Anterior Interbody Fusion in Fracture and Fracture-Dislocation of Spine

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=국문초록=

척추의 불안정골절 및 골절성 탈구에 대한 전방추체 유합술

가톨릭의과대학 정형외과학교실

문명상 · 김 인 · 우영균 · 이장정

척추 손상중 척추의 불안정 골절은 손상된 척추분절의 불안정성과 신경손상의 높은 발생률로 동통, 기형, 신경증세악화 등 여러가지 문제를 갖고 있어, 그 치료에도 많은 방법이 발표된 바 있으나, 어느 것이 가장 좋은지에 대하여 아직 알려져 있지 않으며, 서로 의견을 달리하고 있는 실정이다. 어떤 저자들은 불안정 골절은 골절부의 자연유합을 통해 안정성을 얻을 수 있다고 하였지만, 이 자연유합이 모든 예에서 이루워지지 않으며, 자연유합이 이루워지더라도 비교적 오랜 시간이 걸린다는 것은 잘 알려진 사실이다.

저자들은 1975년부터 1979년까지 5년간 가톨릭의과대학 정형외과학교실에서 전방추체유합술을 시행하여 척추의 불안정골절 및 골절성 탈구 환자 38예를 치료, 추적 관찰한 결과 다음과 같은 결론을 얻었다.

1. 수상부위는 경추 10예, 흉요추부 23예 그리고 요추 5예이었으며, 손상기전을 살펴보면 굴곡회전에 의한 것이 38예의 환자중 21예(55%)를 차지하였다.
2. 38예의 환자중 20예에서 신경손상이 있었는데, 불완전 신경마비 8예, 그리고 완전 신경마비 12예 이었으며, 이중 13예에 대하여는 전방추체유합술에 앞서 관혈적 정복 및 후궁절제술을 시행하였다. 신경손상의 회복 정도는 불완전마비 8예중 예에서 운동력 회복이 있었을 뿐이었다.
3. 수술 후 완전한 골유합이 이루워질 때까지 골유합 부위로 이루워지는 척추후만각의 증가는 경추1.9°, 흉요추부 3°, 요추 7°이었으며 척추간극의 감소는 경추 1.8mm, 흉요추부 1.6mm 그리고 요추 2.1mm 이었다.
4. 임상적 골유합은 경추 8주, 흉요추부 12주, 요추 16주이 었으며, 방사선학적 골유합은 경추 10주, 흉요추부 21주, 요추 25주 이었으며, 신경증상의 유무가 골유합시기에 영향을 미치지는 않았다.
5. 38예 환자중 2예에서 수술적 술기의 잘못으로 유합부전이 있었다.

이상의 결과로 미루워 보아 전방추체유합술은 척추의 불안정골절 및 탈구의 치료에 있어서 척추의 안정성을 효과적으로 얻을 수 있고, 금속내 고정없이 조기활동을 할 수 있으며, 후에 생길 수 있는 기형방지에 좋은 방법이라고 생각되어, 저자들이 설정한 골유합의 판정 기준과 함께 발표하는 바이다.

Key Words: Traumatic unstable spine, Anterior interbody fusion, Time of union

INTRODUCTION

The Unstable spine has been characterized by rupture of the anterior or posterior ligaments-osseous complex with segmental instability of the injured part, and a high incidence of neurological damage(Nicoll 1949, Holdsworth and Hardy 1953)[8,13]. The type of treatment for unstable fracture and/or dislocation of the spine, with or without neurological damage, remains controversial. Both

*이 논문은 1981년도 가톨릭 중앙의료원 학술연구비로 이루어진 것임.

conservative and surgical management have been recommended, however, it has not still been established which is the superior method.

Guttmann (1969)[6] opposed surgical stabilization of the spine and advocated conservative therapy including postural reduction.His study found that patients undergoing open reduction and internal fixation showed results no better than those treated by conservative means. In the other hand, although the unstable spine can gain stability through spontaneous interbody fusion, the fact remains that this does takc a longer period of time and it does not occur in all cales. Holdworth (1953,1963)[8,10] also indicated that rehabilitation of the patient may be impaired if the spine is allowed to heal with gross angulation.

He further stated that early open reduction and internal fixation facilitated neurological recovery, made nursing less difficult and improved the ultimate function of the spine.

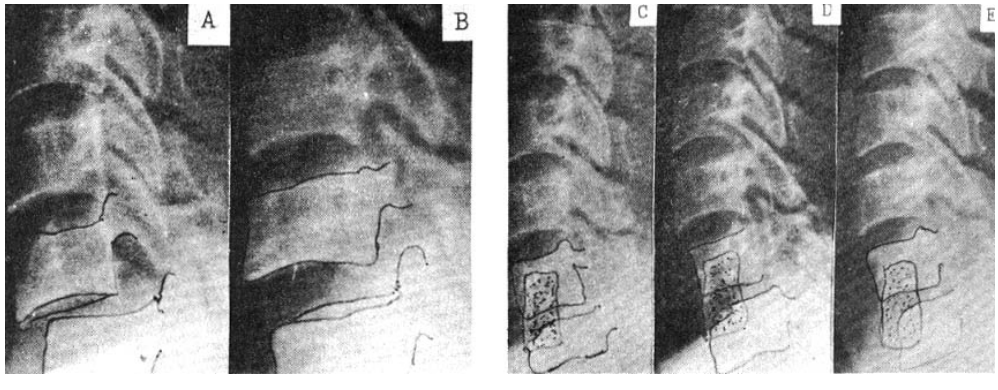
Many methods of internal fixation have been employed, including wire loops, plates (Meuring-Williams plate, Wilson plate), Weiss spring, methyl-methacrylate reinforced with steel mesh,and recently Harrington instrumentation.

The purpose of this paper is to report the results of a retrospective study involving 38 unstablespine patients treated by an anterior inter body fusion, and is to determine the union time in the different level of injury by using our criteria for union.

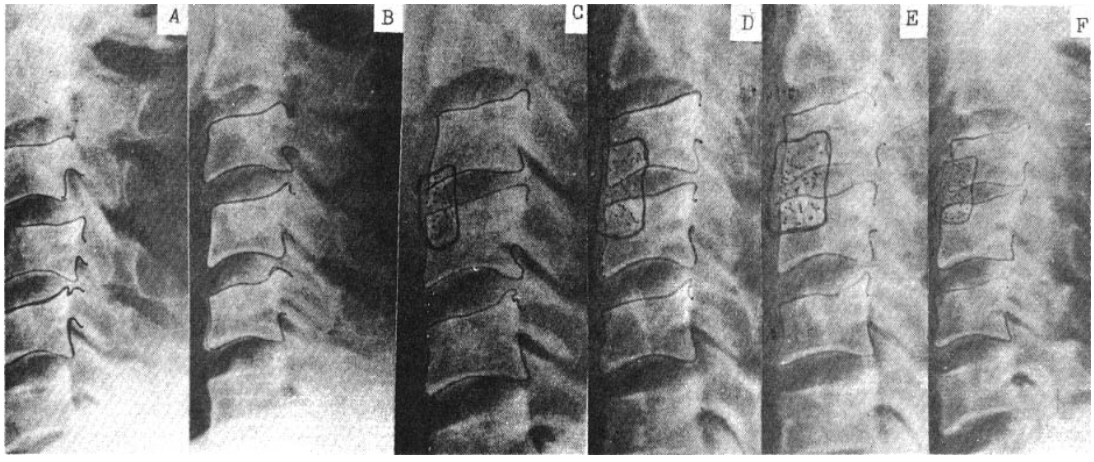
MATERIALS AND METHODS

The hospital records and radiographs of all patients who were treated for unstable fractures, dislocations or fracture-dislocations of spine(without posterior fusion or internal fixation) were reviewed. Three subjects were excluded; one not seen by us until one year following his injury and two lost to follow-up, The remaining subject group totalled 38 between 1975 and 1979.

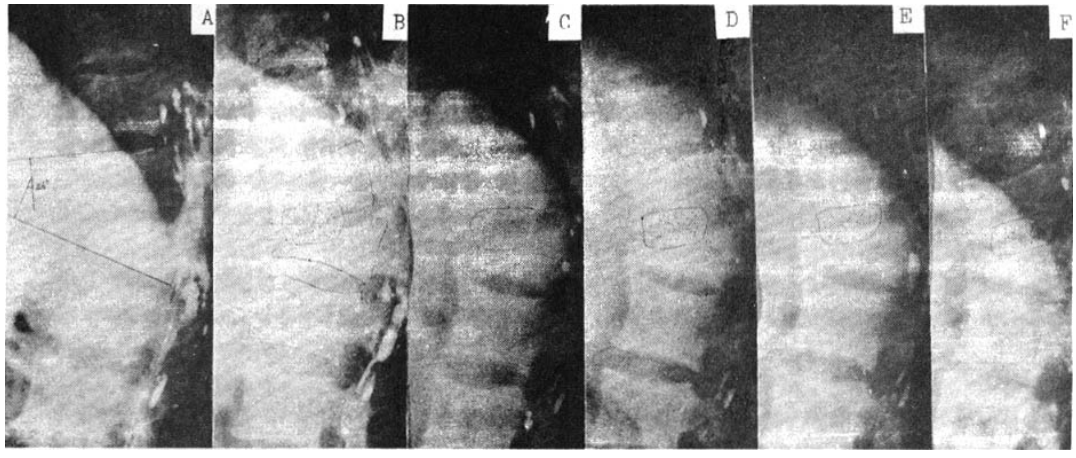
All patients were male with one exception. Age at the time of injury, ranged from 18 to 52 years with average of 33 years. The majority of patients (79%) were between 20 and 39 years of age.



Figs.1 A-E. A 38 year old man had the complete cord lesion below C7 level as a result of fall from a height. Initial roentgenogram revealed the severe fracture-dislocation of the sixth on seventh cervical vertebra (A). We applied the Crutchfield tong for 8 weeks (B). But, there was still instability in the flexion-extension lateral roengenograms. And we performed the anterior interbody fusion between C6 and C7 (C). The follow-up roentgenograms on 6 weeks and 12 weeks after operaticn revealed good healing process without change of kyphosis angle and disc space height (D,E).



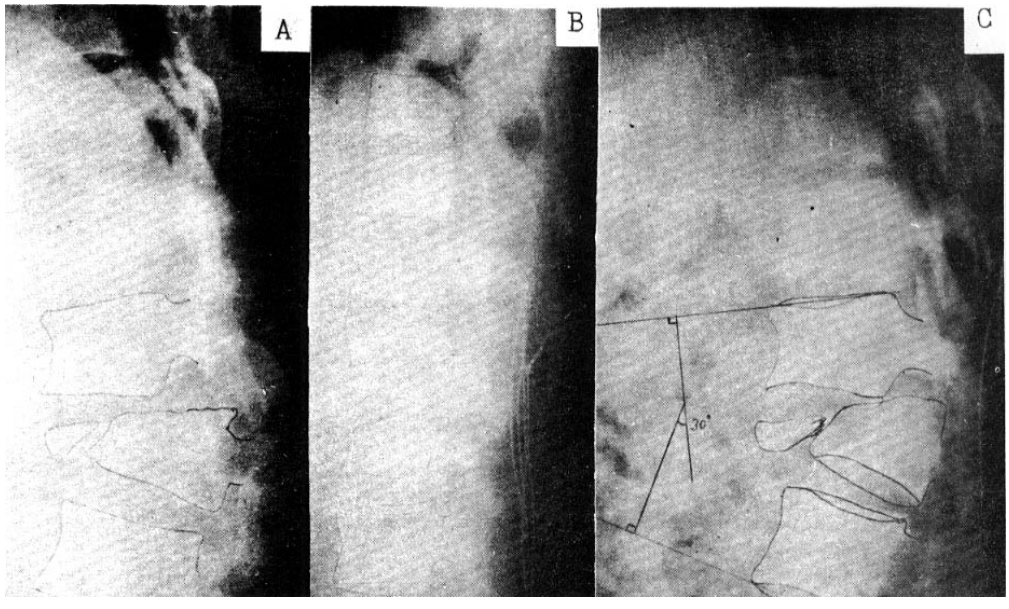
Figs. 2 A-F. A 42 year old man got hurt in the cervical area during football palying. Initial roentgenogram revealed tlhe C3 subluxation on C4 without neurologic (A). And it was reduced with Crutchfield tong traction and maintained for 6 weeks (B). The anterior interbody fusion was done between C3 and C4 (C). The follow-up lateral roentgenograms which were taken at 4 weeks interval postoperatively showed the good alignment and well healed status (D,E,F).



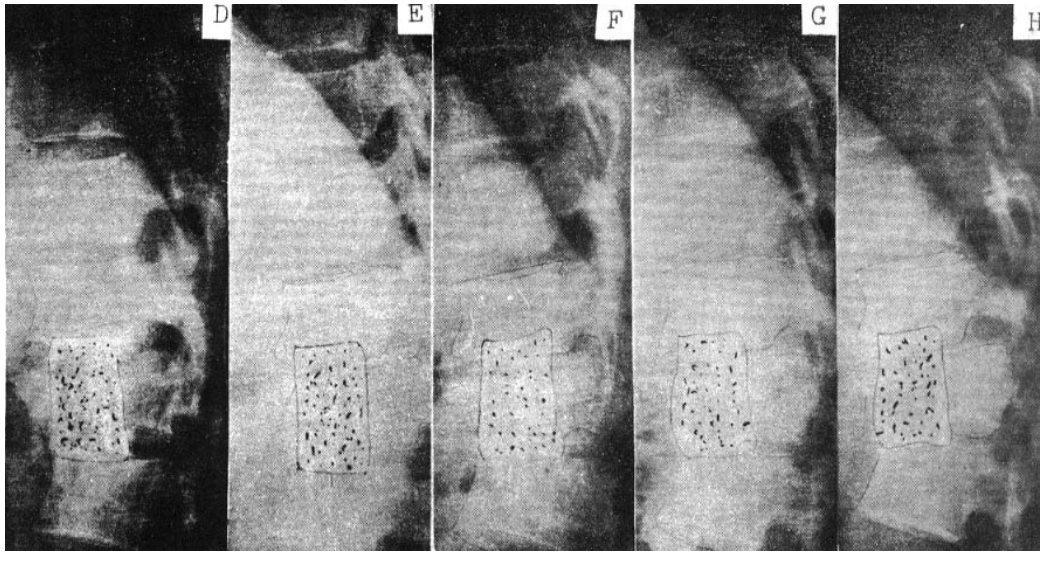
Figs. 3 A-F. A 30 year old man sustained the direct injury on the back by iron plate with incomplete neurologic daage. He visited our hospital 3 months after injury and complained the back pain. Also, it was said that only laminectomy was done at the private neurosurgery cliniic. Initial roentgenogram at our hospital revealed the somewhat unreduced twelfth thoracic fracture-dislocation on the first lumbar vertebra and 26° kyphosis angle (A). The anterior interbody fusion was done between D12 and L1 with restoration of alignment of spinal curve (B). Postoperative follow-up roentgenograms at 4 weeks interval revealed the stout corticocancellous iliac bone graft. There was no angular loss and disc space change postoperatively in this patient (C-F).

The follow-up after anterior interbody fusion ranged from 9 months to 3 years. Twenty patients visited our hospital immediately after injury, but eighteen patients were seen after care at another hospital. It was ranged from 4 days to 11 months(average 105 days).

Six patients among them had their initial treatment including open reduction and/or



Figs. 4 A-C. This patient was 25 year old coal miner. He sustained the injury of the fall of roof in a mine. There was complete cord lesion below D 12 level. Initial roentgenogram revealed the severe fracture- dislocation of the twelfth thoracic vertebra (A). And we performed open reduction and wiring (B). But, the follow-up roentgenogram showed the redisplacement which was probably caused by incorrect surgical technique and wire loosening. The kyphosis angle was 30°(C).

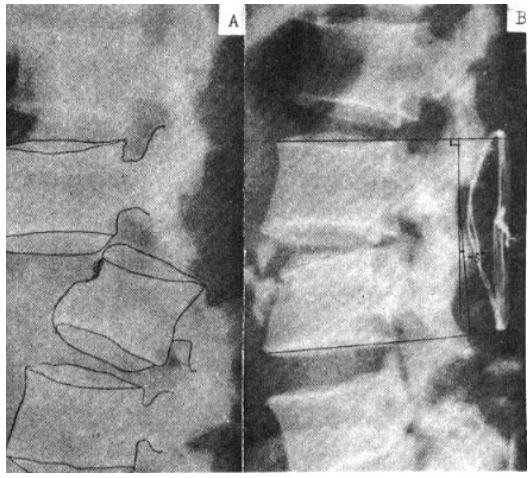


Figs. 4 D-H. The anterior interbody fusion was done between D11 and L1 with use of vertebral spreader. The kyphotic deformity was relatively well corrected (D). There was only 3° of angular loss in the follow-up roentgenogram (E,F). But there was no change of kyphosis angle since 12 weeks postoperatively (G,H). The last one showed the 20° of kyphosis angle.

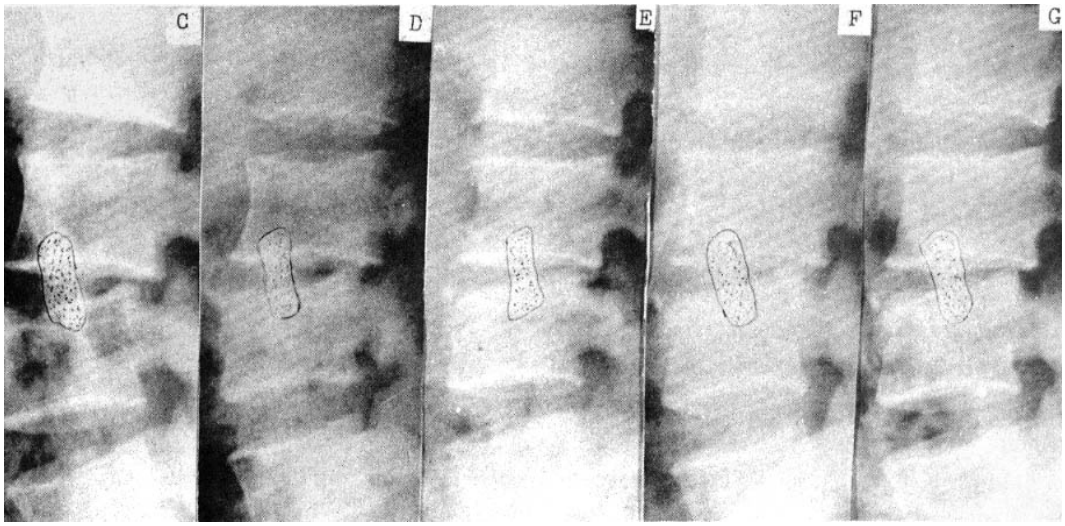
laminectomy at another hospital.

The injury mechanism and stability were determined on the basis of radiologic features and neurological examination. The spinal stability was assessed both in regard to the shape of vertebral body (bone instability), and the alignment of the spinal curves (ligamentous instability)[9,14] The lamina or pedicle fracture below the fouth lumbar vertebra was considered as an unstable fracture even though the mechanism of injury is extension in type (Weitzman, 1971)[19]. The neurologic examination was done as complete as possible. In addition to the observation of sensation, motor power and reflexs, we examined the sensation and reflex state in the sacral and perianal regions[14]. With the clinical examination it is frequently possible to decide whether there is complete cord section or not.

Surgical management: open reduction and/or decompression laminectomy was done in all patients having neurological damage with the exception of seven patients. At the same, time wiring procedure was done for maintenance of reduction (7 complete paralysis, 6 incomplete paralysis). The operation was done early as soon as their general condition permitted. The time of operation ranging from the day of injury to 2 months after injury.



Figs. 5 A-B. A 40 year old man sustained the injury of fall of roof in a mine with complete neurologic damage. The lateral roentgenogram revealed the severe fracture -dislocation of L4 on L5(A) And we immediately performed the open reduction, wiring and laminectomy. The kyphosis angle was minus 5 degrees (B).



Figs. 5 C-G. The anterior interbody fusion was performed 6 weeks after injury (C). The follow-up lateral roentgenograms were taken 8 weeks, 12 weeks, 16 weeks and 20 weeks postoperatively (D-G).

Nine patients underwent surgery within 24 hours of injury, 1 after three days, 2 after 1 month, and 1 after 2 months.

The last 3 patients were operated on following transfer from another hospital.

Stabilization Operation: The anterior interbody fusion was usually done 6 to 8 weeks after injury. Prior to the fusion operation, we assessed the spinal instability in the flexion-extension lateral roentgenogram which revealed the difference of angle more than 10 degrees[15]. All but 9 of patients had a one level fusion. In 14 cases a rib graft was used and an iliac bone graft in 24 cases.

Postoperatively management: After anterior interbody fusion, the patients with no neurological damage were usually kept in bed; for 6 to 10 weeks of head halter traction for those with cervical injuries and 3 or 4 months those with dorsal and lumbar injuries before permitting sitting or ambulation. Now, the patients with neurological damage were kept on a Stryker frame for 3 months regardless of level of injury. Then it was substituted to the conventional hospital bed. The patients were lead to wheel chair ambulation and walking exercise according to the extent of neurologic recovery.

Assessment of results: Result of interbody fusion was assessed by clinical and radiological findings with particular attention to kyphosis angles and intervertebral disc space changes at the fusion site (Table 1).

The kyphosis angle was assessed by intersection line drawn along the superior end plate of superior vertebral body and inferior end plate of inferior one. The lordotic curve was expressed in the minus angles. And mean kyphosis angle on each observation time was assessed at the fusion sites(cervical, dorsolumbar and lumbar).

Table 1. Criteria evaluating the clinical and radiological union

Diagnosis of clinical union
i) No progression of the spinal deformity
ii) Absence of pain at fusion site during motion
iii) No further narrowing of disc space
iv) No further change of kyphosis angle
v) No progression of neurological deficits
Diagnosis of radiological union
i) No evidence of abnormal motion in flexion-extension roentgenogram
ii) Solid bony bridge between fused joints

Also, the disc space change was assessed in the lateral roentgenogram routinely taken with 4 weeks interval postoperatively. The disc height was measured at the midportion of the disc on lateral roentgenogram by use of sliding caliper which could be measurable to 0.05mm.

RESULTS

Eight injuries were caused by automobile accident, 18 by fall, and 12 by heavy shearing blow to the back The site of injury was located in the cervical spine in 10 cases, the thoracolumbar in 23 and the lumbar in 5. In 21 patients the mechanism of injury was of the flexion-rotation type, 7 of pure hyper-flexion, 3 shear, 6 of extension and 1 of axial compression (Table 2).

Twenty of the 38 patients had major neurologic damage. Eight patients had incomple te cord lesion and 12 complete. Among these 20 patients, 4 were injured in the cervical spine, 15 in the thoracolumbar junction (twelfth thoracic-second lumbar vertebra) and 1 in the lumbar spine. According to the type of injury, 13 were due to flexion-rotation type of injury, 2 pure hyper-flexion, 2 shear force,

Table 2. Type of violence and injury level

Type of violence \ Injury level	Cervical	Dorso-lumbar	Lumbar	Total
Pure hyper-flexion		7(2)		7(2)
Extension	4(2)		2	6(2)
Axial compression	1(1)			1(1)
Flexion-rotation	5(1)	14(11)	2(1)	21(13)
Shearing		2(2)	1	3(2)
Total	10(4)	23(15)	5(1)	38(20)

*The parenthesis means the number of neurologic damage.

Table 3. Neurologic damage at each level of injury

Injury level \ Extent	Incomplete	Complete	Total
Cervical	2	2	4
Dorso-lumbar	6	9	15
Lumbar		1	1
Total	8	12	20

2 extension and 1 axial compression (Table 2,3).

There were complete recovery in one patient having anterior cord syndrome at the cervical spine, and 5 patients with cauda equina lesion. But there was only one partial motor recovery out of 12 patients with complete cord lesion.

Usually, those injured at the cervical or lumbar area had no significant kyphosis at the time of injury. But, a relatively severe kyphosis was observed in patients injured at the level of thoracolumbar junction. Twenty-nine patients had a kyphotic angle at the time of admission. The postoperative total increase of kyphosis angle was zero in 5 cases, between zero and 5 degrees in 22, between 5 and 10 degrees in 7 and more than 10 degrees in 2 cases regardless of spinal level.

However, in the other 2 cases there were decrease of kyghosis angle: 4 and 10 degrees after surgery, respectively. Two failure were in the lumbar spine, one in L2-3 fusion and the other L5-S1 fusion. Average angular loss was 1.9 degrees in the cervical spine, 3 degrees in the thoracolumbar junction and 7 degrees in the lumbar spine (Table 4).

Amounts of changes of angle at each observation interval is shown at table 5. There was no change of kyphosis angle after 8 weeks in the cervical, 12 weeks in the thoracolumbar and 16 weeks in the lumbar spine postoperatively. Also, amounts of changes of disc space at the same period revealed that disc space narrowing was not seen after 8 weeks in the cervical, 12 weeks in the thoracolumbar and 16 weeks in the lumbar spine postoperatively.

Under the our criteria clinical union had occured eight weeks in average after fusion operation at the cervical spine, 12 weeks at the dorsolumbar area, and also 16 weeks at the lower lumbar spine (Table 5).

Table 4. Changes of spinal curve in the different level of injury (°)

Injury level	Angle pattern \ Postop. time	Immediate	4 wks	8 wks	12 wks	16 wks	20 wks	T.A.L
Cervical (10)	Lordotic angle (5)	8.5	7.3	6.8	6.8	6.8	6.8	1.7
	Kyphotic angle (5)	7.5	8.6	9.5	9.5	9.5	9.5	2
D-L (23)	Kyphotic angle (23)	24	25	25	27	27	27	3
Lumbar (5)	Lordotic angle (4)	7	5	3	3	0	0	7
	Kyphotic angle (1)	23	27	30	30	30	30	7

*T.A.L means the total angular loss postoperatively. **The parenthesis means the number of patients.

Table 5. Amounts of changes of spinal curve at each observation time

Injury level	Postop. time	Immediate	4 wks	8 wks	12 wks	16 wks	20 wks
Cervical (10)	Kyphotic angle (°)	−0.5	4.5	0.6	3.4	1.4	2.7
	Disc space (mm)	1.4	2.7	1.4	2.7	1.4	2.7
D-L (23)	Kyphotic angle (°)	24	25	25	27	27	27
	Disc space (mm)	7.0	6.2	5.9	5.4	5.4	5.4
Lumbar (5)	Kyphotic angle (°)	−1	1.4	3.6	3.6	6	6
	Disc (mm)	9.1	8.2	7.7	7.3	7.0	7.0

*The parenthesis means the number of patients. **Minus means the lordotic angle.

A solid bony bridge between adjacent vertebral bodies was formed 10 weeks in the cervical, 21 weeks in the thoracolumbar and 25 weeks in the lumbar spine on the A-P and lateral roentgenograms. The was no difference of union time at the fused segment between two groups with or without neurologic impairment (Table 6).

Table. 6. Average union time in each level of spinal injury

Injury level	Time of union (Weeks)					
	Clinical union			Radiological union		
	NP	P	Average	NP	P	Average
Cervical (10)	6	6	6	10	10	10
D-L (23)	12	12	12	20	22	21
Lumbar (5)	14	18	16	26	24	25

**NP: Non-paraplegic patient P:paraplegicpatient

Even after clinical union was obtained, some patients still complained of pain at the fusion site up to 6 months after interbody fusion.

The pain was not due to segmental instability but soft tissue orgin because the radiological study showed no motion at the fusion site and no increase of spinal deformity after solid fusion. Two patients with failure in fusion were not relieved of pain with analgesics which interfered with their normal activity. The posterolateral fusion was performed for these two patients 6 months after anterior interbody fusion.

DISCUSSION

The spinal stability means no progression of the deformity at the fracture site, with or without eventual spontaneous vertebral body fusion, while instability means progressive deformity at the fracture site.

Nicoll suggested that a spontaneous anterior fusion, gives a better functional result than a surgical fusion[13]. In 1953, Holdsworth reported that the final stability of post-traumatic unstable spine is achieved by spontaneous fusion. Lewis and Mckibbin reported that anterior interbody fusion occurred in 67 % of patients treated conservatively, and in 63% of patients treated by plating[12], while Roberts and Curtiss found that a progressive defomity developed in 75 per cent of their patients and that spontaneous fusion occurred in only 8 per cent of those with fracture-dislocation when no attempt was made to reduce the dislocation[15]. Kaufer and Hayes also reported that the incidence of spontaneous anterior fusion was only 14 per cent[11].

There are no common findings which can lead one to anticipate a stability or instability with reasonable certainty. Moreover, although spontaneous anterior fusion can occur, it is not sure to be achieved without

deformity. For these reasons, we thought that anterior surgical fixation of unstable spine is better indicated to prevent late complications-further neurologic deterioration, progressive deformity and pain at the fracture site.

As previously described there are many methods of internal fixation. Several earlier studies have recommended instrumentation with posterior fusion as a first choice in restoring stability and allowing fracture healing in patients with or without neurologic deficit with spinal injuries. These studies indicate that after such treatment, rehabilitation time is shortened.

According to Harrington[2] and Flesch[3] Harrington instrumentation may reduce morbidity and shorten hospitalization. But it is recognized that Harrington instrumentation has some disadvantages in that the operation itself requires a wide exposure and has been known to damage back muscles and ligaments, causes stiff back. Also, if kyphotic deformity is severe, the fixation of Harrington rods is most difficult and can easily fail to stabilize the spine.

Guttmann and Roberts and Curtiss reported a high incidence in failure of fixation (loose bolts, broken plate) and recurrence of deformity when spinal plates were used[15]. Also, it have some technical difficulty. Surgical exposure is very poor in the cervical spine, and the plates are more difficult to use in the thoracic area due to smaller spinous process.

Some said that the spine functions not as one column but as two-one of solid bone,one composed of neural arches[16]. While not primarily weight-bearing, the column of neural arches has great strength and is capable of weight-bearing. And when good stabilization of the posterior column was achieved, spontaneous restoration of anterior stability is likly. Generally speaking, it is well known that liability of the anterior interbody fusion was unlikely to be in presence of posttraumatic posterior instability[2,16,17].

As indicated above, we performed the wiring procedure after open reduction and/or laminectomy in thirteen patients. And the remaining patients kept good alignment in the bed, sometimes with using Crutchfield-tong traction. Intial fusion was not carried out due to the high operative risk, high infection rate for prolonged operation time and avoidance of additional operative trauma.

Rather, we preferred to do anterior interbody fusion in the later stage because it had the advantages of effective stabilization without internal devices and short segment of stabilization resulting in less pseudoarthrosis rate.

Many of the patients in this series underwent an anterior interbody fusion from six to eight weeks after injury. Although it is time consuming to wait over 6 weeks before performing anterior fusion, this delay is beneficial in that it allows time for healing of the ruptured ligaments and muscles surrounding the fracture site as well as increase in circulation which enhances union in the fusion area.

With an anterior interbody fusion, placing the graft bone at the anterior position offers a more effective immediate postoperative stability against the axial rotation and flexion or anterior collapse, because it is placed further away from the respective axis of rotation. Moreover, this procedure can prevent further development of kyphotic deformity and maintain correction[20,21].

There were many methods of assessing re-

sults of anterior fusion. Some relied only on the clinical examination with the patient's own statements about pain and his capacity for work. Another method is the exploration of the operation site at about 6 months after operation[18]. But, we made our criteria for assessment of the fusion which depended upon the clinical examination and radiological changes of kyphosis angle and dise space.

There were only two failures in 38 patients. These two had lesion in the lumbar spine. Although we mobilized the 36 patients using our criteria of clinical union, solid bony fusion was obtained in all without complication (dysphagia, vascular injury, impotence of vertebral body). Some authors[1,12] recommended 12 weeks of bed rest following plating or Harrington instrumentation. Another said that a period of only 6—8 weeks is essential[4]. Also Kaufer and Hayes[11] recommended the early progressive walking with extension cast 2 weeks after operation.

As our resuls indicate, it is said that fracture dislocation in the non-paraplegic dorsolumbar junction heals in a similar way as it is in the paraplegics[4].

There was complete neurologic recovary in 6 out of 20 patients with neurological deficit.

Whether neurological recovary is related to surgical treatment (open reduction plus laminectomy and interbody fusion) or whether it simply reflects the natural tendency of incomplete cord and cauda equina lesion to improve are not clarified. As noted by Guttmann[6], it is believed that the most important determinant of neural recovery is the extent of damage to the neural tissue at the time of injury. In his series further loss of function occurred during closed reduction and postural reduction as well as after secondary by handling. No patient in our series showed any deterioration of neural function during treatment.

SUMMARY

There are many methods of treatment for unstable spine which causes the segmental instability with progressive deformity, neurologic deterioration and pain.

Although anterior interbody fusion was criticized that it was not satisfactory in presence of post-traumatic posterior instability, we performed the anterior interbody fusion in the spine to stabilize the unstable segment 6 to 8weeks after injury. This delayed interbody fusion after injury is tedious but have some advantages; provides sufficient time for healing of injured soft tissue and increases the local circulation enhancing graft union.

There were many methods of assessing the spinal stability after spinal fusion, but we made our criteria for evaluating the clinical and radiological union with particular attention to kyphosis angles and intervertebral disc space changes. This criteria provided informations or data to manage all the patients with traumatic segmental instability of spine.

Under the our criteria clinical union had occured eight weeks in average after fusion operation at the cervical spine, 12 weeks at the dorsolumbar area, and also 16 weeks at the lower lumbar spine. A solid bony bridge between adjacent vertebral bodies was formed 10 weeks in the cervical spine, 21weeks in the thoracolumbar area and 25 weeks in the lumbar spine on the A-P and lateral roentgenograms. Only two failures in fusion out of 38 patients were encountered, and they were due to unsuccessful operative technique.

Through this study anterior interbody fu-

sion was found to provide effective stabilization, relatively early mobilization without internal fixation and to prevent late deformity.

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