donated to the section in form of an awarded such as a Synthes Award for the best spinal paper.

E. RESIDENCY PROGRAM DIRECTORS REPORT

Dr. Gregory Mavian, the program in Columbus has funding for four residents. They currently have two residents. They have a large volume of spine and trauma and wish to develop their vascular cases.

Dr. Robert Decker he has funding and has filled five resident positions. They have a well rounded program with approximately 2200 cases per year, and it is now part of the North Shore Long Island Jewish Health System. He stated that he has a very high caliber of residents.

Dr. Lou Jacobs he has funding for and has filled three residency positions.
He has many more applications. They are part of the Michigan State
University Health System.

Dr. Kanoff stated that there is a new residency program in California associated with the Osteopathic Medical School (Western University). The program is at Arrowhead Regional Medical Center 400 N. Pepper Avenue, Calton, CA 92324. The director is Dr. Javed Siddiqi, associates are Dr. Chenyere Obasi and Dr. Timothy Wiebe. The residents are Dr. Daryl Warner,

Dr. John Spitalieri, and Dr. Dennis Miller.

Dr. Kanoff stated that he has five residents in his program.

Dr. Thomas Goodall reported that his program is approved for three residents and currently has one resident.

Dr. Armen Marouk stated that Dr. Gregory Wilson was in charge of the program in Tulsa, Oklahoma. It is in flux, they have one resident at this time.

Dr. Clark Okulski stated that he has three residents in training.

F. MEMBERSHIP COMMITTEE: Dr. Robert Baker

Dr. Baker stated that one of the requirements of membership is to attend the ACA meeting once every 3 years. If you do not attend the meeting you will lose your membership and that may have a role in whether or not you remain a fellow and possibly if you remain certified. The American College of Osteopathic Surgeons has over *75* members that have not been present at the ACA meeting since 1992 and these members and other members do not make the meeting requirement and will start to be investigated.

G. AWARDS COMMITTEE: Dr. Miulli

Dr. Miulli stated that the resident achievement award winners are:
Neurological surgery: Dr. Larry G. Armstrong.
Urological surgery: Dr. Brian R. Drabik
General Surgery: Dr. Allan Dana Lamb.
General Surgery: Dr. Gregory Messner
Plastic and Reconstructive Surgery: Dr. Gregory Zella

The Robert E. Erwin literary achievement awards:
First Place: Dr. Faustoy Vinces
Second Place: Dr. Michael G. Waters.
Third Place: Dr. Christoper P. Moyer

The awards committed is going to send out letters requesting nominations for the Orel F. Martin Award, the Distinguished Osteopathic Surgeon Awarded and the Humanitarian Award. These letters will be sent out throughout the year as well as being advertised in the American College of Osteopathic Surgeons News. The residency program directors are being asked to submit names and papers for the 2001-year residency achievement awarded and Robert E. Erwin Literary Award. The forms must be completed and submitted by April 13, 2001 both by the residency program director and the resident themselves.

Dr. Micheal Moncman brought up that the American College of Osteopathic Surgeons does send out questionnaires asking for member's input. They take these responses deeply and base further action. He suggested that if you do receive a questionnaire in the mail do not throw it out, but fill it out and return it and let your voice be heard.

IV OLD BUSINESS

A. Coding and reimbursement advisory panel. Dr. Detamore states that our section did not have a representative at the coding and reimbursement advisory panel. Therefore, we will continue to ask Dr. Steven Fletcher to participate and assist Dr. MacDougall in his roll.

B. Spinal Surgery Section of the American College of Osteopathic Surgeons and American Osteopathic Association of Orthopaedics. Dr. Gregory Mavian the liaison to the Spinal Surgery Section gave the report. He stated that the spinal section was asking for neurosurgical input to the C.A.Q., which stands for Certificate of Qualification examination. The spine surgery section of the orthopedic section requests that the neurosurgeons participate so that they may upgrade the spine surgery subsection standards. There were questions regarding the applications for membership in the Spinal Surgery Section. Dr. Mavian stated that the section has been going through changes in leadership and with review of the applications for membership. There were multiple discussions regarding the ability to become members of a Spinal Surgery Section of the joint American College of Osteopathic Surgeons and AOAO. Dr. Mavian stated that if anybody contacts him in Columbus, he will make sure they get an applications for membership of the Spinal Surgery Section. He asked that members submit question for the certification examination of the Spinal Surgery Section that the orthopods will take. It was brought up during the meeting that the Neurosurgical Section in general once again request that all members submit questions to the Neurosurgical Section for the residency test in addition to the Spinal Surgical Section. Members of the American College of Osteopathic Surgeons Neurosurgical Section can belong to the spinal surgical section and become officers of the section. The spinal surgical section is requesting that the Neurosurgical Section continue to have input to the Spinal Surgical Section. Dr. Mavian will follow-up on the requirements to become a member of the Spinal Surgical Section but he stated that it is open to many different types of physicians.

C. Neurosurgical Section banner. The banner was presented and is in the front of the room. There was unanimous approval of the banner.

D. Neurosurgical Section Website. Dr. Detamore discussed the fact that the web site was voted on and approved at the October 3, 1999 annual meeting in Seattle Washington. He then performed a great deal of work on the Website and invested a fair number of funds into developing it. He obtained the help of an outside firm. He then sent out a letter to the membership to advise them of the cost. Many members of the membership responded in a negative fashion. There was a great deal of discussion regarding the Website. The membership stated that it should be a static site that is devoted to the distribution of information among the neurosurgeons and other individuals and public. It should not be interactive. As far as interaction among the neurosurgeons in the review of cases and other materials, the section stated that this may best be accomplished through individual E-mails. The Website should be devoted to the posting of members, business of the organization and information regarding the organization. Dr. Detamore stated that he will work over the next 1-2 months with the assistance of Dr. Miulli and Dr. King to have an active Website. The Neurosurgical Section will fund the Website development and upkeep. He will also attempt to obtain digital pictures to be placed in the Website. The motion was made, seconded, and unanimously approved for Dr. Detamore to go ahead with the Website as outlined above.

E The membership of the Neurosurgical Section requested that larger rooms and more appropriate rooms be used for future meetings. This year the Neurosurgical Section has funded the refreshments at break. The Neurosurgical Section approved of the use of Treasurer funds for refreshments at the annual meeting. The Secretary will write a letter to the ACOS.

F World Federation of Neurological Surgeons: Dr. Miulli stated that at the annual meeting of the

World Federation of Neurological Surgeons the American Organization of Neurological Surgeons was not accepted as a group membership. No reasons were given.

V NEW BUSINESS

A Residency program match. There was lengthy discussion regarding the intern residency program match. The Neurosurgical Section programs may participate. For further information interested individuals should contact the AOA.

B. Dr. Decker has initiated a neurosurgical rotating internship, if the physicians participate this will count as time towards their neurosurgical residency. For further information individuals should contact the AOA.

C. A spine fellowship is being offered by Dr. Dixon at Columbus Hospital. The spine fellowship will offer a very broad selection of cases and multiple areas of spinal reconstructive surgery.

D. The Journal of the American Organization of Neurological Surgeons. The American College of Osteopathic Surgeons Neurosurgical Section and the AONS will be starting a journal that will be published at least on a yearly basis. There will be an attempt to publish the journal on a quarterly basis. The initial call for papers will be taken from the residents' annual paper submitted. We have asked that the residency program directors submit the papers this year, by October 31, 2000, and on an annual basis. Minor grammatical changes will be made in the papers prior to publication. Members may also submit papers from the annual meeting of the ACOS-NSS/AONS for publication. All papers must be submitted by the end of October 2000. A reminder will be sent out with the minutes.

E The minutes from the 73rd American College of Osteopathic Surgeons meeting of the Neurosurgical Section and American Organization of Neurological Surgeons will be distributed to all members with a membership roster in October of 2000.

There was a motion for adjournment and second, the meeting was adjourned. The next meeting is set to reconvene in Palm Desert California in the year 2001.

Respective submitted:

Dan E. Miulli, F.A.C.O.S.
Secretary Treasurer Neurosurgical Discipline
Secretary Treasurer Neurological Surgeons

THE AMERICAN ORGANIZATION OF NEUROLOGICAL SURGEONS

MISSION STATEMENT

The American Organization of Neurological Surgeons exists for the purpose of ensuring the public trusts through the advancement of neurologic surgery. The organization is dedicated to the continued advancement of the education of neurological surgeons, as well as the furthering of scientific knowledge, research, promoting public education in the neurosciences, upholding the highest standards of neurosurgical clinical practice to the public and our fellow neurosurgeons. The American Organization of Neurological Surgeons is an independent group. The American Organization of Neurological Surgeons, its officers and its membership will work in conjunction with other members of organized neurological surgery to promote the advancement of the professional scientific knowledge, research, public education and volunteership.

MEMBERSHIP

It is open to those members who have completed a formal AOA or ACGME approved neurosurgical residency program. Candidate members must be currently enrolled in either an AOA or ACOME approved neurosurgical residency program. Associate membership is open to those individuals who are dedicated to the neurosciences. All individuals for consideration of membership are held to the highest standard of personal and professional quality. Members must be licensed by their local governing bodies and remain in the highest ethical and professional stature. Honorary membership may be granted to any person who has contributed substantially to the neurosurgical profession upon recommendation of the Membership Committee and unanimous vote of the Executive Committee. The applicant shall agree to abide by the bylaws, rules and regulations of the organization and the Code of Ethics. Retired membership may be granted to any active or associate member, who has permanently retired from practice and does not qualify for a life or inactive membership. Retired members shall not be obligated to satisfy the requirements for continuing surgical education, attendance at annual meetings and licensure to practice in the state in which they reside. The retired member shall agree to abide by the bylaws, rules and regulations of the American Organization of Neurological Surgeons and its Code of Ethics. Life membership shall be granted to active, associate or retired members who will have reached the age of 60 and will have been a member for 20 years. The applicant shall agree to abide by the bylaws, rules and regulations of the American Organization of Neurologic Surgeons and its Code of Ethics. Inactive member is a member who is temporarily not in surgical practice who applies to be an inactive member upon the recommendation of the Membership Committee and the vote of the Executive Committee. The members should be fully licensed to practice in his or her category in the state. The member shall agree to abide by the bylaws, rules and regulations of the American Organization of Neurological Surgeons and its Code of Ethics.

OFFICIALS

The American Organization of Neurological Surgeons shall have a chairperson, vice-chair and secretary-treasurer, all of which will be elected for a two year time period. The elected officials will be by the active and candidate members who are in good standing.

MEETINGS

The American Organization of Neurological Surgeons shall hold an annual meeting for the promotion of education, research, scientific knowledge, increasing practice parameters and quality, and promoting public welfare and education. The American Organization of Neurological Surgeons Annual Meeting must be attended at least once in a five year time period to continue membership.

DUES

The membership dues will remain low and as determined by the membership body and the elected officials.

PUBLICATION

The American Organization of Neurologic Surgeons will distribute an at least annual publication to its membership.

COMMITTEES

Executive Committee: The Executive Committee should consist of the elected officers, the chair elect and the immediate past chair. Their term shall be for two years. These individuals should oversee the development and revision of bylaws, the advancement and upholding to the highest standards of the annual meeting, the publication and distribution of the American Organization of Neurological Surgeons publication and the appointment of the membership committee.

Membership Committee: The Membership Committee shall consist of those individuals appointed by the Executive Committee. These individuals will be appointed for a four-year time period, unless removed by or reappointed by the Executive Committee. The duties of the Membership Committee are to verify applications for membership and recommend or reject such applications.

REVOCATION OF MEMBERSHIP

Upon recommendation of the Membership Committee and unanimous vote of the Executive Committee, any member may be suspended or terminated for any violation of the bylaws, Code of Ethics or any lawful rule or practice duly adopted by the organization or any other conduct prejudicial to the interest of the organization.

A) Such activities but not limited to these are the conviction of a felony or any crime, limitation or termination of any rights associated with practice of medicine in any state, province, or country, including the imposition of any requirement for surveillance, supervision or review by reason of violation of the Medical Practice Act or other statute or governmental regulations, disciplinary action by or entry into consent order with any medical licensing authority, or voluntary surrender of license.
B) Improper financial dealings including the direct or indirect division of fees with other physicians, and the payment or acceptance of rebates of fees for services or appliances.
C) Participation in deception of a patient as to the identity of the operating surgeon.
D) Performance of unjustified surgery.
E) Grossly immoral, dishonorable, unethical or unprofessional conduct.
F) Performance of surgical operations when the responsibility of diagnosis and/or care of the patient is delegated to another who is not fully qualified.
G) Failure or refusal to cooperate reasonably with an investigation by the American Organization of Neurological Surgeons of a disciplinary matter. Any member who has been suspended or expelled from the American Organization of Neurological Surgeons may request reinstatement of his or her membership status. The process shall be established by the Executive Committee.

The Executive Board upon the recommendation of the membership shall determine dues and special

assessments.

The process for termination and reinstatement of membership for failure to pay dues or special assessments shall be determined by the Executive Board.

MISCELLANEOUS

Robert's Rules of Order shall govern the rules of order, meetings of the members, Executive Committee, Newly Revised, unless otherwise specified in the bylaws.

AMENDMENTS

Amendments to the bylaws may be made during the annual meeting by a majority vote of the members present.

SEAL

The seal of organization shall be a circular one, 3/4" in diameter, in which there is a shield, the top half composing a hand holding a scalpel, the bottom right a brain, and the bottom left carotid vascular tree with a ribbon underneath and the initials AONS.