# COMPARISON OF SHORT SEGMENT TRANSPEDICULAR SCREWS AND LONG SEGMENT HOOK APPLICATIONS WITH RESPECT TO STABILISATION, CORRECTION AND INDIRECT CANAL DECOMPRESSION ABILITIES IN THE TREATMENT OF BURST FRACTURES OF LUMBAR VERTEBRAE

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***ABSTRACT :***

*The purpose of this study is, to investigate and to compare the interrelation between stabilisation achievement, correction ability, indirect medullary decompression and indirect medullary decompression achievement in cases of lumbar burst (L1, L2, L2) fractures treated with short segment transpedicular screw fixation (SSTS) and long segment hook applications (LSH).*

*Patients were divided into two groups. In Group 1, there were 17 patients who were treated with Short Segment Transpedicular Screw (SSTS) and in Group 2 there were 27 patients treated with Long Segment Hook (LSH) applications. Distribution of lesion levels in Group 1–SSTS and Group 2–LSH were L1: 6-17, L2: 5-8, and L3: 6-2, respectively. Mean follow-up in Group 1-SSTS and Group 2-LSH were 40 months (not less then 30 months) and 46 months (not less than 12 months), respectively. Mean age was 31.6 in Group 1-SSTS and was 33,8, in Group 2-LSH. In both groups stabilisation was performed by Alıcı Spinal System.*

*Cases were evaluated according to their loss of anterior vertebral height, anterior compression angle and local kyphyosis angle in plain radiographs (preoperatively, postoperatively and follow-up) and medullary encroachment in preoperative and postoperative CAT–scans.*

*Therefore, we conclude that: (1) Alıcı Spinal System and posterior instrumentation is sufficient in stabilisation and restoration of lumbar burst fracture. (2) In posterior instrumentation of lumbar burst fractures Group 1-SSTS and Group 2–LSH have no superiority to each other. (3) Also, medullary decompression and stabilisation abilities of Group 1-SSTS and Group 2-LSH have no superiority to each other. (4) Although performance of medullary decompression decreases with the delay of operation, statistically we haven't seen significant difference, in both groups. (5) It is very important to verify the status of posterior longitudinal ligament by MRI prior to indirect canal decompression. (6) There was no significant difference between two groups with respect to complications. (7) There was no difference between two methods in order to give permission early mobilisation, (8) Both methods have equal capability of returning daily activity and previous work. Also, pain in the follow-up didn't show difference in both groups.*

***Key words:*** *Lumbar Vertebrae, Burst Fracture, Short Segment Pedicular Screw, Long Segment Hook, Stabilisation, Correction, Indirect Canal Decompression.*

## INTRODUCTION

There are actually many controversies in the treatment of burst fractures of vertebrae. These are mainly as follows; stability of burst fracture, role of conservative treatment in such fractures, choice of surgery (anterior, posterior or combined), choice of instrument and application technique, necessity of decompression, way of its application (directly or indirectly) and correlation of surgical timing and achievement of medullary decompression.

The purpose of his study is, to investigate and to compare the interrelation between stabilisation achievement, correction ability, indirect medullary decompression achievement in cases of lumbar burst (L1, L2, L3) fractures treated with short segment

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transpedicular screw fixation and long segment hook application.

## MATERIAL AND METHODS

One-hundred twenty three patients having unstable thoraco-lumbar vertebrae fractures were stabilised surgically by means of Alıcı Spinal System through posterior approach at the 1st Department of Orthopaedics and Traumatology, İzmir Atatürk Education Hospital, between February 1990 and December 1995. Forty-four patients who had burst fractures at the levels of L1, L2 and L3 were divided into two groups according to instrumentation types applied and also, those cases were followed (not less then 12 months) prospectively.

Short Segment Transpedicular Screws (Group 1-SSTS) and Long Segment Hook (Group 2-LSH) applications are shown in Table 1, in details.

**Table 1.** Details of the Cases

| | Group 1 SSTS | Group 2 LSH |
|---|---|---|
| Number of patients | 17 | 27 |
| Mean follow-up | 40 (54-30) months | 46 (72-12) months |
| Sex distribution | | |
| male | 12 | 16 |
| female | 5 | 11 |
| Mean Ages | 31.6 (17-62) years | 33.8 (16-65) years |
| Aetiology | | |
| Fall from height | 10 | 16 |
| Vehicular accident | 5 | 10 |
| Crush under heavy substance | 2 | 1 |
| Additional lesions | 5 | 11 |

While, additional lesions were 5 Group 1-SSTS on the other hand, this amount was 11 Group 2-LSH. Distribution of additional lesions were 1 tibia fracture, 1 calcaneus fracture, 1 mandible fracture, 1 clavicle fracture and 1 malleoli-talus fracture in Group 1-SSTS. Group 2-LSH 1 cranio-cerebral trauma, 1 intra-abdominal haemorrhage, 1 distal radius fracture, 1 radial head fracture, 1 humerus fracture, 1 ischium - pubis fracture, 2 calcaneus fractures, 1 metatarsi fracture, 1 malleoli tibia fracture and 1 calcaneus + tibia fractures were additional lesions (Table 1).

Levels of burst fractures, distribution of Denis classification (17), mean time between injury and operation, the interval between injury to operation, mean operation time and mean mobilisation time are summarised in Table 2.

Neurologic evaluation was based on Frankel's classification (28) (Table 3).

### Surgical Technique:

Surgical intervention was applied via posterior approach in both groups.

In Group 1-SSTS, Alıcı Transpedicular Screws were bilaterally applied to superior and inferior neighbouring of burst fractured vertebra Gradual distraction was achieved by means of incorporated rods bilaterally and finally two transverse rods were applied in order to complete frame grafts configuration (Fig. 1). In this Group, only 3 cases were undergone short fusions with iliac bone grafts.

In Group 2-LSH, Alıcı Pedicular (superior) or Alıcı Laminar (inferiorly) Hooks were applied one or in some situations two upper or lower vertebrae with respect to fractured vertebra. Gradual distraction was achieved by means of incorporated rods bilaterally and also transverse tension rods were added (Fig. 2). Only 6 patients were undergone short fusions in this group. Claw hooks weren't applied in both groups.

In all cases lumbo-sacral corsets were used as an external support during mobilisation. Rehabilitation program was started immediately at the 1st post-operative day in-patients with neurodeficits. Mean time of postoperative hospitalisation was 9.7 days in both groups. At the end of 3rd month external corset support was discarded in all cases and without excessive flexion motion was permitted.

### Radiological Technique:

Computerised Axial Tomography (CAT) interventions of all cases were performed with Hitachi w 950 S.R., GE C.T. Max 640 and Toshiba T.C.T. 600 S CT scanners. Spinal canal window of fractured

**Table 2.** Features of fractures and operation technique in-patients with burst fractures.

| | Group 1–SSTS | Group 2–LSH |
|---|---|---|
| Levels of burst fractures | | |
| L1 | 6 | 17 |
| L2 | 5 | 8 |
| L3 | 6 | 2 |
| Distribution of Denis Classification | | |
| Type A | 4 | 6 |
| Type B | 12 | 18 |
| Type C | – | – |
| Type D | – | 1 |
| Type E | 1 | 2 |
| Mean time injury to operation | 4.8 days (12 hours–13 days) | 6.6 days (8 hours–28 days) |
| The interval between injury to operation | | |
| 24 hours | 4 (23.5%) | 3 (11%) |
| 25-96 hours | 4 (23.5%) | 10 (37%) |
| After 96 hours | 9 (53%) | 14 (52%) |
| Mean operation time | 2.3 hours (1.5-3 hours) | 2.6 hours (2-3.2 hours) |
| Fusion with iliac grafts | 3 | 6 |
| Mean postoperative hospitalisation | 9.7 days (4-20 days) | 9.7 days (2-23 days) |
| Mean mobilisation time (in-patient without neurodeficit) | 2.5 days | 2.9 days |

vertebra taken at the level of window and as 80+35/1800+150 Hounsfield unit. While 4-5 mm. thickness of slices is preferred at the level of fractured vertebra during preoperative period, 2-mm thickness of slices were obtained during postoperative period. Percent of medullary encroachment were calculated with respect to Hashimato's method (34).

**Method of Statistical Evaluation:**

All data belonging to Group 1-SSTS (17 cases) and Group 2-LSH (27 cases) were recorded by using excel program. Then, statistical analysis was performed by means of SPSS statistics program. Analysis was achieved by using Mann Whitney U, Wilcoxon to tailed sample test and correlation test.

At the final follow-up all cases were evaluated in accordance with Denis' and Work Scale (Table 4-5).

**Table 3.** Distribution of patients' neurologic situations (28) in preoperative and follow-up periods.

| | Group 1–SSTS | | | Group 2–LSH | | |
|---|---|---|---|---|---|---|
| | Preoperative | Transitions | Follow-up | Preoperative | Transitions | Follow-up |
| | A2 | 2 | 2A | A2 | 2 | 2A |
| | B3 | 2 | 2B | B4 | 1, 1 | 1B |
| | C0 | 1 | 1C | C2 | 1, 1, 1, 1 | 2C |
| | D0 | | 0D | D1 | 1 | 2D |
| | E12 | 12 | 12E | E18 | 18 | 20E |
| Total | 17 | | 17 | 27 | | 27 |

**Table 4.** Denis pain scale (17) and distribution of patients.

| Denis' Pain Scale | Group 1–SSTS | Group 2–LSH |
|---|---|---|
| P1: No pain | 15 (88%) | 24 (89%) |
| P2: Occasional, mild pain. No analgesics | 1 (6%) | 2 (7%) |
| P3: Moderate pain: occasional analgesics; no prevention of daily work and activities | 1 (6%) | 1 (4%) |
| P4: Moderate or severe pain: sometimes interrupting working activity; affecting daily activity | — | — |
| P5: Constant severe pain; chronic analgesic ingestion | — | — |

**Table 5.** Denis's work scale (17) and distribution of patients

| Denis' Work Scale | Group 1–SSTS | Group 2–LSH |
|---|---|---|
| W1: Return to previous heavy work or regain physical activity | 9 (53%) | 14 (52%) |
| W2: Return to previous sedentary work or limited activity in performing previous heavy work | 4 (23%) | 5 (19%) |
| W3: Unable to return previous work full day activity in a new occupation | 2 (12%) | 3 (11%) |
| W4: Unable to return full day occupation | 1 (6%) | 3 (11%) |
| W5: Unable to work | 1 (6%) | 2 (7%) |

Anterior compression (%), anterior vertebral angle, lateral Cobb's angle and medullary encroachment were calculated in both Groups preoperatively, postoperatively and at the final follow-up. These are summarised in Table 6.

**Table 6a.** Mean amount of radiological criteria in the preoperative at the follow-up.

| Radiologic Evaluation | Group 1–SSTS | | | Group 2–LSH | | |
|---|---|---|---|---|---|---|
| | Preop | Postop | Follow–up | Preop | Postop | Follow–up |
| anterior colon compression (%) | 44 | 11.7 | 21 | 46.6 | 12.5 | 16 |
| anterior vertebral angle | 23.2 | 8.5 | 11.1 | 21.8 | 6.5 | 10.8 |
| lateral Cobb's angle | 7.6 | −1.4 | 1.2 | 14 | 5.1 | 7.3 |
| medullary encroachment (%) | 46.3 | 21.2 | — | 46.4 | 21.2 | — |

**Table 6b.** Mean difference (delta) of radiologic criteria in pre–operative and post–operative and follow–up in both groups.

| Radiologic Evaluation | Group 1–SSTS | | Group 2–LSH | |
|---|---|---|---|---|
| | Preop-Postop | Postop–Follow–up | Preop–Postop | Postop–Follow–up |
| anterior colon compression (%) | 27 | 4 | 34.1 | 3.5 |
| anterior vertebral angle | 14.7 | 2.6 | 15.3 | 4.3 |
| lateral Cobb's angle | 9 | 2.6 | 8.9 | 7.3 |
| medullary encroachment (%) | 25.1 | — | 25.2 | — |

**Table 7.** Calculation of Medullary Encroachment (%) in the pre and postoperative periods according to Timing of Operation in both Groups.

| Timing of operation | Medullary Encroachment (%) | | | | | |
|---|---|---|---|---|---|---|
| | Group 1–SSTS | | | Group 2–LSH | | |
| | Preop % | Postop % | Follow–up % | Preop % | Postop % | Follow–up % |
| before 24 hours | 43.7 | 16.2 | 27.5 | 56.6 | 28.3 | 28.3 |
| 25-94 hours | 47.2 | 22.0 | 25.2 | 43.9 | 20.0 | 23.9 |
| After 96 hours | 47.1 | 23.2 | 23.9 | 46.5 | 22.7 | 23.8 |

Worsening of neurodeficits haven't been observed in any cases in both groups.

In Group 1–SSTS improper placement of 1 screw (1.5%), inadequate tightening of 1 telescopically nut and fracture of processus transversalis and bleeding of vena vertebralis due to erroneous preparation of pedicle in one case. Bleeding was prevented by means of spongel and bone wax. There were two infections in the postoperative period (1 superficial and 1 deep). While we were able to treat superficial infection with antibiotics, deep infection was treated with debridement and extraction of instruments in the 9th post–operative month sterile sinus syndrome was an another complication in 1 patient. Urinary tract infection was an event in 2 paraplegic patients. Non-union wasn't encountered in any patient. Loosening of 3 screws (4.6%). Plastic deformation of 2 screws (3.1%). Breakage of 1 screw (1.5%) and Loosening of 1 telescopic nut were the remaining complications in this group.

In Group 2–LSH pedicular fracture due to erroneous placement of pedicular hook in 1 case, tear of dura during laminar preparation in 2 case and straight back due to erroneous shapening of rods in 1 case were intra–operative complications. Sterile sinus syndrome is 1 case, urinary tract infection in 1 case. Dislocation of 2 pedicular hooks (3.7%) in 1 case, dislocation of 1 laminar hook (1.8%) and loosening of 2 telescopically nuts in 2 cases were postoperative complications.

According to Mann–Whitney U test there was no statistically significant differences between two groups with respect to complications (z= 1.302, p= 0.3029).

In Group 1–SSTS (17 cases) and in Group 2–LSH (27 cases), lateral Cobb's angle, anterior vertebral angle, anterior compression height (%) and medullary encroachment (%) were calculated and differences of these values pre and postoperatively (Delta value) were documented. Then, using Mann–Whitney U test we compared both groups. According to this, lateral Cobb's angle (z= –0.6409, p= 0.5216). Anterior vertebral angle (z= –0.3257, p= 0.7446) and medullary encroachment (%) (z= 0.6647, p= 0.5064) haven't shown any statistically significant differences. On the other hand, anterior compression (%) showed significant difference between two groups according to Mann–Whitney U test (z= –2.0084, p= 0.0446). With respect to this parameter Long Segment Hook application was more successful than Short Segment Transpedicular Screws in correction of deformity.

Also, Group 1–SSTS and Group 2–LSH were evaluated with respect to injury to operation time. Parameters were lateral Cobb's angle, anterior vertebral angle, correction of anterior compression (%) and medullary decompression (%). Correlation test was used for this purpose (Table 9). But, we haven't been able to obtain meaningful values.

According to Denis' Pain Scale (17), in Group 1–SSTS 15 cases (88%) were P1, 1 case (6%) was P2 and 1 case was (6%) P3. In Group 2–LSH, 24 cases were (89%) P1, 2 cases (7%) were P2 and 1 case (4%) was P3. There was significant difference between two groups (z= 0.0875, p= 0.9303).

**Table 8.** Results pre–operative and post–operative radiologic values according to Wilcoxon to tailed sample test.

| Radiologic Measurements | Group 1–SSTS | Group 2–LSH |
|---|---|---|
| anterior colon compression (%) | z= –3.5162<br>p= 0.0004 | z= –4.4573<br>p= 0.0000 |
| anterior vertebral angle | z= –3.5162<br>p= 0.0004 | z= –4.4446<br>p= 0.0000 |
| lateral Cobb's angle | z= –3.6214<br>p= 0.0003 | z= –4.4446<br>p= 0.0000 |
| medullary encroachment (%) | z= –3.6214<br>p= 0.0003 | z= –4.5407<br>p= 0.000 |

**Table 9.** Postoperative radiologic correlation test data of the cases.

| Injury to Operation Time | local Cobb's angle | anterior compression angle (delta) | correction of anterior colon (delta) | restoration of medullary canal encroachment (delta) |
|---|---|---|---|---|
| Group 1 SSTS | r= 0.1260 (17) p= 0.630 | r= 0.1382 (17) p= 0.597 | r= –0.3477 (17) p= 0.171 | r= –0.0517 (17) p= 0.884 |
| Group LSH | r= –0.0686 (27) p= 0.734 | r= –0.1827 (27) p= 0.362 | r= –0.1534 (27) p= 0.445 | r= 0.0589 (27) p= 0.770 |

According to Denis Work Scale (17) distribution of cases were as follows: In Group 1–SSTS, 9 cases (53%) were W1, 4 cases (23%) were W2, 2 cases (12%) were W3, 1 case (6%) was W4 and 1 case (6%) was W5. In Group 2–LSH 14 cases (52%) were W1, 5 cases (19%) were W2, 3 cases (11%) were W3 and 3 cases (11%) were W4 and 2 cases (7%) were W5. Comparison with Mann–Whitney U test both groups haven't shown any significance (z= 0.2620, p= 0.7933).

## DISCUSSION

Challenge in management and choice of surgical methods in the treatment of spine fractures still keep its actuality.

There are 5 stager in the treatment of spine fractures: (1) Immobilisation, (2) Medical stabilisation, (3) Spinal direction (alignment), (4) Decompression of spinal canal, (5) Spinal stabilisation. While, 5 stages remains constant main controversy persist in the choice of treatment modality.

Maximum neurologic function, reduction of fracture and dislocation and restoration of painless stable spine constitute aims of treatment (11). In order to fulfil their aim number of segments (11, 55). Also, performed method had the capability of minimal complication and neurodeficite development rate (32). In addition, low cost, short time of hospitalisation, shortening of postoperative, immobilisation and return to previous function and work capacity should be compared (32).

In the treatment of vertebrae burst fracture anterior or posterior approaches are other challenging problems (6, 11, 23, 40, 56). Some studies have shown that anterior and posterior approaches have no superiority to each other in order to achieve recovery of incomplete neurodeficits (11, 25). Although, anterior interventions have the capability of affective spinal canal decompression it has technical difficulties and risks when compared with posterior approaches (11). Some authors stated that any of their methods were inadequate and so two procedures must be combined (11, 60). Although, it has individual indications and some limitations, we believe that posterior approaches are adequate in, stabilisation and decompression of medullary encroachment. Therefore we prefer posterior stabilisation in the treatment of burst fractures.

Decompression in order to achive canal decompress can be performed directly or indirectly (6, 23, 24, 56). In addition, some authors believe that bone fragments in the medullary canal are reportable so decompression (12, 15, 26, 38, 54). Direct decompression it possible via anterior and posterior approaches (11, 32, 40, 56). Anterior decompression offers clear vision and direct decompression (6, 8, 14, 20, 31, 47, 48, 57, 62). Also, it is possible to perform decompression directly or indirectly via posterior approaches (6, 23, 56).

In situations of intact posterior longitudinal ligament, it is suggested that fragments in the spinal canal will decompress by means of ligamentotaxis (9, 21, 22, 27, 29, 33, 38). In case of for of posterior longitudinal ligament it is impossible to perform indirect decompression (3, 38). Timing of operation is an another important factor in achieving ligamentotaxis, the first 48 or 96 hours are accepted as golden period for this purpose (1, 5, 33, 35, 53). Studies have shown that indirect decompression is impossible in cases whose operations delayed more than 96 hours (7, 22, 29, 39, 41, 59, 61). We applied posterior approach and indirect decompression with instrumentation. In all 44 patients we researched the relationship between timing of operation and performance of medullary canal decompression. In addition, we compared two different stabilisation systems.

We used Alıcı Spinal System as an instrument for this purpose. Biomechanical studies confirmed mechanical strength of this system (2, 36, 37, 50). Alıcı spinal system in posterior stabilisation may be used with hooks and transpedicular screws or combination of both. We compared with thoracal vertebrae having, lumbar vertebrae had different biomechanics and anatomy. Although, authors who applied successful results with long instruments in lumber region (19, 30, 45). An et al (4) and Sasso et al. (49) avoid long instrumentation in this region. According to An et al (4) loss of lumbar lordosis due to long instrumentation and immobilisation of a long segment can become a pain-inducing factor. In addition, cartilage degeneration in this region due to immobilisation is an another pain factor (4). Some authors, support short segment screw fixation because of its capability of lesser-immobilised vertebrae (5, 10, 13, 18, 42). Screw method in addition, some authors emphasised reduction loss and screw problems in this type of fixation (43, 46).

The purpose of this study is to find out answers of following questions:

(1) Is posterior approach and fixation adequate in the treatment of lumbar burst fractures.

(2) Whether short segment transpedicular screws or long segment hooks are suitable in instrumentation of lumbar burst fractures.

(3) In order to achieve better correction and perform indirect canal decompression of lumbar burst fractures, what is the best choice? SSTS or LSH.

(4) Is there any relationship between timing of operation and indirect canal decompression in both groups.

(5) Is there any difference between two methods, in the aspect of complication rates.

(6) Is there any superiority of two methods to each other in the aspect of pain in the late follow-up, return to daily activity and previous work.

To find out answers to above questions all data, radiological values and follow-up results were transferred to computer and evaluated by using SPSS statistics program. When two groups compared with each other according to mean whiting in test there was no significant difference with respect to sex distribution, age and mean follow-up time. On the other hand, level of fractured vertebrae were significantly different (z= -2.5026, p= 0.0123). However, because of close similarity between upper lumbar vertebrae (L1, L2 and L3) (53), we reflected this difference as it might not affect the results. There weren't significant difference between two groups in the aspect of Denis' burst fracture subgroups (17). In our cases the most common type was as in the literature. There were no significant statistical differences between two groups. In the aspect of radiological evaluation also, medullary encroachment (%) hasn't shown difference in the pre and postoperative periods.

In both groups, lateral Cobb's angle, anterior colon compression height (%), anterior vertebral angle and medullary encroachment (%) in CT were evaluated and compared with "Delta" Mann-Whitney U test, in preoperative and postoperative periods. Lateral Cobb's angle, anterior vertebral angle and medullary encroachments (%) in CT haven't shows significant differences in both groups. But, anterior colon compression height % was restored more successfully in Group 2-LSH when compared with Group 1-SSTS also, in the follow-up radiological criteria other than anterior vertebral angle shown stabilisation insufficient loss. But, less of anterior vertebral angle was statistically significant in Groups 2-LSH. Although, there are studies cancelling approval-added mag of two methods, but we haven't been able to identify a study such as ours, which evaluated two systems in the some study and in the save region.

As a result, we decided that instrumentation have adequately capable of stabilisation.

Although, it has been shown that indirect spinal canal decompression (Delta) decreases with the delay of operations but this is not statistically significant. Intact posterior longitudinal ligament is essential in order to achieve indirect canal decompression.

In addition, in the lower lumbar region ligamentotaxis effect is not strong enough. In out stud, we tried to perform indirect canal decompression without evaluation of posterior longitudinal ligament neither with MRI nor with naked eye during operation. Also we didn't consider preoperative amount of medullary encroachment (%). This factor may be responsible of statistically insufficient results.

There were no recovery in-patients with complete neurodeficits in both groups. Recoveries of incomplete lesions were more successful in Group 2– LSH, than Group 1–SSTS. Although, this results is statistically meaningful indirect canal decompression performance was similar in both groups, so this difference is thought to have been incidental.

We both haven't seen any difference between two groups when compared with respect to pain during follow–up return to daily activity any previous work according to Denis (17). As we mentioned previously although there wasn't any study including both groups, our results showed similarity with the literature when each group evaluated individuallly.

Evaluations of complications haven't shown significant difference between two groups. Malposition of screws, fracture of pediculae, loosening of screws and breakage of screws are the most common screw complications (16, 43, 58). However pedicular fractures and dislocation of hooks are also common for hook applications (52). Although, we have never had neurodeficit due to malposition of screws or hooks, loosening of screws, breakage and malposition of screw and dislocation of hooks in our series have close similarity with the literature (16, 58). Claw hooks will be a good solution for insufficieny of both screws and hooks. In addition especially in patients having poor bone quality, bone cement and screws may be combined (63).

## CONCLUSIONS

(1) We decided that, Alıcı Spinal System and posterior instrumentation is sufficient in stabilisation and restoration of lumbar burst fracture.

(2) In posterior instrumentation of lumbar burst fractures Group 1–SSTS and Group 2–LSHA have no superiority to each other.

(3) Also, medullary decompression and stabilisation abilities of Group 1–SSTS and Group 2–LSHA have no superiority to each other.

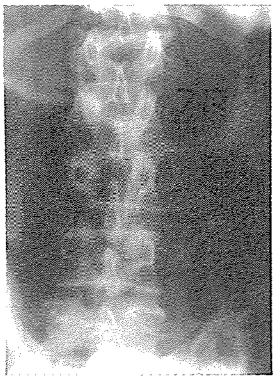
(4) Although performance of medullary decompression decreases with the delay of operation, statistically we haven't seen significant difference, in both groups.

(5) It is very important to verify the status of posterior longitudinal ligament by MRI prior to indirect canal decompression.

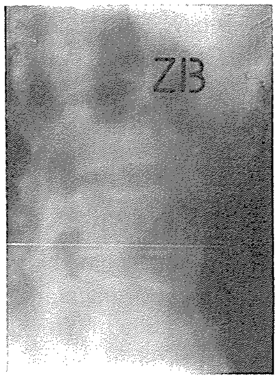
(6) There was no significant difference between two groups with respect to complications.

(7) There was no difference between two methods in order to give permission early mobilisation.

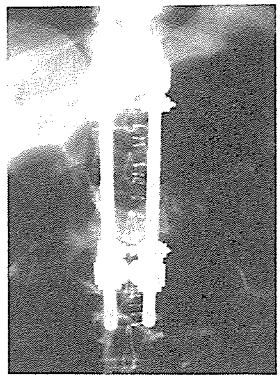
(8) Both methods have equal capability of returning daily activity and previous work. Also, pain in the follow–up didn't show difference in both groups.



Preoperative AP




Preoperative Lateral



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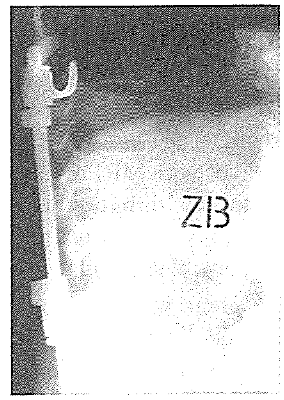


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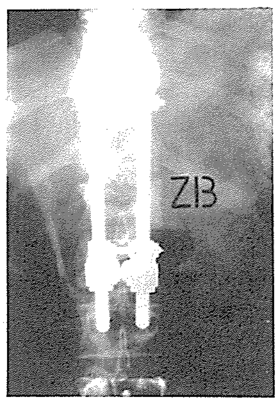
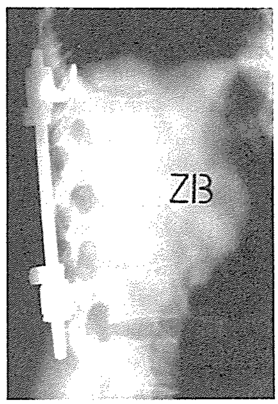
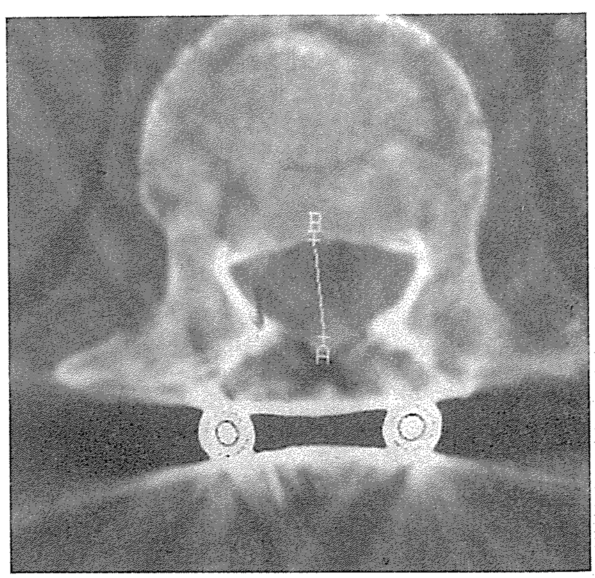



Follow-up AP
Postoperative 18th month



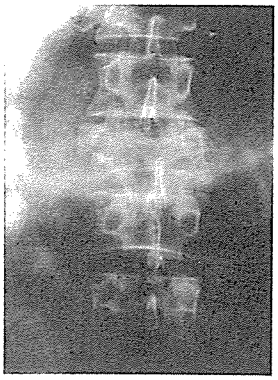

Follow-up Lateral
Postoperative 18th month

Preoperative CAT

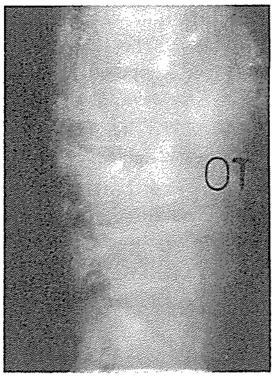


Postoperative CAT

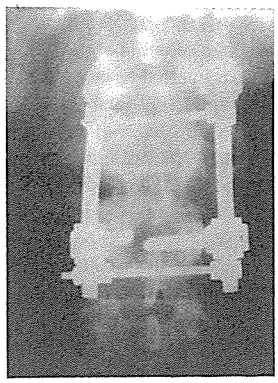
**Figure 1.** Long Segment Hook Applications



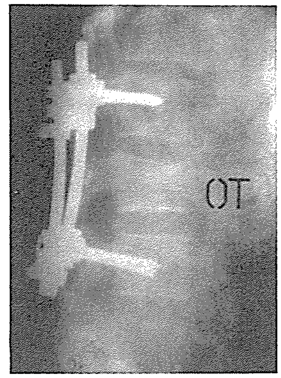
Preoperative AP



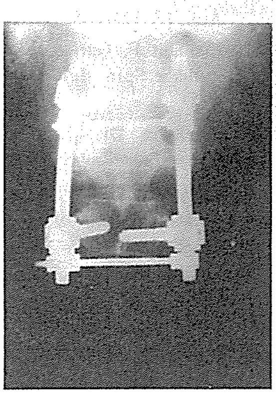

Preoperative Lateral



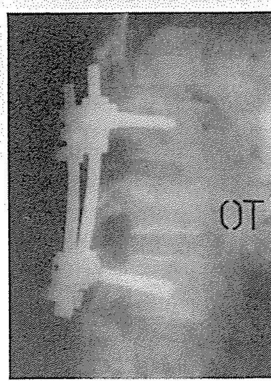
Postoperative AP



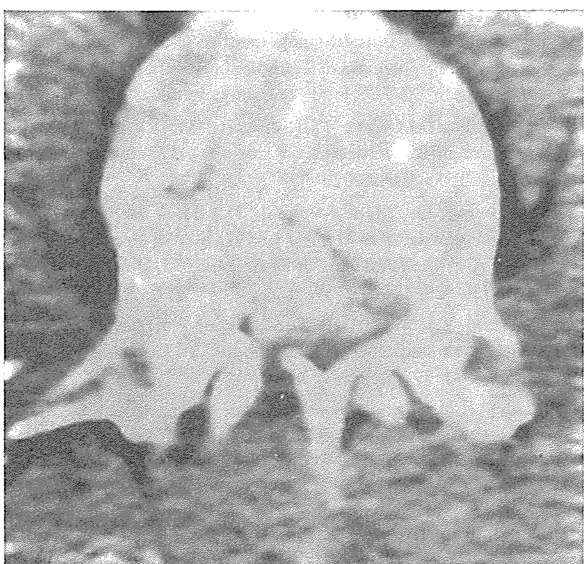

Postoperative Lateral



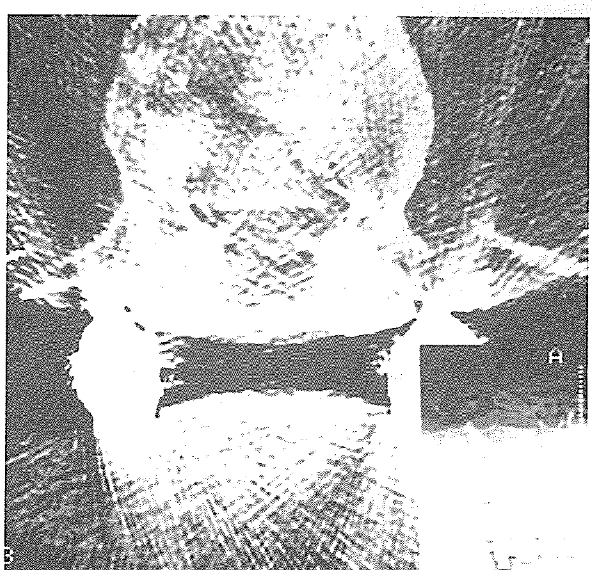
Follow–up AP
Postoperative 9th month




Follow–up Lateral
Postoperative 9th month



Preoperative CAT




Postoperative CAT

**Figure 2.** Short Segment Transpedicular Screw Application

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