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Comparative Study of Instrumentation for Dl Junction Spine Fractures.

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INTRODUCTION AND OVERVIEW

Vertebral injuries of the thoracolumbar spine are a major cause of long-term morbidity in trauma patients. Care of vertebral injuries contributes to the major expenditure of health care resources.

Thoracolumbar injuries in trauma are concentrated at the thoracolumbar junction,60% occurring between T11 and L2. Lumbar and thoracic injuries together represent 37-41% of traumatic spinal cord injuries. A neurologic deficit occurs in 26% of TL junction fractures.

Since the earliest attempts, the treatment of fractures and fracture-dislocations of the thoracic and lumbar spine has been controversial. Initially, all fractures of the DL junction were treated conservatively. Since the past 30 years, more and more surgeons are shifting towards open reduction and intCernal fixation of these fractures.

In the early years, laminectomy was the mainstay of surgical treatment. Recently reports by Levine and Edwards, Bohlman, McAfee, Bohlman & Yuan, Luque, Cassis and Ramirez-weill, Cotrel – Dubosset and Guillamat have emphasized the advantages of open reduction and internal fixation with instrumentation.

AIMS AND OBJECTIVES

1. Comparison of results of various types of instrumentations in fractures of the dorsolumbar junction.

2. Determination of the optimum type of instrumentation, type of decompression and type of reconstruction for different types of fractures of the dorsolumbar junction.

REVIEW OF LITERATURE

Since the 1960s, there have been regular periodic attempts at the improvement of fixation of fractures in the thoracolumbar spine.

The following is a summary of the origin and development of various methods of fixation of fractures in the thoracolumbar spine.

1970 – HARRINGTON INSTRUMENTATION.

Invented by Paul Harrington in 1970. Originally meant for fixation and correction of scoliosis and other spinal deformities. Later on, modified for fixation of vertebral body fractures. Now rarely used for the same.

1986 – Modification of the Harrington system by Edwards and Levine, Distraction rods, Polyethylene sleeves & anatomical hook design provided simultaneous hyperextension and distraction forces that eliminated kyphotic deformity and restored vertebral body height.

1984 – LUQUE INSTRUMENTATION

Another modification of the Harrington system. It provided more resistance to rotational forces than the traditional system.

1984 – SUBLAMINAR WIRING WITH HARRINGTON DISTRACTION INSTRUMENTATION

Combines the advantages of the Harrington and Luque systems by sublaminar wiring of the Harrington distraction rods, is supposed to increase stability and resistance to pullout.

1986 – STEFFEE AD, BISCUPS RS, SITKOWSKI DJSegmental spine Plates with pedicle screw fixation. A new internal fixation device for disorders of the lumbar and thoracolumbar spine 1986 Clinical Orthopaedics. This system uses pedicle screws with notched plates as the longitudinal linking component.

1986 – ROY CAMILLE, R, SAILLANT.G, MALEL C.

Plating of thoracic, thoracolumbar and lumbar injuries with pedicle screws Orthopaedic Clinics of North America. 1986.

1988 – WISCONSIN (DRUMMOND) INTERSPINOUS INSTRUMENTATION

This eliminates the risk of nerve/cord injury as the instrumentation is completely outside the spinal cord.

1988 – COTREL – DUBOSSET INSTRUMENTATION

Cotrel. Y, Dubosset.J, Guillamat M proposed new universal instrumentation in spinal surgery in Clinical Orthopaedics – 1988. This system consists of rods that are attached to the hook/screw system. This provides segmental fixation at multiple vertebral sites. Compression, Distraction and translation may all be used in the same construct, making it a powerful tool for multisegmental injuries.

1988 – TEXAS SCOTTISH RITE HOSPITAL SYSTEM.

Segmental fixation at multiple levels by hooks and /or screws, smooth rods are used.

ANATOMY AND BIOMECHANICS OF THE DL JUNCTION

The spine is a mechanical structure. The vertebral articulate with each other in a controlled manner through a complex system of joints, ligaments and levers. The stability is exhibited by ligamentous stability and dynamic neuromuscular structure.

FUNCTIONS OF THE SPINE

a) Transfers the weight and bending movements of head and trunk to the pelvis.

b) Allows physiologic motion between head, trunk and pelvis.

c) The spine possesses curvatures in saggital plane. It gives flexibility and shock-absorbing capacity at the same time maintaining stiffness and stability of intervertebral joints.

VERTEBRAL ANATOMY

A typical human vertebral consists of an anterior cylindrical body and posterior elements. The posterior elements are two pedicles, two laminae, two transverse processes, one spinous process and four articular processes. Vertebrae are connected by

1) Intervertebral discs – This consists of a central gelatinous nucleus pulposus which is surrounded by the annulus fibrosus.

2) The synovial joints and their capsules – Each vertebra articulates with its adjacent vertebrae by forming synovial joints with its articular processes.

3) Spinal ligaments – The spinal ligaments are the (a) anterior longitudinal ligaments (b) posterior longitudinal ligaments (c) Interspinous ligaments (d) Intertransverse ligaments (e) ligamentum flavum (f) Capsular ligaments and (g) supraspinous ligament.

FUNCTIONS OF LIGAMENTS

1. Uniaxial Structure is most efficient in carrying loads along the direction of fibers.

2. Resist tensile force, buckle to compressive force.

3. Allow adequate physiologic motion

4. Prevent / Reduce displacement in the injured spine to provide static stability.

5.Anterior and posterior longitudinal and supraspinous ligaments play a principal role in ligamentotaxis

Pedicle Morphology:

The pedicle is a part of the vertebral body connecting the body anteriorly with the laminae, transverse processes and the superior and inferior articular processes posteriorly. It is a tubular bone with an intramedullary different from putting a Rush rod in radius.

The diameter of the pedicle is largest in the lower lumbar spine and decreases in the thoracic area. Not only does the diameter of the pedicle decrease as one goes cephalad, but the angle of inclination also decreases, starting at about 30* at the L5 level to approximately 10* at L1. The resultant triangular construct form by attaching plates to the divergent screws makes this system exceedingly secure in resisting deforming forces.

Table: Pedicle diameter and distribution by size.

LEVEL	MEAN	SD	NUMBER	3-3.9 mm (%)	4-4.9 mm (%)	5-5.9 mm (%)	6-6.9 mm (%)	7-7.9 mm (%)	8-19.4 mm (%)
T9	6.88	2.23	14	14	7	14	21	7	35
T10	7.47	2.24	18	11	-	11	39	-	39
T11	7.83	1.56	22	-	-	14	18	14	55
T12	7.63	1.79	24	-	-	21	21	12	46
L1	7.01	1.84	22	9	-	18	18	14	41
L2	8.67	0.64	14						92
L3	9.30	1.51	24				8	12	79
L4	11.03	1.36	24						100
L5	15.15	1.97	20						100

Just posterior to the pedicle proper is the mammary, and accessory process, to which the origin of the lumbar multifidus and the insertion of the latissimus muscles attach. These muscles are responsible in part for segmental rotations, side-bending, and extension of the spine. Their anatomie position gives further evidence of the functional importance of the pedicle in controlling motion and transmitting force to the anterior spinal body.

ZANCOLLIS CONCEPT OF THE FORCE NUCLEUS

The force nucleus is a point where the ridge on the transverse process, the ridge of the pars interarticularis and the ridge of the intervertebral joint meet. The forces acting on the following five structures - the transverse process, the superior and inferior articular processes, the lamina and the pedicle are channeled to the vertebral body through this point

Opening the cortical bone at this point offers a window into the intramedullary canal of the pedicle through which the screw must pass through the force nucleus into the vertebral body which allows complete control over all six degrees of freedom of each vertebra.

MUSCLES OF DORSOLUMBAR JUNCTION

They are divided into two layers. The superficial layer consists of the latissimus dorsi. The deep layer has in the superficial portion, the erector spinae and in the deep portion the rotators and multifidus.

FUNCTION:

1. Dynamic stability
2. Reduce abnormal and potentially dangerous motion in the damaged spine.
3. Prone to fatigue
4. Cannot counter forces when major bony / Ligamentous structures are disrupted.

BLOOD SUPPLY

The vertebral column is supplied bilaterally by the segmental arteries. In the cervical spine they arise from the vertebral, costocervical and thyrocervical arteries. In the dorsolumbar spines, they arise from the aorta. Each segmental artery gives rise to three branches with one branch supplying the paraspinal structure and one branch entering the canal to supply the spinal cord. The Intervertebral foramen is termed the distribution point. The third branch continues as the posterior intercostal artery.

The common iliac arteries are directly opposite the pedicles at L3 L4 levels. Penetration of the anterior cortex of the screws can lead to vascular complications. The spinal cord between T4 and T9 vertebra has less blood supply than other regions and interference with circulation at this level can leave to paraplegia.

The venous drainage is through the Batson's plexus which is a large complex of valveless veins which communicates with both the IVC, the SVC and the Azygousvein.

VERTEBRAL CANAL

The vertebral canal extends throughout the spinal column at the DL junction filled up to 50% by the spinal cord and the rest by CSF, Epidural fat and Meninges. The mylomere lies at the same level as the correspondingly number vertebral body upto C 7. It lies one level above upto T 7 and it lies two levels above upto T 10.

The lumbar mylomeres are concentrated between T 11 and L 1 vertebral bodies with the cord ending at the lower border of L 1. Conus medullaris containing sacral and coccygeal mylomeres is dorsal to the L 1 body and end at D12-L1 disc.

BIOMECHANICS

The different parts of the Vertebral column are adapted to counteract different deforming forces. Vertebral and IVD counteract compression, Annulus Fibrosus counteract rotation, the facet joints counteract shear and other posterior elements and ligaments counteract tensile forces.

Three column concept of Denis:

The vertebral bodies are divided into three columns namely, the anterior column which comprises the anterior half of the vertebral body, IVD and ALL. The middle column comprises the posterior half of the vertebral body IVD and PLL. The posterior column comprises the posterior elements and other ligaments. The middle column bears > 40% of the axial load, the anterior column about 30% and the posterior column <25%.

Normal Physiologic forces at the DL junction :

Transmits 400 Newton of axial force owing to the weight of the body and 25 Nm of bending movement owing to the anterior location of the center of gravity. This axial compression is converted to 400 N of shear at the DL junction on bending forwards and bending moment increases to 120 Nm. Torsion movement is 20 Nm at the DLJ while turning in bed. Lateral bending and extension exert bending movements of 30 Nm.

Any instrumentation at the DL junction should be able to oppose the above forces adequately.

Stress concentration at the DL junction.

The flexibility of the spine changes from the relative stiffness of the dorsal spine to the increased flexibility in the lumbar spine.

The spinal curvature changes from dorsal kyphosis to lumbar lordosis. The facet joint orientation changes from the coronal plane in the dorsal spine to the sagittal plane in the lumbar spine. The dorsal spine is supported by the rib cage whereas the lumbar spine is not. All these factors contribute to the increase in the incidence of fractures at the DL junction.

REVIEW OF CLASSIFICATION OF VERTEBRAL COLUMN INJURY

Classification of thoracolumbar fractures has evolved continuously over the past 40 years. The first attempt was made by Nicoll(1949)

who classified them into stable and unstable fractures. Holdsworth(1963) classified them into five groups by mechanism of injury. 1. Pure flexion 2. Flexion and rotation 3. Extension 4. Vertebral compression 5. Shearing.

Kelly and Whitesides(1968) classified them into two broad groups 1. anterior column fractures and 2. Posterior column fractures. McAfee et al(1981) classified them into the following six types 1. Wedge compression 2. stable burst 3. Unstable burst 4. Chance fractures 5. Flexion-distraction 6. Translation injuries. The most recent and widely accepted classifications are the following

1. DENIS THREE-COLUMN CLASSIFICATION

BASIC TYPES OF SPINE FRACTURES AND THEIR MECHANISMS

Type	Mechanisms
Compression	Flexion
Anterior	Anterior flexion
Lateral	Lateral flexion
Burst	
A	Axial load
B	Axial load plus flexion
C	Axial load plus flexion
D	Axial load plus rotation
E	Axial load plus lateral flexion
Seat belt	Flexion-distraction
Fracture-dislocation	
Flexion-rotation	Flexion-rotation
Shear	Shear(anteroposterior or posteroanterior)
	Flexion-distraction
Flexion-distraction	

From Denis F. The three-column spine and its significance in the classification of acute thoracolumbar spinal injuries. Spine 1983;8:817-831, with permission

MODIFIED AO/ASIF CLASSIFICATIONOF THORACOLUMBAR INJURIES

Type	Group
Compression	1. Impaction (wedge) 2. Split (coronal) 3. Burst(complete burst)
Distraction	1. Through the posterior soft tissues (subluxation) 2. Through the posterior arch (Chance fracture) 3. Through the anterior disk (extension spondylolysis)
Multidirectional with translation	1. Anteroposterior (dislocation) 2. Lateral (lateral shear) 3. Rotational (rotational burst)
ASIF, Association for the Study of Internal Fixation. From Gertzbein SD. Spine update. Classification of thoracic and lumbar fractures. Spine 1994; 19626-628, with permission	

LOAD SHARING CLASSIFICATION (PARKER ET AL) (Spine 2000,25(9) 1157-69, with permission)

I. Comminution/Involvement

1. Little = <30% Comminution on sagittal plane section CT.
2. More = 30%-60% Comminution.
3. Gross = > 60% comminution

II. Apposition of fragments

1. Minimal = Minimal displacement on axial CT cut.
2. Spread = At least 2mm displacement of <50% cross section of body.

3. Wide == At least 2mm displacement of >50% cross section of body.

III. Deformity correction

1. Little = Kyphotic correction $\leq$ 30 on lateral plain films
2. More = Kyphotic correction 40-90.
3. Most = Kyphotic correction $\geq$ 100.

According to Parker et al a score of 7 or above necessitates an anterior–alone procedure and a score of 3 to 6 requires a posterior–alone procedure.

MATERIALS:

Different types of implants used for the D-L spine are described as below:-

DESCRIPTION OF VARIOUS FIXATION SYSTEMS.

MOSS MIAMI SPINAL FIXATION SYSTEM:

Components – Moss Miami monoaxial, polyaxial screws, hook and road.

These screws are fabricated from 316-L stainless steel as also from implant-grade titanium. The screws are composed of a T16-Al-4V Alloy cancellous buttressed threaded shaft which is available in 4 mm, 5 mm & 6 mm diameters and lengths of 30-45 mm.

The shaft is attached to a hollow head which is divided into 2 semicircular parts by a hollow U – groove. The walls of the hollow U - groove are threaded both on the inside and outside. The smaller hollow screw corresponds to the inner threads & a nut corresponds to outer threads.

Rods of 5 mm is used as the longitudinal linking component between screws. The rods fit with the grooves with 5 point contact between screw & rod.

Transverse connectors connect the two rods and make the whole construct more stable. They use 2 mm stainless steel rods as the horizontal linking component.

STEFFE PLATE SCREW SPINAL FIXATION SYSTEM

The Steffee plates are fabricated from 22-13-5 stainless steel. The plate contains from one to five nested slots whose length may vary depending on the number of vertebral levels to be stabilized, the length increases by half slot increments. These slots, with their precisely machined sloped nests, offer the possibility of accurate yet *variable screw placement* along the spinal column. The plate may be bent to mirror or create, the saggital curve of the spine.

The Steffee screws are fabricated from specially hardened 22-13-5 stainless steel and are composed of two parts, a machine threaded section on the end of which is a hexagonal drive head. The screw and plates are fixed to each other with a double nut locking system. In the latest design modification, the screw features an integral fixed lower nut that is machined from the same bar stock and has the advantage of being stronger and more resistant to stress and breakage.

The cancellous portion of the screw has a buttress thread design and is available in 4.5 mm, 5.5mm and 6.5mm diameter and having a range of length from 32mm to 40mm with 2mm increments. A 10-32 machine screw thread is common to all the screws.

The design of the slotted plates allows for the possibility of variable screw placement along the spinal column and gives the surgeon a choice of angulation for the system once it is assembled.

Finally, many devices may be attached to the transpedicular screw and plates including cross-braces and serrated rods. e.g. Triangulation of pedicular Instrumentation.

The other instruments needed for the introduction of Steffee screws and plates are probe, tap, screwdriver, nut driver and an industrial cutter.

De-Puy ANTERIOR TITANIUM LOCKING PLATE

The Isola plating was fabricated from implant grade titanium Titanium 6-A1-4V alloy. It consists of a rectangular plate with 4 nested slots in the four quadrants. The member of nests in each quadrant ranges from 2-6 depending upon the number of segments to be spanned.

Screws: The screw has a cancellous buttress thread with lengths from 30 m to 50 m. The screws and plates are fixed to each other with a double nut locking system. The lower nut is fixed to the shaft and is machined from the same bar stock and has the advantage of being stronger and more resistant to stress and breakage.

Cage: Material – Implant grade titanium.

Size and Shape – cylindrical with a parallelogram mesh pattern varying diameters and lengths.

Procedure

Hartshill frame & Sublaminar wires

Fabricated from 22-13-5 stainless steel consists of a rounded rectangular frame with a curve in the lateral plane to accommodate the normal kyphosis of the dorsal spine.

The Drummond wires consist of stainless steel wires with buttons fixed in a middle. These buttons have holes through which the wires are looped. The frames have a fixed width and variable length depending upon the number of segments to be spanned.

BRIEF OUTLINE OF OPERATIVE PROCEDURES

Pre-operative planning and preparation

After thoroughly clinical examination and investigating the patient, keeping an adequate amount of cross-matched blood ready, the patient is prepared in the form of thorough shaving, salvon bath, Foley's catheterization. The patient has also explained the procedure which he is going to undergo.

The patient's general condition should be such to allow him to bear a major operation.

A lateral roentgenogram is obtained and pre-operative measurement of the screw length necessary is measured, as 75% of the length of the vertebra in an AP direction from its anterior border to the posterior surface of the pedicle on the lateral roentgenogram.

Generally, 4.5mm screws are used for dorsal vertebrae and 5.5mm for lumbar and sacral vertebrae, otherwise, the size is determined pre-operatively from the size of the vertebras for a particular patient.

Approach and Surgical Technique of Posterior Spinal Fixation

The patient under general anesthesia is positioned on the operating table Relton – Hall Scoliosis Frame or bolsters in a prone position to keep the abdomen free from pressure to reduce venous pressure in the epidural veins. The scoliosis frame also provides the necessary stability. The aorta and abdominal organs are followed to fall anteriorly which provides an adequate measure of safety and room for manipulation.

Hypotensive anesthesia may be used to reduce blood loss.

After proper painting and draping the spine is exposed through a posterior midline incision centered over the involved lumbar segment. Infiltration of the skin and subcutaneous tissue with a 1:500,000 epinephrine solution aids hemostasis. Carry the dissection down in the midline through the skin, subcutaneous tissue, and lumbodorsal fascia to the tips of the spinous processes. Use self-retaining retractors to maintain tension on soft tissues during exposure. Subperiosteally expose the posterior elements from distal to proximal using electrocautery and periosteal elevators to detach the muscles from the posterior elements. Pack each segment with a taped sponge immediately after exposure to lessen bleeding. If the procedure requires exposure of both sides of the spine, use the same technique on each side. We recommend accurate localization of the involved segment with a permanent roentgenogram in the operating room. After completion of the spinal instrumentation, close the wound in layers over a drain.

Table: Pilot Hole Preparation

Techniques for transpedicle screws.

Author	Method
Roy – Camille et al	Awl to locate entry Drill (3.2 mm); Screw
Steffee et al	Awl or probe through pedicle Tap through pedicle; Screw pedicle Screw.
Wiltse	2 mm k-wire through the Mamillary process.
Dick	K'wire (2-mm) into body (approx- 3cm deep) Drill (3.5mm) 5-10 mm deep screw under X-Ray control
Edwards	Hole developed with 3-0 curet replacement with guide wire, x-ray screw
Guyer et al	Awl pedicle probes through pedicle blunt K eire driven in under x-ray control. K wire removed; threads tapped to 2 cm
Krag	Burr to enter cortex, centered over pedicle by x-ray "Coaxial View" Drill along pedicle axis to anterior cortex monitor by X-ray "near approach view" Screw; orientation with nearby guide wire depth by x-ray "near approach view"
Louis Luque and Rapp	2.8 mm drill (depth ?) screw Enter pedicle (Use drill?) Curet thought pedicle Drill in blunt K wire to anterior cortex Cannulated tap over K wire Cannulated screw over K wire.
Magerl	Drill 3.5 mm approximately 4 cm deep Replacement with K wire; x-ray Screw to anterior cortex monitor with x-ray
Olerud et al	K wire and x-ray to define entry site Drill through cortex Screw to anterior cortex; monitoring with lateral view

Approach and Surgical Techniques of Anterior Spinal Fixation

Preoperative planning plays an important role in the preparation for surgery. Titanium ATLP system X-ray templates are available to assist in selecting the appropriate range of plate sizes. The decision on which side to approach the patient is based on the vascular anatomy and spinal pathology.

If a disk excision or a vertebrectomy has been performed, the vertebral body spreader is used to restore the normal sagittal profile. The height is maintained by the use of a tricortical graft or substitutes vertebral body.

Ensure that the patient is positioned in a true lateral position and that he is held secure throughout the procedure. When positioning and securing the patient, take care to prevent undue pressure points and nerve palsies. Approach the thoracolumbar junction through the bed of the tenth or eleventh rib. After exposing the spinal segments to be instrumented, excise the discs above and below the area of abnormal anatomy. Perform a corpectomy and complete canal decompression. When necessary, perform reduction at this time. Using the depth gauge, measure the coronal diameter of the vertebral body above and below the corpectomy. This distance is used to determine the length of the bolts and screws to be used. The bolts and screws of the De-Puy ATLP system are intended to engage the opposite cortex of the vertebral body.

Two bolts each are inserted in the proximal and distal vertebral starting with the posteroinferior screw. The posterior screws are angled 100 anteriorly. With a template, the shortest possible plate is selected. The vertebral column is distracted by exaggerating the lumbar lordosis and tricotical bone graft or Harms cage of appropriate sizes filled with rib grafts are placed at the site of the vertebrectomy so that after the release of traction the graft is placed in a compressive mode. The plate is then fixed to the bolts after the application of compression. The incision is closed in layers over a chest tube.

Fusion

Any of the following types of fusion can be performed :

1. Posterolateral or intertransverse fusion.

2. Hibbs fusion.

3. PLIF

4. ALIF

1. Posterolateral fusion or intertransverse fusion: The facets pars interarticular and the bases of the transverse processes are denuded and fused with cancellous chip and a large graft is placed posteriorly on the transverse process.

2. Hibbs fusion: It attempts fusion at four different points: the laminae and articular processes on each side.

3. PLIF : Includes excision of the disc and replacing it with bone grafts between the two bodies of vertebrae.

4. Anterior fusion:

Inserts

What is the best material to place for achieving an anterior arthrodesis or replacing the vertebral body following a total or partial vertebrectomy?

Anterior instrumentation is inherently kyphogenic, and hence a good quality insert is needed to maintain normal thoracolumbar alignment in the sagittal plane at the same time to achieve a solid early arthrodesis. Furthermore, the majority of anterior spinal instrumentations are "load-sharing" in nature and, hence, an appropriate reconstruction of the anterior column is necessary. In their biomechanical study of various anterior fixation devices. An et al [12] found that these devices restored spinal column stability in all loading modes when an interbody graft was inserted.

Anterior decompression and anterior grafting without anterior instrumentation may be done when the stabilization is performed posteriorly. Lim et al [13] in their cadaveric calf spine biomechanical study showed that an anteriorly placed insert was important to improve stiffness in extension for a posterior construct when compared with a similar situation for anterior rod or plate constructs.

Autograft

Autogenous bone grafts have several advantages. Specifically their immune compatibility, no transfer of disease and their osteoinductive capabilities. Disadvantages in their use include the limited amount of bone available, donor site morbidity and inadequate structural support [18]. The largest reported series of cases for anterior thoracolumbar trauma is with iliac crest tricortical graft [2]. This is used along with two or three struts of the excised eleventh rib. It is recommended that the stronger tricortical portion of the iliac crest graft be placed opposite to the side that the instrumentation is placed in the vicinity of the far-side pedicles. This means that usually the stronger portion of the graft will be placed on the right side of the vertebral body. With the cancellous portion facing the instrumentation as the vertebral body is approached from the left side. The tricortical portion of the bone graft is inserted in the frontal plane beyond the far pedicle. A poor graft placement technique has been implicated as the major cause of pseudoarthrosis development [2].

Allograft

With the availability of a whole range of options from tissue banks and the immense advantage of avoiding donor site problems along with a decrease in operative time, structural allografts are now a more suitable choice. One may use a cortical structural allograft such as the femoral ring and pack the medullary canal with autogenous bone chips (of either local bone or bone harvested using one of the new bone harvesting trephines), a preparation of demineralized bone matrix, or in the future, a growth factor along with its carrier (a bone morphogenic protein in a collagen matrix.)

The allograft may be a frozen or freeze-dried femoral shaft of adequate length that can be cut to the desired size on the operating table. The estimate of loads across the lumbar region is in the magnitude of 2,000 lbs. for forwarding bending. The compressive strengths of iliac crest allograft range from 396 lbs. to 1,475 lbs whereas for a femoral ring it is in the order of 15,000 lbs.

Finkelstein et al[18] followed 36 patients with thoracolumbar fractures who had an anterior decompression and placement of a frozen tibial allograft packed with local bone from corpectomy along with stabilization. Over 2 years, 81% of the grafts were fused. Nineteen percent of cases showed lucency at one of the host-allograft junctions. There were no cases of graft resorption or collapse. Although the fusion rate of 81% is lower than that published for autogenous tricortical iliac crest, Finkelstein et al attribute little clinical significance to the radiological appearance of nonunion at the host allograft junction.

Mesh and cages

A complete range of titanium cages is now available to span the gap between adjacent vertebral bodies after anterior decompression. These cages can be filled with autografts or autografts mixed with a bone extender such as putty or strip form of the demineralized bone matrix before their placement. The alignment of these cages is important so that the graft within the cage is in compression mode. If the adjacent bone is osteoporotic, then the spiked edges of the cage potentially can sink into the cancellous vertebral body. Lee et al [19] compared the biomechanical effect of several anterior grafting devices in a calf spine model. Comparing a polymethylmethacrylate block, tricortical iliac crest bone graft, one large Harms cage, and two small Harms cages, they found that the cages improved rotational stability as compared with the iliac bone and polymethylmethacrylate. The more rigid spinal construct is thought to be a result of the improved friction at the cage-bone interface.

Vertebral body prosthesis

A bioactive ceramic (apatite – wollastonite containing glass-ceramic) vertebral prosthesis has been used in anterior column reconstruction along with a rod device for 22 patients with neurological symptoms following cauda equine lesion caused by osteoporotic wedge compression fractures [20]. It is possible to use such prostheses along with augmentation with rib autograft for reconstructive purposes, especially in cases with neurological deficit following a malignant metastasis where life expectancy is limited.

ROLE OF RhBMP-2 IN SPINE FUSION:

Rh-BMP-2(recombinant bone morphogenetic protein, BMP) is a genetically engineered protein that both recruits bone-forming cells to the surgical area and "turns on" local cells to the bone-making process. BMP is used for conditions requiring spinal fusion and stimulation of bone growth.

In the initial experiments done by Marshall Ulrist almost 50 years ago, he was able to identify a mixture of proteins isolated from the bone marrow, which were activated when the bone was damaged. It was not until the late 1980's that the individual protein components could be separated and identified. This is important. The tests used to determine the relative potency of the individual protein components involved placing a small amount of the material beneath the skin of test animals. Some, specifically RhBMP-2, were able to stimulate immature local mesenchymal (soft-tissue) cells to become bone-forming cells.

Recently, RhBMP-2 has been approved by the U.S.Food and Drug administration for use in certain spinal fusion procedures. At this time, BMP has been approved for the treatment of L5-S1 degenerative disease and used along with titanium spacers (called cages) placed anteriorly (from the front of the spine). The anterior approach was chosen because it is the easiest way to shelter the BMP within the spine. By using a collagen sponge soaked with BMP and then placing it within the cage, there is little possibility that the material could seep into unwanted places and form bone where it is not needed. The degenerative disease was chosen as the first condition to be treated with BMP because of concerns from experts in the field that BMP could stimulate the growth of tumor cells or spread infection if used improperly or in the wrong patient. Although the animal studies to date indicate that BMP is safe even when used in the presence of tumor cells or infection, most of us agree upon a cautious course when it comes to trying this material in large groups of human patients. Similarly, BMP has not been approved for use in children, whose developing bodies may react differently to the substances.

Patient Outcomes

In December of 2001 Doctors at the New Hampshire Spine Institute reported on a series of 22 patients who had undergone spinal fusion using RhBMP-2 through a laparoscopic approach. The results were reported in the journal spine 2001;26:2751-2756. the research was done as part of a larger multicenter study sanctioned by the FDA. The average hospital stay was only 1 day, shorter than for any other reported fusion procedure. Of the 21 patients who completed the study; all of them reported improvement in back pain, leg pain, and function. They all achieved a solid fusion by 6 months and all of them were able to return to work. This was the first study on spinal fusion that demonstrated a 100% success rate for both clinical and radiographic outcomes.

METHODS AND MATERIALS

This is a study of 60 patients with dorsolumabar junction fractures who were treated with open reduction and internal fixation at our institute. These patients were subjected to detailed neurological examination according to the proforma given below, at (a) admission (b) immediate post-op period (c) 6 weeks (d) 6 months and (e) after one year. Each patient was assessed using Cotler's criteria after a mean follow-up period of one year and the following results were obtained.

PROFORMA

a. GENERAL DATA

Name OPD Number

Age / Sex IR Number

Address DOA

DOO

Occupation DOD

b. COMPLAINTS

Pain

Onset

Duration

Location

Aggravated by

Relieved by

Weakness

Onset

Location

Duration

Loss of Sensation

Location

Onset

Duration

Bowel/ Bladder Complaints

Urinary

Retention

Incontinence

Bowel

Retention

Incontinence

c. HISTORY

Type & mode of Injury

Flexion

Flexion and Rotation

Axial Compression

Extension

Duration Since Injury

Treatment History

Yes No

M.P.P.S.

Dexona

Past History

d. EXAMIANTION

GENERAL

P RS

BP CVS

CNS

Cranial Nerves

P.A.

LOCAL

Inspection

Skin

Yes No

Deformity — Scoliosis / Kyphosis / Gibbus

Swelling

Para Vertebral

Vertebral

Bed Sore

Yes No

Palpation

Temperature

Location of Tenderness

Swelling

Spine deformity

Examination of the spine	R		L
Range of motion			
SLRT			
SNST			
SIST			

- FNST

Neurological Examination

Tone

Power

R		L
	H	
	K	
	A	
	FHL	
	FDL	
	EHL	
	EDL	

REFLEXES

SUPERFICIAL REFLEXES

	R		L
BABINSKI			
ABDOMINAL			
CREMASTERIG			
ANAL TONE			
ANAL WINK			

DEEP TENDON REFLEXES

KNEE			
ANKLE			

SENSATION

Pin Prick			
Touch			

FRANKELS GRADING

A. Complete Paralysis ☐

B. Sensory Paralysis ☐

C. Motor Paralysis (Useless) ☐

D. Motor Paralysis (Useful) ☐

E. Recovery ☐

CLINICAL DIAGNOSIS

INVESTIGATION

Roetgeno gram

Type of fracture

Level of fracture

Kyphotic angle

MRI Extra Dural Block

Partial

Complete

	Yes	No
Cord transaction		
Cord Oedema		
Cord Hematoma		
Myelomalacea		

CT Scan

Myelo Gram

Routine Investigation

CBC

LFT

RFT

X-ray CHEST

FINAL DIAGNOSIS

TREATMENT HISTORY

1. Type of Instrumentation
   - i. Steffee
   - ii. Harshill
   - iii. Mossmiami
   - iv. Harringtom
   - v. Anterior Plating
   - vi. Cage / strut bone graft
2. Number of Levels of Instrumentation
3. Fusion Yes No

   Anterior

   Posterior
4. Status of Cord

Radiology - Post-op :-

1. Alignment of spine
2. Kyphosis - residual
3. Position of screw
4. No. of segment instrumented

FOLLOW UP EXAMINATION at

EXAMIANTION

GENERAL

P

BP

RS

CVS

CNS

Cranial Nerves

P.A.

LOCAL

Inspection

Skin

Yes No

Deformity

- Scoliosis
- Kyphosis
- Gibbus

Swelling

Para Vertebral

Vertebral

Bed Sore

Yes No

Palpation

Location of Tenderness

Swelling

Temperature

Examination of the spine R L

- Range of motion
- SLRT
- SNST
- SIST
- FNST

Neurological Examination

Tone

Power

R		L
	H	
	K	
	A	
	FHL	
	FDL	
	EHL	
	EDL	

REFLEXES

SUPERFICIAL REFLEXES

	R		L
BABINSKI			
ABDOMINAL			
CREMASTERIG			
ANAL TONE			
ANAL WINK			

DEEP TENDON REFLEXES

KNEE

ANKLE

SENSATION

Pin Prick

Touch

BOWELS

Constipation

Incontinence

BLADDER

Retention

Incontinence

FRANKELS GRADING

F. Complete Paralysis

G. Sensory Paralysis

H. Motor Paralysis (Useless)

I. Motor Paralysis (Useful)

J. Recovery

MOBILIZATION STATUS

Bed ridden

Walking with walker

Walking with stick

Walking without support

ROENT GENOGRAPHIC ASSESSMENT

Kyphotic Angle	Pre-op	Post-op	Final follow-up
Implant Failure	Yes	No	

Type of Implant

No. of segment fixed

Fusion

Complete

Incomplete

No Fusion

RESULT:-

RESULT AND OBSERVATION

1. Age Distribution

Age – Range	Number of Cases	Percentage
0-10 yrs 11-20 yrs 21-30 yrs 31-40 yrs 41-50 yrs 51-60 yrs 61-70 yrs		
Total		

2. Sex Distribution

Pathology	Male	Female

3. Occupation

Occupation	No. of patients	%

Labourer and farmer House Wives Student		
Total		

4. Time From injury to Admission

Present Series (Traumatic Spine)

	24 Hour	2-7 days	8-15 days	16-30 days	> 30 days
No. of Pat.					
%					

5. Time form admission to surgery

Present series (traumatic spine)

	24 Hour	2-7 days	8-15 days	16-30 days	> 30 days
No. of Pat.					
%					

6. Trauma: Mode of injury

Mode of Injury	Present Series		Burke's Series	
	No. Patient	%	No. Patient	%
Total				

7. Level of Fracture

Level	Number of Cases
D11 D12 L1	

L2 L3 L4	

8. Dislocation

Dislocation	Number of Patients	%
Present Absent		
Total		

9. Type of Injury

Type of Injury	No. of Patient	%

10. Based on Denis's three column concept

Column involved	Number of patients out of 31 patients	%
Anterior Column Middle Column Posterior Column		

In all patients anterior column was involved.

11. Based on Frankel's Clinical classification on admission

A : Complete paralysis

B : Sensory Paralysis only

C : Motor paralysis useless

D : Motor paralysis useful

E : Recovery

Type	No. of Patients	%
A B C D E		
Total		

12. Kyphotic angle (Pre-op)

Range	Number of Patients	%
0^o-10^o 11^o-20^o 21^o -30^o 31^o-40^o 41^o-50^o 51^o-60^o		
Total		

13. Vertebral body height %

The expected vertebral body height of the affected vertebra is the average of the vertebral body height of one vertebra above and one below the fractured vertebra.

The percentage of expected vertebral body height was obtained form the lateral roentgenogram for each patient and following was noted

14. Special Investigations :

15. Number of levels instrumented :

Levels	Numbers of patients	%

Total		

16. Pre-Op :

Frankel's grade	Number of Patients	%
A B C D E		
Total		

17. Mobilisation

Days	Number of Patients	%
Within 3 days (early) Within 2 weeks After 2 weeks (late)		
Total		

18. Fusion

Type of fusion	Pathology	Number of Pats.
PLIF Postrolateral Posterior Anterior		

19. Hospital Stay (Post0op)

Range :

Avereage :

20. Infection

Infection	Total no.	Mild	Moderate	Severe

21. Immediate post op Radiological Assessment

Reduction (Correction of deformity)	Number of Patients	%
Complete Partial None		
Total		

22. Follow-up

a. Pain

Pain	No. of Patients	%

b. Implant Complications

Implant Status	No. of Patients	%

c. Deformity

Deformity	No. of Patients	%

d. The Status of Spinal Fusion was as follows

Fusion	No. of Patients	%

e. Functional Status

Status	No. of Patients	%

COMPLICATION

The following complications of steffee plates and steffee screw fixation of the spine have been noted.

1. Infection
2. Loosening of screws or bolts
3. Breakage of screw, bolts or plates
4. Screw impingement against the skin.
5. Spine deformity
6. Bursa
7. Dural tears
8. Impingement of a bone fragment

   on a nerve root.
9. Nerve root irritation and damage due to wrong placement of screws.

COTLERS CRITERIA

1.STABILITY

Mobilization within Marks

3 Days	3
2 Weeks	2
After 2 Weeks	0

2.KYPHOTIC ANGLE

Full Correction	3
Partial Correction	2
No Correction	0

3.PAIN

No Pain	4
Mild Pain	-2
Considerable Pain	-4

4.BED SORE

Anesthesia	3
Hypoesthesia	2
No Sensory Deficit	1

5.INFECTION

No Infection	0
Superficial Infection	-1
Deep Infection	-3

6.NEUROLOGICAL RECOVERY

Significant Worsening	-3
Insignificant Worsening	-1
No Change	0
Non Useful Recovery	1
Useful Recovery	3

7.IMPLANT FAILURE

No Implant Failure	0
Implant Failure	-3

8.FUSION

Complete Fusion	4
Incomplete Fusion	2
No Fusion	0