# ALICI SPINAL SYSTEM

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Though implants that have been used in the treatment of spinal diseases and deformities dates back, most important innovation in spinal surgery has been achieved by the Harrington Instrumentation (3). Indeed, in the beginning instruments that Paul Harrington developed for the correction of paralytic scoliosis became a surgical armament for the treatment of various scoliosis types, kyphosis, vertebral important advance in spinal surgery. Maintaining the stability only in one plane and a need for postoperative external support have been considered as the Harrington Instrumentation's disadvantages and urged orthopaedic surgeons for new advances.

Stabilizing the vertebral column in each segment, obtaining a dynamic correction and early postoperative mobilization without external support have popularized Luque's segmental spinal instrumentation in a short time. This was followed by Durrumont techynyique and combined use of Harrington and Luque's techniques. However, in Leatherman's report of 357 patients and Winter's report of 100 patients, it has been shown that early postoperative mobilization without a cast or brace cause an extreme loss of correction.

Recently, realization of three dimensional nature of scoliosis deformity and the importance of correction in all planes caused another important advance and Cotrel-Dubousset instrumentation was brought into application. This instrumentation is reported to be effective in three dimensional correction of the deformity and early postoperative mobilization without any external support permitted widespread use of this system (1). Late results show only minimal correctional loss. However system's most important disadvantage is its expensiveness.

While the progress on posterior stabilization continued Dwyer (2) has developed his system composed of staples and cables that can achieve anterior correction of lumbar and thoracolumbar curves. This was followed by Zielke's anterior instrumentation (7). There are screws applied to vertebral corpus and flexible rods which are suitable for compression in this system. Good results have been reported with both of these systems on lumbar and thoracolumbar curves that cannot be handled posteriorly.

In 1989 the author has developed a spinal instrumentation that intended to be a solution for all spinal deformities and diseases. The system is composed of rods, screws, hooks and Transverse Connecting Devices (TCD), which can be used both anteriorly and posteriorly to achieve three dimensional correction of scoliosis, lumbosacral stabilization, reduction of spondylolisthesis, and stabilization of fractures and tumoral conditions of the spine. In posterior application, two threaded rods and multiple hooks are mounted to both sides of the column and they are attached to the hooks with the aid of nuts. TCH when applied craially and caudally, adds stability to the system and disperses the stress that condenses in one point.

**ALICI SPINAL SYSTEM**

**INSTRUMENTATION** (Figs 1, 2, 3)

**Rods:** Threaded rods are designed to permit easy movement of nuts on the rod. They have two flat surfaces that can be bend over its entire surface, and are available in 26 sizes from 10 cm to 36 cm. If bending done within one centimeter intervals, does not exceeds 30°, then nuts can easily move on the rods. They are stronger than the Harrington distraction rods.

**Closed Peduncle Hook:** Body of these hooks are hollowed to form a cylinder which permits rods to pass through. Their blades have a notch which are designed to grasp the Peduncle with their tips. They have good stability under distraction, since they hold on to the peduncle firmly.

**Open Peduncle Hook:** In an otherwise same Peduncle hook they have a posterior opening to provide a slot for the rod. Rods are placed from above and attached to the hook with telescopic nuts. These hooks also grasp Peduncle by means of the notch in their blade. They are stable under distraction.

**Closed Laminar Hook:** It has a hollowed body and a blade suitable for the lamina.

**Open Laminar Hook:** Through their posterior opening rods are placed into the hook and are attached to the rod by means of telescopic nuts.

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**Screws:** Body of the screw has a posterior opening to provide a slot for the rod. Screw has a 1.5 cm non-threaded part close to the body and the rest of the screw is threaded up to the tip. Both anterior and posterior transpedicular application may be possible and they are attached to the rod by telescopic nuts.

**Staple:** Staples are used for better screw fixation to the vertebral corpus. Blades of the staple are placed cranial and caudal surface of vertebral corpus and have a hole in the center which permits passage of screws.

**Nuts:** Two kinds of nuts are available. Telescopic nuts are used in connecting rods to open hooks and to Peduncle screws. Common nuts are designed to fix the closed hooks.

**Transverse Connecting Device:** TCD is used in fixation of two rods that are placed on both sides of the vertebral column. Application of TCDs to a pair of rod creates a fixed rectangular structure which provides tremendous stability to the implant, and diffuses any stress concentrated on one point, to avoid loosening.

## INDICATIONS of ALICI SPINAL SYSTEM

**Idiopathic scoliosis:** Scoliosis is a deformity of the vertebral column in frontal, sagital and axial planes. During the evolution of scoliotic curve while the apical vertebra displaces laterally and rotates, it also displaces anteriorly. This movement of apical vertebra in sagital plane is more evident in small curves and appears as thoracic or thoracolumbar lordosis (fig. 4). With the increase in scoliotic curvature, apical vertebra is pulled back, thus first a flat back and then with more increase in the curvature, a kyphosis develops. Changes in apical vertebra position is due to ongoing changes in frontal and axial plane of the spine (fig. 5). By distraction of end segments of the curve, derotation of middle segment and elevation of concave laminae a three dimensional plane correction of the deformity is achieved.

ALICI spinal system is designed to achieve three dimensional correction of spinal deformities. Due to the difficulty in correcting structural lumbar and thoracolumbar curves by posterior instrumentation, anterior correction and fusion may be necessary.

Planning for a right thoracic curve should be done as follows: Fusion should extend from upper neutral vertebra to one bellow the lower end vertebra. Following subperiostal dissection, spinal processes are excised. Places for hooks on concave side of the curve are chosen and prepared. A closed Peduncle hook is inserted on the concave side Peduncle of upper neutral vertebra. Lamina and transverse process of the lower adjacent vertebra should be decorticated before placing the hook. Two vertebra above and below the apical vertebra are instrumented with open Peduncle hook and open lamina hook respectively. Again before placing open Peduncle hook lamina and transverse processes of adjacent vertebrae should be decorticated. Lower hook is a closed laminar hook and it is inserted to the lamina of the vertebra one below the lower neutral vertebra while mounted on the rod, thus entrance should be prepared wider than others (fig 6). Rod is bent approximately 30° over its entire length after all hooks are placed. Bending should be done within one centimeter intervals and any high angulations should be avoided so that the rod is bent evenly. On a carefully bent rod one can move nuts easily. For each open hook two telescopic nuts and for each closed hook a common nut are necessary. Thus on a concave side rod; a common nut, two pairs of telescopic nuts facing each other, another common nut and a closed laminar hook are mounted in descending order (fig. 7). The tip of the rod is inserted into the upper closed peduncle hook and the rod is laid into two open peduncle hooks. Premounted closed lamina hook is slipped into widely prepared area over the lamina. Distraction is applied to intermediate vertebrae by means of turning the telescopic nuts away from each other. Once enough distraction is obtained between intermediate hooks then distraction is carried on between upper and lower closed hooks. After the initial distraction procedure the rod is held with a rod holder and derotated towards concavity. Derotation converts frontal plane curve to physiologic thoracic kyphosis i.e. sagital plane curve and elevates concave laminae. Even at this stage of the procedure a considerable amount of three dimensional correction of the deformity is achieved (fig. 8). To lock the hooks, telescopic nuts are screwed towards each other. Some more distraction is applied to end nuts and the procedure on the concave side is completed. Convex side rod assembly is as follows: A closed Peduncle hook to the facet joint and a closed laminar hook to the transverse process of upper neutral vertebra is placed facing each other. Two open laminar hooks are placed facing each other to the transverse processes of the vertebrae one above and one below the apical vertebra. A rod of appropriate length is bend giving a small curve on proximal part. Then a common nut, two pairs of telescopic nuts a closed laminar hook facing proximally and a common nut are mounted on the rod in descending order. Rod is then passed

through closed Peduncle hook and facing closed laminar hook and secured by a common nut mounted on the tip of the rod, thus neutral vertebra is fixed on convex side. Rod is placed into two open intermediate hooks and distal closed laminar hook is placed under the lamina. A compression is applied by turning the nuts of end hooks towards each other. Once compression is made at desired level, all of the nuts are tightened to secure the hooks (fig. 9). System is strengthened with the application of two transverse connecting devices at upper and lower ends of the rods. Necessity of an arthrodesis should be remembered for good results.

If the curve is a right thoracic and left lumbar double curve and lumbar curve is flexible but small then lower closed hooks are replaced with open hooks.

At the lower neutral vertebra of lumbar curve, compression is made on convex side and distraction on concave side by loading closed laminar hooks in appropriate manner. Rod should be long enough to cover entire curvature and a thoracic kyphosis and a lumbar lordosis should be given to the rod by bending accordingly (fig. 10). Rod is placed as described above.

**Anterior correction of structural scoliotic deformities by ALICI spinal instruments:**

Axial plane deformity is predominant in the structural lumbar curves. Thus, it is not generally possible to handle these deformities by posterior instrumentation. This is why CD group started to use transpedicular screws instead of hooks in this region. The best way of correction is by anterior instrumentation. Lumbar vertebrae are exposed from the convex side by a retroperitoneal aproach or thoracoabdominal incision with excision of 10 th rib. Intervertebral discs including end plates are excised. Staples are placed lateral to corpus vertebrae in a manner so that in apical region where there is more rotation screws are placed more posterior on the corpus, and in end vertebrae screws are placed neutral or even anterior on the corpus. This arrangement of the screws would ease derotation of the spine, since rotation is more at the apex. Rod is bent approximately 30° and telescopic nuts are mounted on the rod. Lower and upper end nuts are screwed towards each other causing a compression on the system thus a considerable correction obtained (fig. 12). Rod is derotated towards concavity so that 30° curve faces dorsally thus, a lateral curvature becomes a physiologic lumbar lordosis. The 30° bent rod and lumbar vertebrae on lateral view appears straight when viewed from anterior. After derotation maneuver nuts are tightened and chips of bone grafts are placed to the disc spaces and wound is closed (fig. 13).

**Correction and stabilization of Scheuermann kyphosis with ALICI spinal system:**

After a standard subperiostal dissection is done and deformity is fully exposed, spinal processes are excised. Two appropriate length rod is bent to 30° which is physiologic thoracic kyphosis and the deformity will be reduced to 30° at the end of the intervention. Three proximal and three distal closed laminar hooks with their common nuts at their back are mounted on prebend rod (fig. 14). Same preparation is done for controlateral side also. Proximal hooks are placed to transverse processes, leaving apical vertebra and one above uninstrumented. Then central distal hook is placed under the laminae of adjacent vertebrae do not pose any correction after placing all hooks in their places (fig. 15). Same procedure is done for controlateral side also. Transverse connecting devices are mounted between the rods proximally and distally, and arthrodesis is done (fig. 16).

**Reduction and stabilization of vertebral fractures, fracture-dislocations and dislocations:**

Indications for reduction and stabilization of vertebral fractures are as follows:

a) fractures and/or dislocations with neurologic deficit

b) fracture dislocations

c) fractures that cause more than 50 % loss in anterior corpus height

d) burst fractures

e) fractures that obliterate the canal with free bone fragments

f) middle column fractures in Denis classification.

Fractures that involve single vertebra below 11 th thoracic vertebra can be reduced and stabilized with transpedicular screws.

After fracture site being exposed, fractured vertebra is determined. Vertebrae one above and one below are instrumented by four transpedicular screws that are directed postero-anterior and 20° latero-medial (fig. 17) Procedure should be done under fluoroscope if and when necessary. A pair of 10 cm rod is smoothly bent and fixed to the screws by telescopic nuts. Distraction is made by turning the screws away from each other to obtain a desired reduction. Application of transverse connecting devices between the rods, increases rotational stability (fig. 18).

Multisegmented fractures and fractures above the 11th thoracic vertebra may be reduced and stabilized by instrumenting laminae and peduncles.

A subperiostal exposure is done to expose two vertebrae above and below the fractured vertebra. Spinal processes are excised and laminae of the two vertebrae below the fracture site are prepared to receive laminar hooks (fig. 19).

Four open peduncle hooks are placed to facet joints of the vertebra two above the fractured vertebra. Two rods appropriate length are taken and two closed laminar hooks are mounted on the rods with their nuts at their backs. A pair of telescopic nuts facing each other are placed to the proximal end of the rods. First, distal hooks are placed into the prepared places on the laminae. Rods then are placed into the open peduncle hooks one after the other (fig. 20) and are fixed by telescopic nuts. Screwing nuts away from each other causes distraction which achieves reduction. Transverse connecting devices are placed to increase the stability of the system. Procedure is terminated by doing posterior arthrodesis (fig. 21).

In burst fractures or when the reduction of bone fragments cannot be achieved by posterior instrumentation, anterior decompression may be necessary. Anterior reduction and stabilization can be done as a second stage procedure. Following anterior corporectomy staples and then screws are placed to the verberae one above and below the fractured vertebra (fig. 22). Telescopic nuts are mounted on the rod and fixed to screws. Following desired distraction nuts are tightened. Interspace is filled with bone graft. Some technique can be applicable to the pathological fractures (fig. 23).

**Reduction and stabilization of Spondylolisthesis with ALICI spinal system :**

Two different techniques are used in reduction of spondylolisis and spondylolisthesis :

**a)** Lumbosacral region is exposed by standard subperiostal exposure and spinal processes are excised. Slipped vertebra and one above and ybelow are instrumented by transpedicular screws. If the slipped vertebra is 5th lumbar then screws are placed to 4th, 5th lubar and first sacral vertebrae; if the slipped vertebra is 4th lumbar then screws are placed to third, 4th and 5th lubar vertebrae. An appropriate length rod is then bent to gain a lumbar lordosis. Telescopic unts are mounted on the rod. After rod is being placed into the screws, telescopic nuts are screwed in. Though telescopic nuts at both ends easily fit in the screws, screws belonging to the slipped vertebra lies below the level of the rod. With the aid of a rod introducer rod is pushed into the screw thus reducing the slipped vertebra. Rod is secured in the screws by tightening telescopic nuts. Since sacral screws should hold anterior cortex, their exact length should be measured by a depth-gauge thus an exact screw is instrumented. Transverse connecting devices are applied after arthrodesis is done (fig. 24, 25, 26).

**b)** Special spondylolisthesis instrument, Sacral hooks are placed to sacral alae after the exposure of lumbosacral region. According to the slipped vertebra laminar hook is placed to the lamina second or third vertebra. Screw stoppers are mounted on the rod and aligned with the slepped vertebra. Partial reduction is obtained after distraction. Peduncles of the slipped vertebra are insturmented by spongious screws through the hole of the screw stopper which slowly reduces the slipped vertebra by pulling it posteriorly. Arthrodesis is done following the reduction (fig. 28, 29).

## REFERENCES

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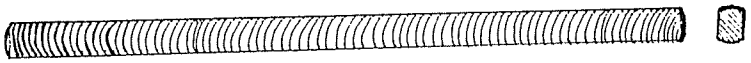
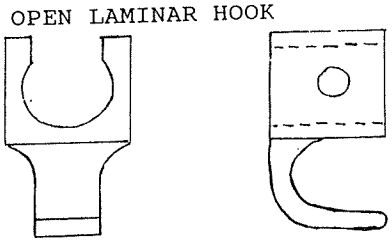
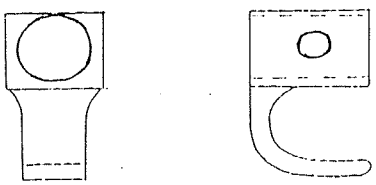
Figure 1
ROD



OPEN LAMINAR HOOK



CLOSED LAMINAR HOOK



CLOSED PEDUNCLE HOOK

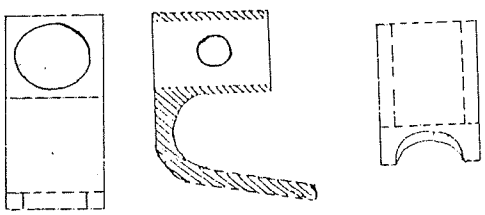
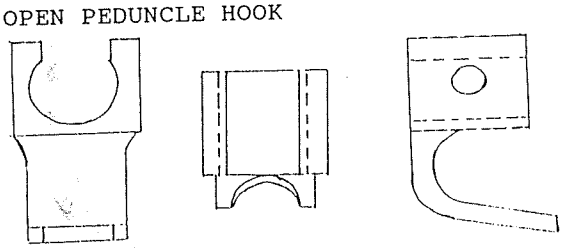
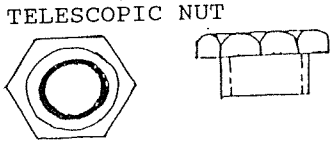


Figure 2

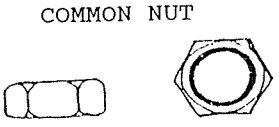
OPEN PEDUNCLE HOOK



TELESCOPIC NUT



COMMON NUT



TRANSVERSE CONNECTING DEVICE

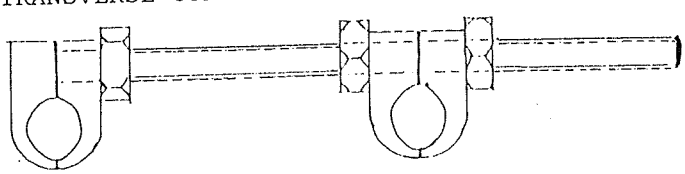


Figure 3 Rod Screw and Staple

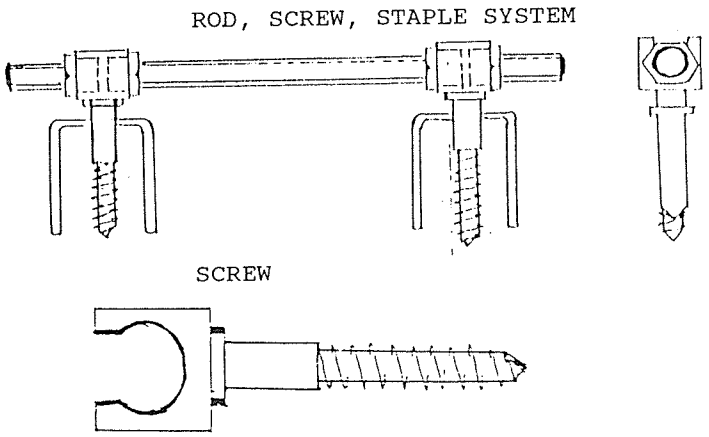



Figure 4 Postural appearance of the spine due to the changes in the apical vertebra

A. Thoracolombar lordosis
B. Flat Back
C. Kyphosis

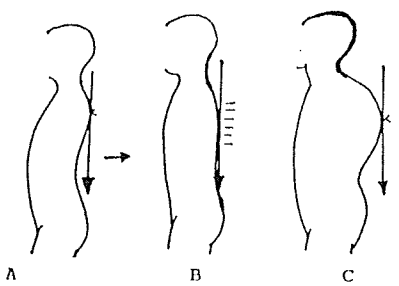
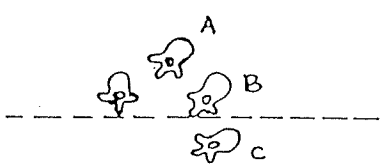
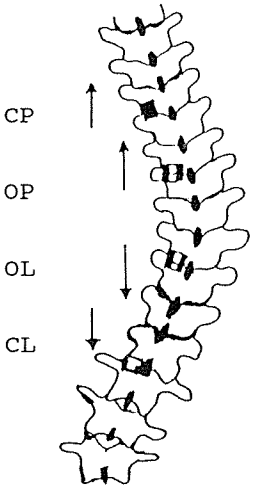



Figure 5 Position of the apical vertebra in scoliosis




A. Thoracolombar lordosis
B. Flat Back
C. Kyphosis

Figure 6 Types and places of hooks placed to the concave side of right thoracic scoliosis




CP=Closed Peduncle Hook

OP= Open Peduncle Hook

OL= Open Laminar Hook

CL= Closed Laminar Hook

Figure 7 The order of nuts mounted on a bent rod

Common nut
A Pair of Telescopic nuts
A Pair of Telescopic nuts
Common nut
Closed Laminar Hook

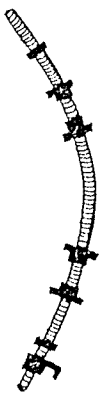
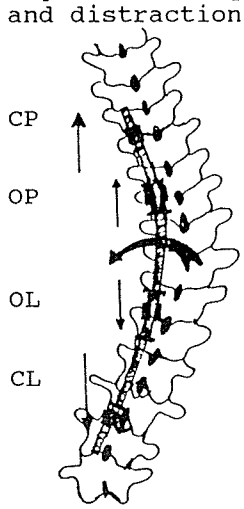


Figure 8 The placement of the rod on concave side, derotation and distraction



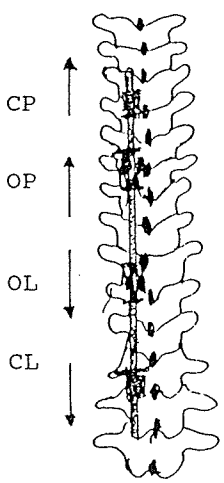



Figure 9 Types and places of convex side hooks in a right thoracic scoliosis; placement of convex side rod and attachment of TCDs

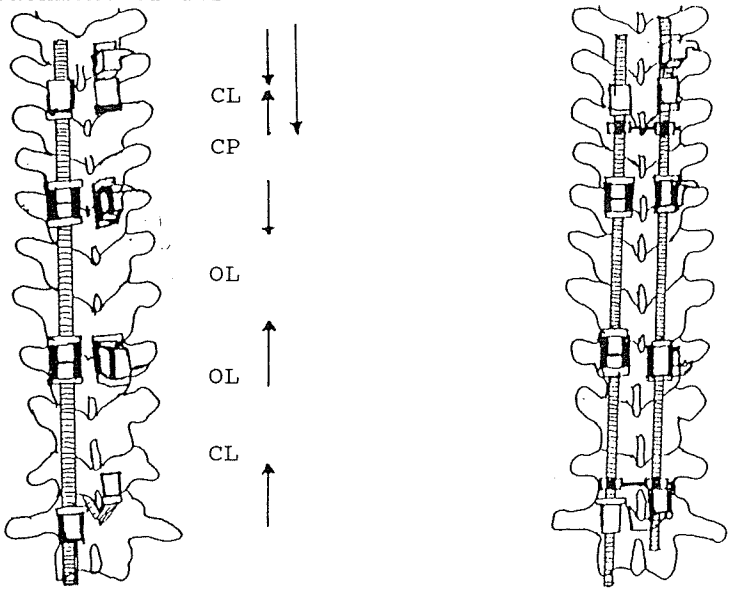



Figure 10 Correction and stabilization of a right thoracic, left lumbar double curve

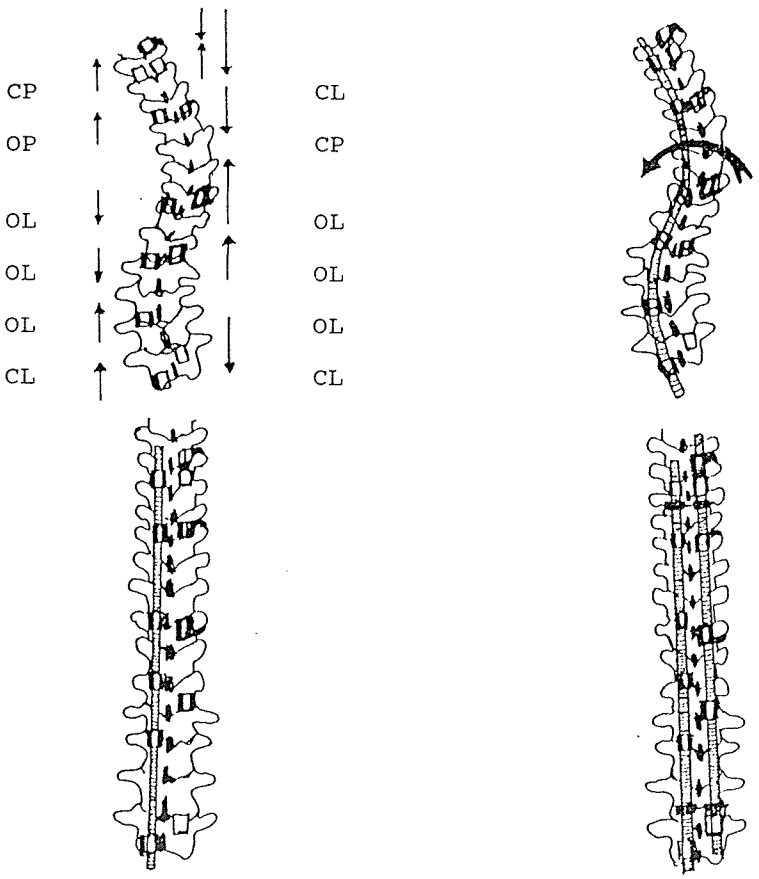


Figure 11 Placement of staples and screws on a lumbar or thoracolumbar curve after intervertebral discs being excised is illustrated. Note that the rod is bent and nuts are mounted

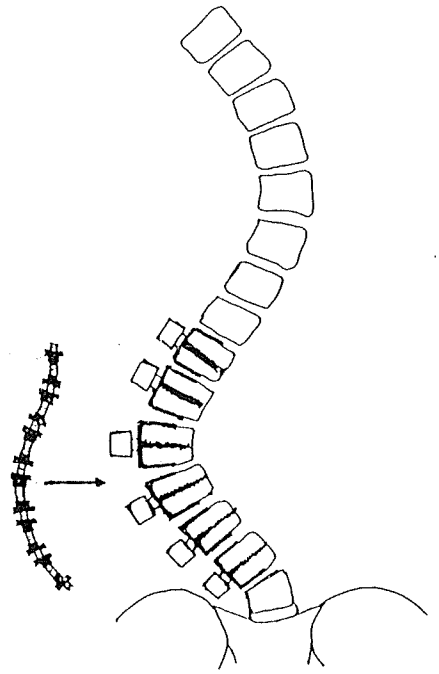


Figure 12 Convex side nuts are tightened to achieve a compression. After partial correction is obtained rod is derotated to turn lateral curve into a lumbar lordosis.

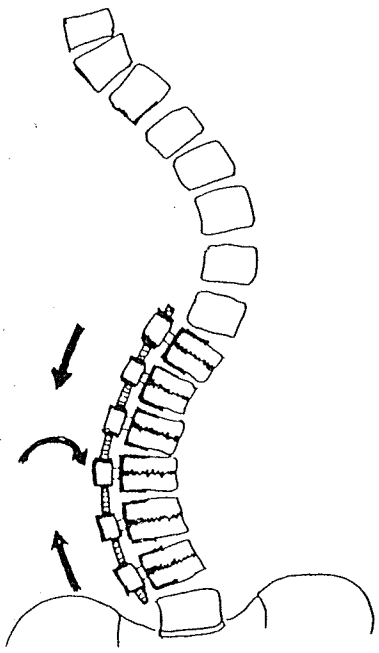


Figure 13

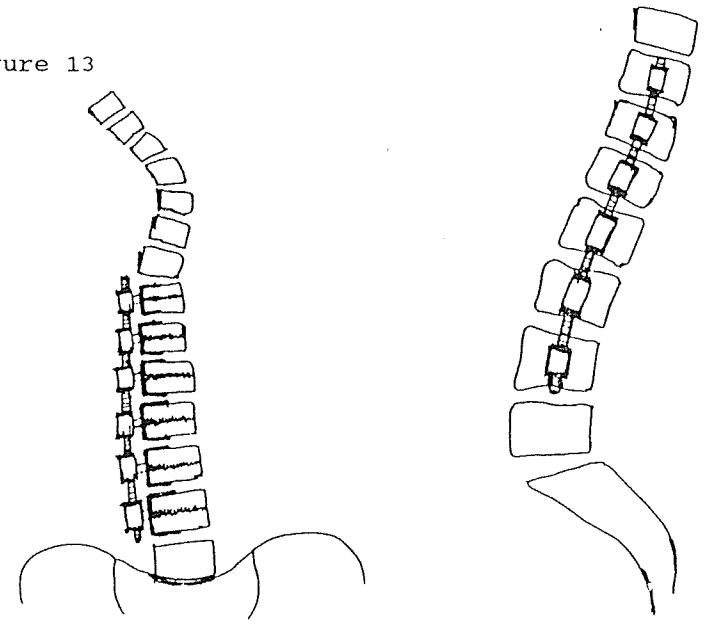


Figure 14 Scheuermann kyphosis is corrected by instrumenting upper three transverse processes and lower three laminae leaving apical three vertebrae uninstrumented by a rod bent approximately 30°

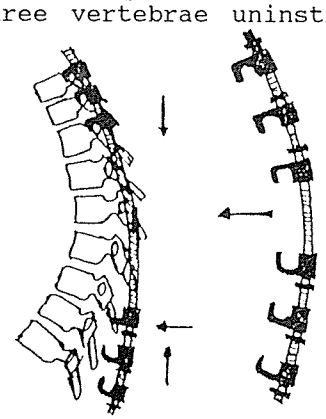


Figure 15 Compression is made to correct the curve

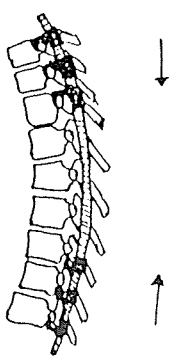


Figure 16 Rods are placed bilaterally, Transverse connecting devices are applied and stabilization is achieved. Arthrodesis is done

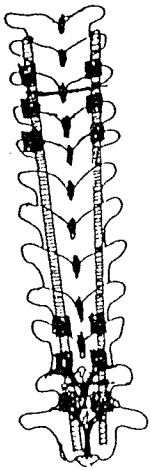


Figure 17

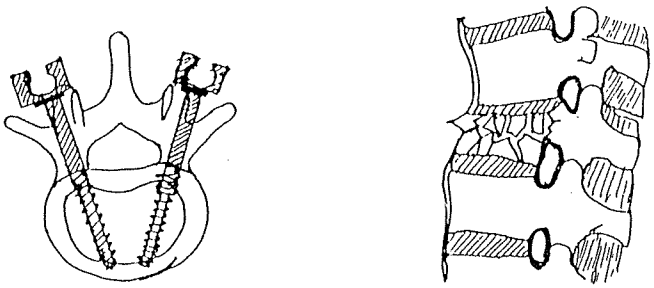


Figure 18

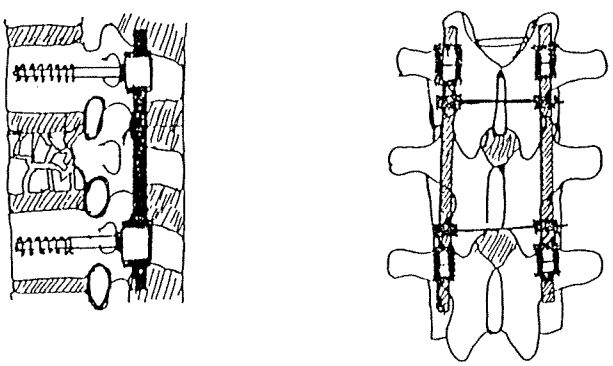


Figure 19 Hook placement in a multisegmented fracture or a fracture above the 11th thoracic vertebra

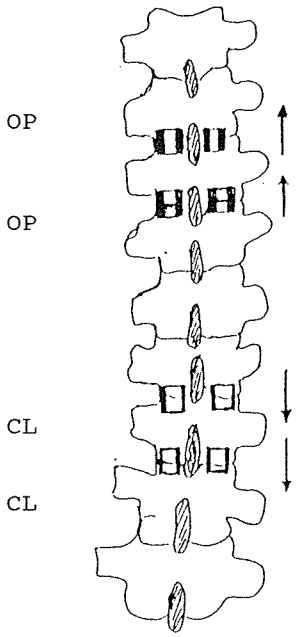



Figure 20 Fixation of rods over the hooks and the spine

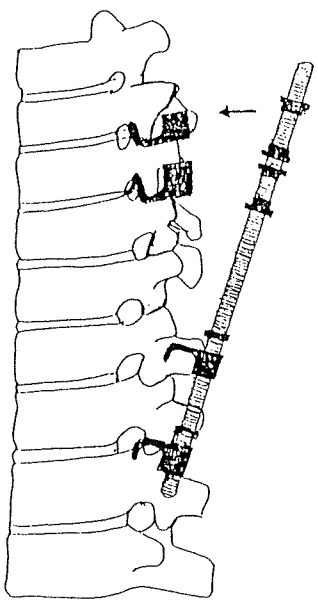


Figure 21 Stabilization of a multisegmental fracture or a fracture above 11th thoracic vertebra

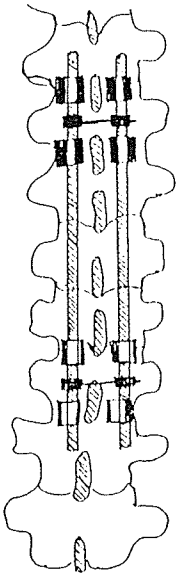


Figure 22 Anterior reduction and stabilization in burst fractures

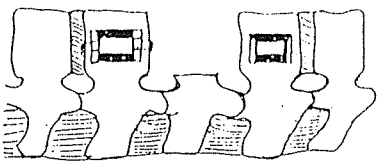


Figure 23 Anterior grafting and fusion

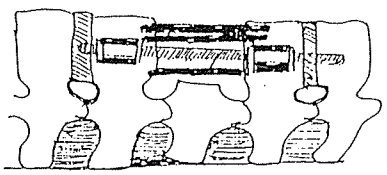


Figure 24 Reduction and stabilization in spondylolisthesis by transpedicular screws and rods

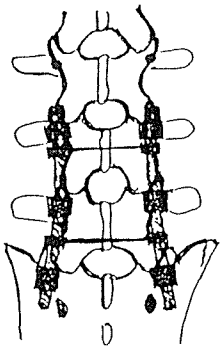


Figure 25 Distraction and reduction with ALICI rods and screws

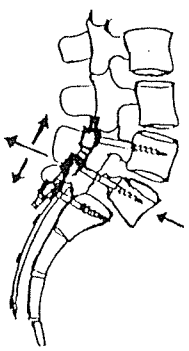


Figure 26 Reduction and stabilization of spondylolisthesis is achieved

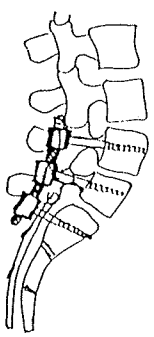


Figure 27 ALICI Spondylolisthesis instruments
1. Rod
2. Upper Laminar Hook
3. Lower Sacral Alar Hook
4. Piece for the screw
5. Nut

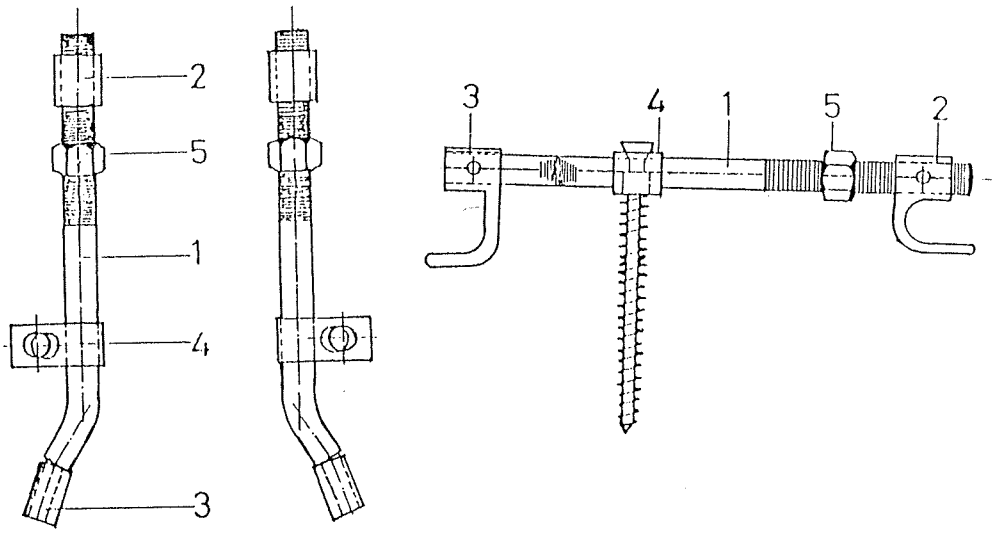



Figure 28 Application of ALICI Spondylolisthesis Instruments