THE COMPARISON OF THE FUSION RATE IN ANTERIOR INTERBODY FUSION BETWEEN NONINFECTIOUS AND INFECTIOUS DISEASES OF THE SPINE

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Three hundred and twenty six cases with spinal diseases (209 noninfectious and 117 infectious) were treated by anterior interbody fusion.

Preoperative plain radiography was done and the periodic plain radiography was performed every three month postoperatively until fusion was completed. Post operative tomogram was done at 6 months in all patients and tomogram or dynamogram was done at nine or twelve months in selected cases to evaluate the status and the patterns of fusion.

The donor bones were obtained from each patient's iliac bones and ribs of their own.

The average of follow-up period was 3.1 years (range one -12 years).

The overall fusion rate of noninfectious spinal diseases was 92% and that of infectious spinal diseases was 88% at one year after operation. Radiologically completed fusion was obtained 73.3%, incomplete fusion in 17.4%, and absorption of the grafted bone in 9.3% at one year after operation.

High fusion rate was obtained from spinal stenosis (90%) and contrary to this low fusion rate was in pyogenic spondylitis (60%).

The fusing pattern of grafted bones could be categorized into five different types and the most common type among them was type I (61.0%).

In clinical results, 79.4 percent of noninfectious group was satisfied and 76.9% in infectious group.

The most favorable clinical result was obtained in lumbar intervertebral disk herniation (86.8%) in noninfectious group and pyogenic spondylitis (80%) in infectious group.

In conclusion, the fusion rate was higher in noninfectious spinal diseases than infectious spinal diseases, but the clinical results were not correlated with the status or pattern of the fusion.

Anterior interbody fusion is useful and recommendable method of surgery not only in.

Key words: *Fusion rate, Anterior interbody fusion, Fusing pattern, Noninfectious and infectious spinal diseases.*

INDRODUCTION

The anterior interbody fusion has become a popular measure in the treatment of the several spinal diseases.

It has several advantages, including an excellent bony fusion rate, maintenance of stability and normal height of disk space, wide and radical removal of diseased tissues, no damage to the spinal cord and nerve root, and early ambulation with light external immobilization.

Since the first report of Capener[1)] in 1932, many authors reported the satisfactory result in noninfectious spinal diseases such as spondylolysis, spondylolisthesis, intervertebral disk herniation, spinal fractures, and spinal tumors.

In 1960 Hodgson and Stook[12)] reported a good result of the spinal tuberculosis treated by radical curettage and anterior interbody fusion. Since then many authors have reported results about the infectious spinal diseases such as tuberculous spondylitis, pyogenic spondylitis, discitis, and brucellosis.

The reports of the results of anterior interbody fusion from the many authors were limited to the clinical results and fusion rates of each disease.

So far we know that there are no reports for the comparison of noninfectious and infectious spinal diseases at same insitute.

The purpose of this study is to calculate fusion rates, compare the fusion rates, evaluate fusing pattern of grafted bones and evaluate clinical results between noninfectious and infectious spinal diseases.

MATERIALS AND METHODS

From January 1979 until December 1991, the authors performed anterior interbody fusion in 326 cases of several spinal diseases.

Two hundred and nine cases of noninfectious spinal diseases included 91 cases with intervertebral disk herniation, 81 cases with spondylolisthesis, 20 cases

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with spinal stenosis and 17 cases with spondylolysis, and 117 cases of infectious spinal diseases included 102 cases with tuberculous spondylitis, ten cases with discitis and 5 cases with pyogenis spondylitis (Table 1a, 1b).

Table 1-a: Age Distribution in Noninfectious Spinal Diseases

Diseases Age	IDH	Spondylolisthesis	SS	Spondylolysis	Total
Under 20	10	4	0	5	19
21 - 30	33	20	0	12	65
31 - 40	34	16	2	0	52
41 - 50	14	25	6	0	45
51 - 60	0	14	11	0	25
Over 61	0	2	1	0	3
Total	91 (43.5%)	81 (38.8%)	20 (9.6%)	17 (8.1%)	209

* IDH: Intervertebral Disk Herniation, SS: Spinal Stenosis
* 17 - 62 yrs. (average 35.7 yrs.) * M:F = 114:95

Table 1-b: Age Distribution in Infectious Spinal Diseases

Diseases Age	Tuberculous Spondylitis	Diskitis	Pyogenic Spondylitis	Total
Under 10	11	0	3	14
11 - 20	25	0	0	25
21 - 30	10	3	2	15
31 - 40	10	2	0	12
41 - 50	25	5	0	30
51 - 61	18	0	0	18
Over 61	3	0	0	3
Total	102 (87.2%)	10 (8.5%)	5 (4.3%)	117

* 3-63 yrs. (average 30.2 yrs.) * M:F = 55:62

Table 2-a: Involved level in Noninfectious Spinal Diseases

Diseases Level	IDH	Spondylolisthesis	SS	Spondylolysis	Total
L_{3-4}	4	0	0	0	4
L_{4-5}	34	35	7	10	86 (41.1%)
L_5 - S_1	32	41	5	6	84 (40.2%)
L_{3-4-5}	5	3	2	1	11
L_{4-5} - S_1	16	2	6	0	24
Total	91	81	20	17	209

* IDH: Intervertebral Disk Herniation, SS: Spinal Stenosis

The average of follow-up period was 3.1 years (range one -12 years).

The age of the patients ranged from 17 to 62 years (average, 35.7 years) in noninfectious group, and from 3 to 63 years (average, 30.2 years) in infectious group.

One hundred and fourteen patients were men and 95 patients were women in noninfectious group and 55 patients were men and 62 patients were women in infectious group.

Before the operation, main clinical symptoms were back pain and radiating pain in noninfectious group and back pain, mass, deformity and neurologic signs in infectious group.

The most frequent site of the lesion was lumbar level (L_{4-5}) in both noninfectious and infectious group (Table 2a, 2b).

The donor bones were autobones obtained from ilium and/or ribs. The ribs were grafted only into the infectious group (Table 3). The allobones were from deep frozen femoral head.

Preoperative plain radiography was performed in all cases, and myelography, CT (General Electric 9800 Milwaukee, Wisconsin, and Philips Tomoscan 350, Eindhoven, Holland), myelo CT Scans, MRI (1.5 T machine Signa, General Electric, Wisconsin) or whole body bone Scan (ADAC gamma camera, ADAC Laboratories, Milipitas California, of ORBITER gamana camera, SIEMENS Gamma Sconics Inco, Des Plaines Illinois) were done in selected cases for accurate diagnosis.

For the evaluation of soundsness of bony union, all patients were checked by clinical examinations such as presence of pain, tenderness over the operation sites and pain during spinal motion.

Post operatively periodic plain

Table 2.b: Involved Location in Infectious Spinal Diseases

Involved Vertebrae Location	No of Total Involved Vertebrae	No. of Patients (%)	Average Involved Vertebrae
Cervical	15	10 (8.5)	1.5
Thoracic	65	31 (926.5)	2.1
Thoracolumbar	34	19 (16.3)	1.8
lumbar	86	57 (48.7)	1.5
Total	200	117	

Table 3: Donor Bone

Donor bone	No. of Patients (%)
Autoiliac	275 (84.3)
Autorib	33 (10.1)
Autorib + autoiliac	10 (3.1)
Allobone	8 (2.5)
Total	326 (100.0)

Table 4-a: Postoperative Radiological Union Rate at One Year in Noninfectious in Noninfectious Spinal Diseases

Diseases Union Status (%)	IDH	Spondylolisthesis	SS	Spondylolysis	Total
Complete	72	56	18	15	161
	(79.1)	(69.1)	(90.0)	(88.2)	(77.0)
Incomplete	11) 91.2	17) 90.1	2) 100	1) 94.1	31) 92
	(12.0)	(20.9)	(10.0)	(5.9)	(14.8)
Absorption	8	8	0	1	17
	(8.8)	(10.0)		(5.9)	(8.1)
Total	91	81	20	17	209

* IDH: Intervertebral Disk Herniation, SS: Spinal Stenosis

Table 4-b: Postoperative Radiological Union Rate at One Year in Infectious Spinal Diseases

Diseases Union Status (%)	Tuberculous	Diskitis	Pyogenic	Total
Complete	68	7	3	78
	(66.6)	(70)	(60)	(66.6)
Incomplete	22) 88.2	2) 90	1) 80	25) 88
	(21.6)	(20)	(20)	(21.4)
Absorption	12	1	1	14
	(11.8)	(10)	(20)	(12.0)
Total	102	10	5	117

Table 5-a: Fusing Pattern of Graft Bones in Noninfectious Spinal Diseases

Diseases Fusing Pattern (%)	IDH	Spondylolisthesis	SS	Spondylolysis	Total
Type I	61 (67.0)	47 (58.0)	13 (65.0)	10 (58.8)	1361 (62.7)
Type II	10 (11.0)	9 (11.1)	5 (25.0)	5 (29.4)	29 (13.9)
Type III	9 (9.9)	13 (16.0)	2 (10.0)	1 (5.9)	25 (12.0)
Type IV	3 (3.3)	4 (4.9)	0	0	7 (3.3)
Type V	8 (8.8)	8 (9.9)	0	1 (5.9)	17 (8.1)
Total	91	81	20	17	209

* IDH: Intervertebral Disk Herniation, SS: Spinal Stenosis

Table 5-b: Fusing Pattern of Graft Bones in Infectious Spinal Diseases

Diseases Fusing Pattern (%)	Tuberculous	Diskitis	Pyogenic	Total
Type I	59 (57.8)	6 (60)	3 (60)	68 (58.1)
Type II	9 (8.8)	1 (10)	0	10 (8.5)
Type III	16 (15.7)	2 (20)	0	18 (15.4)
Type IV	6 (5.9)	0	1 (20)	7 (6.0)
Type V	12 (11.8)	1 (10)	1 (20)	14 (12.0)
Total	102	10	5	117

Table 6-a: Clinical Result in Noninfectious Spinal Diseases

Diseases Fusing Pattern (%)	IDH	Spondylolisthesis	SS	Spondylolysis	Total
Excellent	20 (22.0)	18 (22.2)	2 (10)	7 (41.2)	47 (22.5)
Good	59) 86.8 (64.8)	46) 79.0 (56.8)	9) 55.0 (45)	5) 70.6 (29.4)	119) 79.4 (57.0)
Fair	8 (8.8)	14 (17.3)	5 (25)	5 (29.4)	32 (15.3)
Poor	4 (4.4)	3 (3.7)	4 (20)	0	11 (5.3)
Total	91	81	20	17	209

* IDH: Intervertebral Disk Herniation, SS: Spinal Stenosis

Table 6-b: Clinical Result in Infectious Spinal Diseases

Diseases Fusing Pattern (%)	Tuberculous Spondylitis	Diskitis	Pyogenic Spondylitis	Total
Excellent	18 (17.6)	2 (10)	1 (20)	21 (17.9)
Good	61) 77.5 (59.8)	5) 70.0 (50)	3) 80.0 (60)	69) 76.9 (59.0)
Fair	19 (18.6)	2 (20)	0	21 (17.9)
Poor	4 (3.9)	1 (10)	1 (20)	6 (5.1)
Total	102	10	5	117

radiography was done in all patients every three month until fusion completed and tomogram was done in all cases at 6 months. If there was no evidence of complete fusion, tomogram or dynamogram were performed at nine or twelve months in selected cases.

The fusion state was categorized as three different types by tomogram; complete fusion, incomplete fusion (fused some parts of grafted bones), and absorption (decreased intervertebral disc height compare with immediate post operative state) of grafted bones.

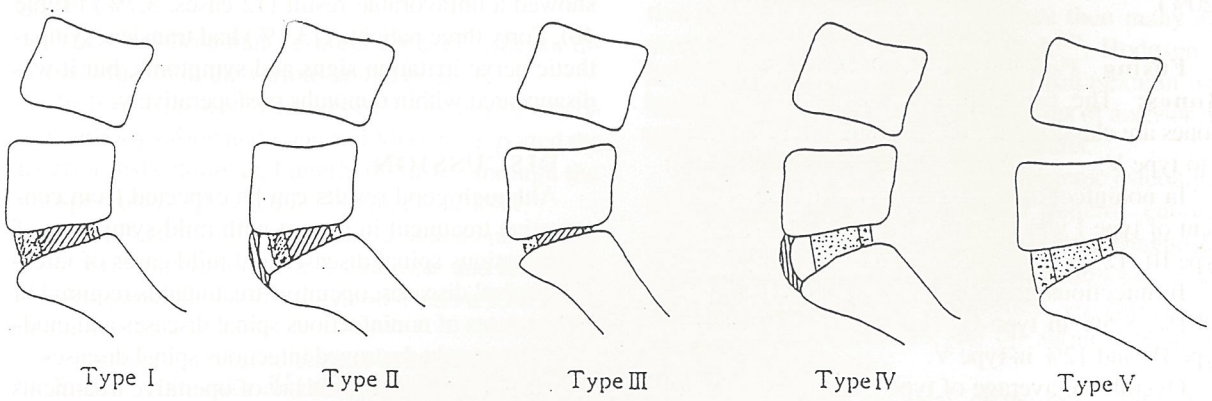
The fusing pattern and fate of the grafted bones could be classified into five defferent types according to Kang and Kim's method (Type I: fusion without disk space narrowing, Type II: fusion with anterior bridging, type III: fusion with disk space narrowing, type IV: fusion with anterior bridging and partial absorption of grafted bones, type V: fusion failure with absorption or aseptic necrosis of grafted bones. (Fig. 1).

The evaluation of clinical results was performed at one year postoperatively by Kim and Kim's criteria.

The patients with intervertebral disk herniation were encouraged to sit up within three days, and the patients with spondylolysis, spondylolisthesis and spinal stenosis were encouraged to sit up seven days after operation. Ten to 14 days after operation the back brace (Knight type for L_{3-4} and L_{4-5} lesion, Kinght-Kim type for L_5-S_1 lesion, Yonsei Rehabilitation Center Seoul, Korea) was fitted and the walking exercises were begun.

The back brace fitting was continued until three to six months postoperatively. At that time, a tomogram was performed to evaluate fusion. When the fusion was complete, the brace was discarded. When the fusion was incomplete, the brace was remained for three or additional months.

Patients with tuberculous spondylitis, discitis and pyogenic spondylitis were encouraged to sit up seven to ten days after operation. Fourteen days after operation Mninerva cast for the cervical and cervicothoracic lesion, Body jacket cast for the thoracic and lumbar lesion and above Knee bilateral cast for L_5-S_1 lesion were applied and continued until three to six months postoperatively.



I : fusion without space narrowing
II : fusion with ant. bridging
III : fusion with disc space narrowing
IV : fusion with ant. bridging & partial absortion of the grafted bone
V : fusion failure

Figure 1: Diagram of fate of the grafted bone

Also in infectious spinal diseases, at the six months all patients were performed tomogram when fusion was complete he cast was discarded. When the fusion was incomplete brace or cast was remained for three or additional months according to the conditions of the cases.

RESULTS

Fusion Rate: In about one quarter of the patients with noninfectious spinal diseases, fusion was completed at 6 months postoperatively. It, however, was delayed in the patients with infectious spinal diseases.

At 12 months postoperatively a complete union was noted as an average of 77% (range, 69.1 - 90%) in noninfectious group and 66.6% (range, 60-70%) in the infectious group. Incomplete union at 12 months postoperatively was obtained as an average of 14.8% (range, 5.9-20.9%) in noninfectious group and 21.4% (range, 20-21.6%) in infectious group. The overall fusion rate including incomplete union was 92% in noninfectious spinal diseases but it was 88% in infectious spinal diseases (Table 4-a, 4-b).

Absorption of the grafted bones was noted as an average of 8.1% (range, 5.9-10%) in noninfectious spinal diseases and 12% (range, 10-20%) in infectious spinal diseases (Table 4a, 4b).

The high fusion rate was obtained in noninfectious spinal diseases; the most high fusion rate was in spinal stenosis (90%) and low fusion rate in pyogenic spondylitis 60%).

The incidence of nonunion was high in infectious spinal diseases especially in pyogenic spondylitis (20%).

Fusing Patterns and Fates of Grafted Bones: The fusing patterns and fates of grafted bones are classified into five different types from type I to type V.

In noninfectious spinal diseases, the average precent of type I was 62.7%, that of type II was 13.9%, type III, 12.0%, type IV 3.3% and type V 8.1%.

In infectious group, the average of type I was in 58.1%, 8.5% in type II, 15.4% in type III, 6.0% in type IV and 12% in type V.

Overall the average of type I was in 61%, 12% in type II, 13.2% in type III, 4.3% in type IV and 9.5% in type V (Table 5a, 5b).

The average of fusing patterns and fates of grafted bones in the cases of complete union (type I) were about the same in both noninfectious (62.7%) and infectious (58.1%) group. However the unusual pattern of fusion (type III) and absorption of grafted bones (type IV and V) were inclined to occur in infectious group.

Complete fusion was observed in type I and type II, incomplete fusion was observed in type III and type IV, absorption and nonunion in type V.

The type I was high in intervertebral disk herniation (67%) and type II was high in spondylolysis (29.4%). None of the absorption (type V) was noted in spinal stenosis.

CLINICAL RESULTS

The satisfactory clinical results at one year after anterior interbody fusion was 79.4% in noninfectious spinal diseases and 76.9% in infectious spinal diseases.

The best clinical result (86.8%) was obtained from lumbar intervertebral disk herniation and unfavorable result (55%) from spinal stenosis in noninfectious group (Table 6a).

The best clinical result (80%) was obtained from pyogenic spondylitis and unfavorable result (70%) from discitis in infectious group (Table 6b).

The status of the bony union was not correlated with clinical results.

The superficial wound infection or abscess were occured in 21 cases (6.8%) which had no difference between noninfectious or infectious spinal diseases and healed up within several days. Partial absorption of the grafted bones was noticed in 31 cases (9.5%). Among them the patient with tuberculous spondylitis showed a unfavorable result (12 cases, 3.7%) (Table 4b). Forty three patients (13.1%) had transient sympathetic nerve irritation signs and symptoms, but it was disappeared within 6 months postoperatively.

DISCUSSION

Although good results can be expected from conservative treatment in patient with mild symptoms of noninfectious spinal diseases and mild cases of infectious spinal diseases, operative treatment is required in severe cases of noninfectious spinal diseases and moderate to severely destroyed infectious spinal diseases.

There are many methods[23] of operative treatments including laminectomy through the posterior approach, posterior decompression and posterolateral fusion, posterior decompression and vertebral fusion with an instrument and anterior interbody fusion

which was performed in this study.

According to the article (Kim et al.)[6, 19] regarding the biomechanics of vertebral column, the load acts as a positive force and is supported by the intervertebral disks, posterior articular processes, articular capsule and surrounding muscles.

Therefore at the lesion site of spondylisthesis the length of ligaments of the segment should be maintained in order to maintain the height of the intervertebral disc space.

When it is required to correct instability of the vertebral column caused by noninfectious spinal diseases or infectious spinal diseases it could be achieved by anterior interbody fusion[3,19].

The advantages of anterior interbody fusion are:[10,17].

1) Direct vision of the lesion sites, 2) prevention of injury of the posterior supporting ligaments, 3) little transfusion needed, when familar with the technique, 4) capability of early postoperative exercise and shortened hospital stay, 5) high rate of bone union, and, 6) minimal external support needed.

In the long-term follow up evaluation it was found that anterior interbody fusion resolves intersegmental instability, which was a major problem of spondylolysis and spondylolisthesis[14,24].

As for intervertebral disk herniation, in addition to the restoration of disk height and the correction of spinal alignment, anterior interbody fusion relieves the posterolateral nerve compression by the disk herniation ventral to the lateral recess[14,20,24]. In spinal stenosis, anterior dural decompression could be obtained through anterior interbody fusion by the sound strut graft[24].

There has been many reports about the anterior interbody fusion in the various spinal diseases.

In 1932 Capener[1] first reported 32 cases of anterior interbody fusion and Lane and Moore[25] reported the anterior diskectomy and interbody fusion through the transperitoneal approach in 36 patients in 1944.

In 1963 Harmon[11] reported the results of 244 patients with intervertebral disk syndrome and his series showed good clinical results in 90% and a 95% bony union rate.

Thereafter, other good clinical results were reported by Sacks[28], Stauffer and Coventry[29], Fujimaki et al[9], Kim and Soe[20] and Kim and Kim[23], and Kim et al[24].

In their reports clinical results were excellent or good in 63.7% - 96% and the bony fusion rate was 85-96%.

The high fusion rate was obtained from previously reported articles in noninfectious spinal diseases; 90 percent by Freebody and Taylor[8], Fujimaki et al.[9] (96%), Harmon[11] (95%), Inoue[15] (94.3%), Kim and Kim[23] (91%) and Kim et al.[24] (78.3%). On the contrary low fusion rate was reported by Flynn and Haque[7] (56%), Chow et al.[2] (63%), Stauffer and Coventry[29] (56%).

In the current study the one quarter of the patients with noninfectious spinal diseases fusion was completed at 6 months postoperatively.

The fusion rate at 12 months postoperatively including incomplete union was 92% in noninfectious spinal diseases, however it was 88% in infectious spinal diseases.

At 12 months postoperatively a complete fusion rate (complete bony union) was 73.3%, but the fusion rate including incomplete union were 90.5% in both noninfectious and infectious spinal diseases.

The clinical result in the current study was satisfactory 85% and it was almost same result as previous articles.

In infectious spinal diseases the advantages of radical curettage and anterior interbody fusion through anterior approach are: 1) to debride and curett out the lesions under direct vision, 2) to obtain high concertration of antituberculous drugs to the lesion site by the increased blood flow, 3) to decompress the compressed neural tissues, 4) to correct the deformity by the bone grafts at the lesion sites, 5) to get stability by the sound strut bone grafts, 6) to increase bony union rates and shorten the hosital stay.

In 1934 to et al.[16] reported the new radical operative method for Pott's disease. since then many authors (Erlachter, Hodgson and Stock[12], Hodgson et al.[13], Chu[3], Chung et al.[4] and Rajasekaran and Soundarapandian[27]) reported the results of anterior interbody fusion in tuberculous spondylitis.

For the treatment of vertebral pyogenic osteomyelitis McNeill[26] described five general categories: ① initial biopsy for precise bacterial diagnosis, ② emergency surgery for epidural abscess when present, ③ bed rest and antibiotics, ④ surgery for drainage of other abscesses, and ⑤ surgical treatment of late spinal deformity.

He emphasized mainstay of the treatment is bed rest until the acute pain subsides and intensive antibiotic therapy for four to six weeks.

According to the author's opinion, the definite diagnosis of pyogenic osteomyelitis of the spine is not

easy only by the clinical symptoms, signs and laboratory findings.

The advantages of surgical treatment of pyogenic spondylitis are to confirmation of the diagnosis, eradication of the infected focus, reconstruction of the defect space by strut bone graft, stabilization of the painful instability and prevention of the late spinal deformity.

The fusion rate of tuberculous spondylitis had wide range from 41% to 95.9%. By Rajasekaran and Soundarapandion[27] the fusion rate was 41% but according to the reports of Hodgson and Stock[12] it was 93% and 95.9% by Chu[3], and 94.9% by Chung et al.[4] In the current study the fusion rate of tuberculous spondylitis was 88.2% and in all infected spinal diseases it was 88%.

Rajasekaran and Soundarapandian[27] advocated that the poor fusion rate was ralated to length of the graft, and they recommended that these patients in whom the length of the graft exceeds two disc spaces might benefit by additional measures, such as an extended period of non-weight bearing, posterior arthrodesis after six to twelve weeks, and prolonged use of a brace.

By author's opinion the grafting bed is very important for the grafted bones to survive; the dead bones should be completely removed until healty bones exposure and postoperatively sound external immobilization and sufficient period of use of brace should be assured until complete consolidation is evident.

In the infectious spinal diseases the best fusion rate 90% from diskitis and the worst rate was 80% from phyogenic spondylitis.

In 1980 Kim and Lee[3] reported the results of 15 patients with pyogenic spondylitis treated by radical curretage and anterior interbody fusion. Their series showed 93.3% of bony union. All the cases were immobilized by body jacket cast in upper lumbar lesions and by bilateral above knee cast in below L_3 lesions.

In the current study the fusion rate of pyogenic spondylitis was 80% and clinical results were satisfactory in 80%. The difference of fusion rate compared with previous study of Kim and Lee[18] might be due to the immobilization method.

The overall clinical results of infectious spinal diseases were satisfactory in 76.9%.

Most authors reported that the clinical symptoms were not correlated to the bony union.

In the current study, also, the bony union did not influence the clinical symptoms.

The four cases of poor result from tuberculous spondylitis were reoperated and got union finally.

One of the reasons of absorption of the grafted bones was insufficient immobilization. All the cases of absorption in noninfectious spinal diseases were immobilized insufficiently due to poor cooperation of the patients.

The fusing patterns of the grafted bones were different in the diseases and classified into five types.

In this series the over all percentage of type I was 61; 62.7% in noninfectious spinal diseases but 58.1% in infectious spinal diseases (Table 5a, 5b). the grafted bones classified as type I and II in were thought to be a complete union.

An overall complete union rate was 73%; 76.5% noninfectious group but 66.6% in infectious group. The calculated percentages shown in table 5A and 5B were a little bit different from the numbers in table 4A and 4B, because they were calculated in different ways; the numbers in table 4 were obtained directly from the result of the tomograms but those in table 5 were calculated after classifying the fusing pattern into 5 groups.

In the grafted bones classified as type V, bone absorption occurred leading to a fusion filure.

The percentage of the type V was 8.1 in the noninfectious group but 12 in the infectious group, with the mean of 9.5 (31 cases).

The different patterns of fusion and fate of grafted bones were due to amount of removal of dead bones from the receiving sites, amount of grafted bones, length of the grafted bones, and duration of external immobilization.

When complete removal of the dead bones from the lesion sites was done blood supply to the grafting bones would be sufficient. The sound tricortical strut graft was mandatory for the support of diseased structures until consolidation was completed. If it was unable to get tricortical strut graft bones, more than four pieces of autorib would be recommended.

Rajasekaran and Soundarapandia, pointed out that length of grafted bones had influence on bone union, and recommended not to exceed more than two disk spaces.

When bony defect is longer than two disk spaces, iliac strut graft with some sound internal fixation is recommendable in noninfectious spinal diseases.

Postoperative immobilization is essential for the bony union. For the noninfectious spinal diseases body jacket or special type of brace is sufficient exter-

nal immobilization. In determining the type of brace and cast, the lesion site is very important.

Body jacket cast or Knight type back brace is necessary for the above L_5 lesion and bilateral above knee cast or Knight-Kim type brace for L_5-S_1 lesions[23, 24].

The duration of immobilization is different in lesion sites, diseases, and individual.

Periodic radiography, therefore, is necessary until fusion is completed. In the most of the reports[12, 13, 14, 17, 20, 22, 23, 24], the fusion was completed at six to nine months postoperatively but in this series one quarter of the cases were completed at six months.

For the infectious spinal diseases more strong and sound external immobilization is necessary, such as plaster bed, body jacket cast for above L_5 lesion and bilateral above knee cast for L_5-S_1 lesions. Hodgson and Stock[12] used Lorenz plater bed for three months and twelve days, after then gradual mobilization for six months. If a long transplant covering many vertebrae has been introduced, the time of immobilization may be much longer.

The causes of low fusion rate in infectious spinal diseases were thought as follows; the first is poor internal immobilizing effect between the grafted bones and beds due to softening of the bed resulting from long immobilization and pathologic conditions. The second is poor blood circulation of the bed due to insufficient removal of dead bones. The third is poor holding effect of the grafted bones due to their length. The fourth is poor condition of surrounding soft tissues which is friableness, scar, poor circulation resulting bariers that prevent high concentration of medicine in the lesion site. The last is poor external immobilization and insufficient period of immobilization.

In summary, in the infectious spinal diseases, the frequency of lesion sites were lumbar, thoracic, thoraco-lumbar, and cervical spine in descending order and in the noninfectious spinal diseases all the sites were lumbar spine.

The fusion rates were 92% in the noninfectious group and 88% in the infectious group. Among fusing patterns, the type I was most common (61.1%).

The most favorable results were obtained from lumbar intervertebral disk herniation. In conclusion the fusion rate was better in the noninfectious spinal diseases than the infectious spinal diseases, but the clinical reasults were not correlated with the status or pattern of the fusion.

Anterior interbody fusion is useful and recommendable method of surgery in both noninfectious and infectious spinal diseases.

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