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J Korean Neurosurg Soc 42 : 6-10, 2007

Clinical Article

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Bone Cement Augmentation of Pedicular Screwing in Severe Osteoporotic Spondylolisthetic Patients

Objective : The purpose of this study was to determine the effect of bone cement augmentation of pedicular screwing in severe osteoporotic spondylolisthetic patients.

Methods : Twenty patients with spondylolisthesis (8 : spondylolytic spondylolisthesis 12 : degenerative spondylolisthesis) who had undergone pedicular screwing and interbody fusion for osteoporotic lumbar spine (T-score on bone mineral density<-3.0) from 2002 to 2005 were reviewed. Mean age was 62.3 years with 3 male and 17 female patients. Average follow-up period was 14 months. Average T-score on bone mineral density (BMD) was -3.62. After decompression of neural elements, about 6cc of polymethylmethacrylate (PMMA) was injected into the each vertebral body through transpedicular route. All patients underwent one level interbody fusion and pedicular screw fixation. Clinical outcome was assessed using Oswestry Disability Index (ODI) on the last clinical follow-up. In addition, a modified MacNab's grading criteria was used to objectively assess patient's outcome postoperatively. Radiographic analysis of sagittal contour was assessed preoperatively, immediately postoperatively, and at final follow-up including fusion rate.

Results : Eighteen of 20 patients were graded as excellent or good according to the modified MacNab's criteria. An significant improvement of ODI was achieved in both groups. Mean sagittal angle at the preoperative state, postoperative state and at the last follow-up state was 11.0°, 20.1° and 18.3°, respectively, with mean sagittal angle correction gain 7.3°. Firm fusion was achieved in all patients. There were one compression fracture above the fused segment after 6 months follow-up and one case of seroma. But, there were no postoperative complications related to bone cement leakage and pedicular screwings such as screw pullout or screw cut-up.

Conclusion : Bone cement augmentation of pedicular screwing can be an effective procedure for osteoporotic lumbar spine in spondylolisthetic patients.

KEY WORDS : Spondylolisthesis · Severe osteoporosis · Bone cement · Augmentation.

INTRODUCTION

Traditional procedures for spondylolisthesis with low back pain and neurologic involvement entail spinal decompression and fusion with supplemental instrumentation. More recently, interbody fusion has improved fusion rates[7,8]. However, in spondylolisthesis accompanying severe osteoporosis, these surgeries are fraught with complications because of the poor quality of bone and the debilitated state of these elderly patients. The most important internal factor exerting an effect on the screw fixation strength is bone quality, and the weakening of the fixation strength depending on it may cause the fusion failure, and thus it has important significance[10]. In addition, due to the defect in the vertebra itself, to obtain the stability in the contact area of the cancellous bone with screws has technical limitations, and thus to improve the fixation strength of the vertebra with poor bone quality, additional procedures in any types are required. The current retrospective study describes our results with posterior interbody fusion and bone cement augmented pedicular screwing in the setting of lumbar spondylolisthesis accompanying severe osteoporosis.

MATERIALS AND METHODS

Between 2002 to 2005, 20 patients of spondylolisthesis accompanying severe osteoporosis with symptomatic neural compression were treated by posterior lumbar interbody fusion and bone cement augmented transpedicular screwings (8 : spondy-lolytic spondylolisthesis, 12 :

• Received : January 24, 2007
• Accepted : June 25, 2007
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degenerative spondylolisthesis).

The follow-up period was from the shortest 12 months to the longest 25 months, and the mean period was 14 months. The age of patients was 51-60 years in 7 cases, 61-70 years in 9 cases, 71-80 years in 4 cases, and the mean age was 62.3 (52-74) years. The spondylolytic spondylolisthesis group had a mean age of 58.1 years (range 52-71 years), whereas the degenerative spondylolisthesis group had a mean age of 65.2 years (range 60-74 years). All cases with the T-score lower than -3.0 by BMD were considered as severe osteoporosis and the mean T-score of these cases were -3.62 (Table 1).

Surgical methods

Under general anesthesia, in the prone position, the lesion was reached by posterior midline approach. The lesion was exposed sufficiently, the right and left facet joint capsule and the ligamentum flavum were removed carefully, and complete decompression of the affected nerve roots running the inferomedial part of pedicle was performed. The bony spur compressing the nerve root was also removed, and the intervertebral disc were exposed by removing the enlarged bilateral articular processes, and discectomy was performed. After confirming the complete decompression of the compressed nerve roots, tapping was performed using the first tapper of the transpedicular screwing.

Under the C-arm guide, tapping was performed by the 2nd tapper considering the location where bone cement would be injected. A bone biopsy needle was inserted to the 2nd tapper site, and located in 1/2-1/3 anterior area of the vertebral body. Bone cement slightly thinner than tooth paste in viscosity was prepared. If it is too thick, injection of bone cement would cause problems, the time for transpedicular screwing could not be gained. If it is too thin, it may leak to the blood vessel or the neural foramen, and furthermore, bone cement would spread too widely on the vertebral body, the fixation strength would be lowered. Hence, it is important to control the viscosity well.

Under the C-arm guide, through a bone biopsy needle, bone cement was injected, and it was allowed to be localized maximally in the vertebral body area.

With regards to the amount injected, approximately 3-4cc in a bone biopsy needle and thus 6-8cc per vertebra was injected. After the injection of bone cement, under the C-arm guide, transpedicular screws were inserted as soon as possible. By applying the identical method, bone cement augmented transpedicular screwing in other areas was performed. Bone cement is hardened completely after from a few minutes to 10 minutes, hence, the rod was connected after at least 10 minutes. After the fixation of rod, 2 cages filled with autologous bone chips were inserted to the disc space (Fig. 1).

Safety and Outcome Evaluation

Patients were evaluated according to the modified MacNab's criteria for characterizing clinical outcome after spinal surgery (Table 2). Anteroposterior and lateral plain radiographs were obtained preoperatively, immediately after the cement

Table 1. General data of the patient's group

	Spondylolytic Spondylolisthesis (n=8)	Degenerative Spondylolisthesis (n=12)
Age	58.1 (52-71)	65.2 (60-74)
Male patient	2	1
Mean T-score on BMD*	-3.32	-3.82

BMD* : Bone Mineral Density

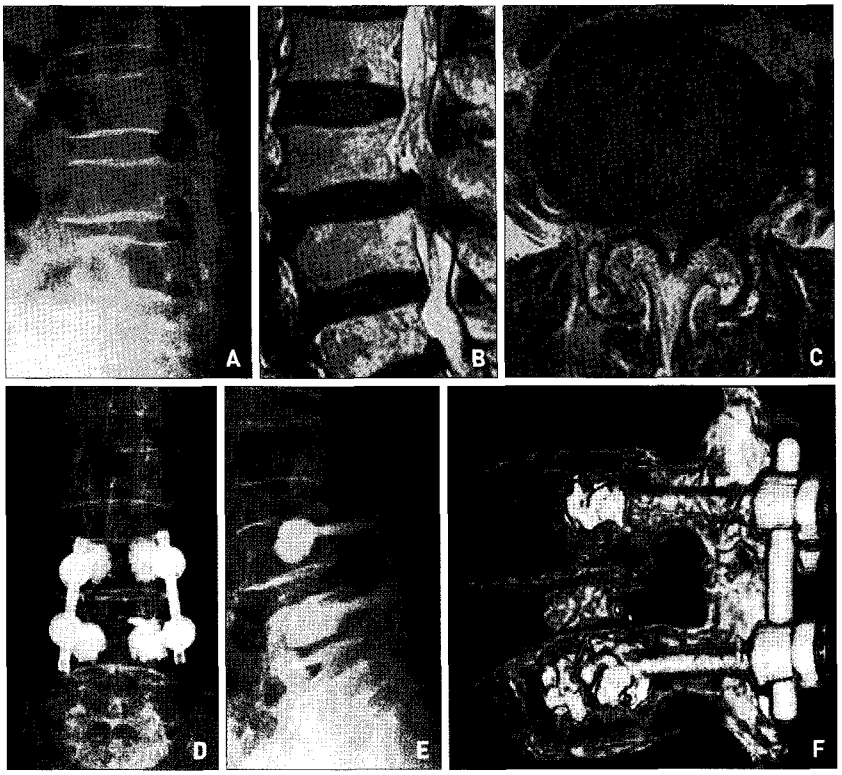

Fig. 1. A 64-year-old woman with L3-L4 degenerative spondylolisthesis with severe osteoporosis (T-score on BMD : -3.48). A, B, C : Preoperative simple lateral radiograph and magnetic resonance images showing degenerative spondylolisthesis and severe spinal stenosis at L3-L4 level. D, E, F : Postoperative simple radiographs and 3-dimensional computed tomography scan revealing L3-L4 interbody fusion cages and bone cement augmented pedicular screwings.

Table 2. Modified MacNab's criteria for characterizing outcome after spinal surgery

Outcome	Description of Criteria
Excellent	No pain; no restriction of mobility; return to normal work & level of activity
Good	Occasional nonradicular pain; relief of presenting symptoms; return to modified work
Fair	Some improved functional capacity still handicapped and unemployed
Poor	Continued objective symptoms of root involvement; additional operative intervention need at the index level irrespective of length of postoperative follow-up

Table 3. Radiographic measurement of preoperative and postoperative sagittal plane angulation after cement augmentation

	Preoperative Contour	Initial Postoperative Contour	Final Follow-up Contour	Loss of Correction
Spondylolytic Spondylolisthesis (n=8)	11.8°	21.9°	19.7°	2.2°
Degenerative Spondylolisthesis (n=12)	10.6°	18.9°	17.4°	1.5°
Combined patients (n=20)	11.0°	20.1°	18.3°	1.78°

Table 4. The ODI* of the patient's group according to time

	Spondylolytic Spondylolisthesis (n=8)	Degenerative Spondylolisthesis (n=12)
Preoperative	25.0	27.2
Postoperative	12.9	13.2
Final follow-up	13.0	13.4

ODI* : Oswestry Disability Index

Table 5. Modified MacNab's outcome assessment of patient satisfaction with the surgical procedure at final clinical follow-up

MacNab's Criteria	Overall (n=20)	Spondylolytic Spondylolisthesis (n=8)	Degenerative Spondylolisthesis (n=12)
Excellent	16	7	9
Good	2	1	1
Fair	2	0	2
Poor	0	0	0

augmentation procedure, and at the final clinical follow-up. In addition, the follow-up was performed clinically using Oswestry Disability Index (ODI), which is an internationally established score for outcome measurement in lumbar spine surgery[9]. Radiographs were used to evaluate, where appropriate, angulation and instrumentation integrity at the level of operative segments, respectively.

Statistical Analyses

All data sets were collected and entered into a coded spread sheet. Statistical analysis was conducted with SPSS vr.11.5 software. Tests for parametricity between various data sets were conducted, and appropriate statistical independent and dependent tests were performed. ANOVA, X2, correlation, regression, and subgroup analyses were also conducted. The level of statistical significance was established at $p<0.05$.

RESULTS

In the spondylolytic spondylolisthesis group, the operated segment were L4-L5 (n=5), L5-S1 (n=3), and in the degenerative spondylolisthesis group, the most commonly operated level was L4-L5 (n=5) followed by L5-S1 (n=4) and L3-L4 (n=3). Although the mean age was younger than in the spondylolytic group, no statistically significant difference was noted between the two groups with respect to age, sex and anatomic distribution ($p>0.05$). The average preoperative, immediate postoperative, and final follow-up sagittal contour is listed in (Table 3). No significant differences were identified between the two groups (p=0.080). Approximately 20.1 degrees of lordosis was obtained postoperatively in this series, reflecting an initial correction of 9.1 degrees. At the final follow-up, the average amount of correction loss overall was 1.78 degrees, representing 7.3 degrees change in angulation from the original ($p<0.05$). Firm bone union was achieved in all patients. The successful bone fusion criteria included the evidence of bridging bone without radiolucent halo and below 5° on lateral flexion and extension radiographs. In both groups, a significant improvement in ODI was achieved (Table 4). Eighteen out of 20 patients were graded as having a excellent or good result according to the modified MacNab's criteria (Table 5). There were no major complications such as deep wound infection, bone cement leakage, and the pullout of screwings. One patient showed L1 compression fracture from slipped down accident after 6 months follow-up. Two weeks after the injury, the patient underwent balloon kyphoplasty and complete pain relief was obtained. In another case of a seroma, a debridement with secondary suture was necessary.

DISCUSSION

Spondylolisthesis is a common disease with an incidence approximately 5% of the population[11], and recently, with aging, its incidence is on the rise. Decompression was introduced as the treatment for spondylolisthesis that induces radiating pain by Gill in 1955, and subsequently, various surgical techniques have been performed, and generally, decompression, bone graft, and transpedicular screwing have been performed, and good outcomes have been shown[3,7,9]. Due to the increase of the life-span of humans and the

improvement of the quality of life, a trend is that the frequency of surgery using transpedicular screwing for degenerative spinal diseases with poor bone quality is on the rise. However, for severe osteoporosis cases, the anchoring effect that holds transpedicular screw is decreased, the probability of the failure of the fixation of screws is high and thus the possibility of non-union is high, hence, the apparatus fixation and bone fusion have been contraindications for such patients[13]. Therefore, some spinal surgeons perform simple discectomy for nerve decompression, nonetheless, in such cases, the vertebral instability becomes more deteriorated and the disc space becomes narrower, and simultaneously, the deviation to the anterior side becomes more severe, consequently, the space of intervertebral foramen becomes narrower and the compression of nerve roots become more severe, and thus it may rather exacerbate its symptoms. To gain successful transpedicular screwing, the strength of the contact area of screws with the vertebra becomes the most important factor, and in osteoporosis patients, firm fixation strength could not be obtained due to the poor defective vertebra, and thus any types of additional procedure to improve screw fixation may be required. According to several studies, in instrumentation for degenerative spinal diseases, osteoporosis has been pointed out to be one of the major factors causing poor outcomes, and to solve these problems such as screw relaxation and pull-out, various principles such as the above and below vertical lengthening of the fixation segment, lessening of the degree of the deformity correction, and to avoid the internal device fixation surgery in the kyphosis segment, etc. have been emphasized[4,6]. Also, methods to improve the fixation by supplementing hooks or transverse fixators have been suggested as a substitute[5], nonetheless, actually for the internal instrumentation for segments to be operated, that suggested supplement measurements are absent. Therefore, in spondylolisthesis patients with concomitant severe osteoporosis (T-score<-3.0), we reinforced the fixation strength by injecting bone cement through the transpedicular route for the cases whose insertion strength was noticeably weak during operation. In 2002, Cho et al reported that about 10° sagittal angle correction could be restored successfully in patients with bone cement augmentation of pedicular screwing for osteoporotic lumbar spine[2]. According to Hu, in the instrumentation for osteoporosis patients, the immediate concern after surgery is the pull-out of screws, and it may occur during the connection of metal rods to screws or the deformity correction, alternately, while the lumbar spine undergoes motion, the contact area of cancellous bone with screws receives the tilting or cut-up load in addition to the pull-out load. Thus, it may be developed prior to bone union after surgery, and the non-union cases may be developed as the delayed type[6]. In our cases, by the supplement surgery with bone cement in the vicinity of screws during surgery, the pull-out that becomes a problem immediately after surgery could be prevented. On the other hand, Brantley and Zdeblick et al. considered a type of the failure of screw fixation as the flexion-extension load of the lumbar vertebra or "toggling", which was considered to be related to the "fit" level of screws within the pedicles[1,15]. Okuyama et al.[10] also have reported that osteoporosis is a major factor in the screw relaxation. In all our cases, the posterior lumbar interbody fusion using two cages was performed, and the data directly comparing with other types of fusion are not available. Nevertheless, it is considered that by supporting the anterior with the interbody fusion, the possibility of the load on the weak cancellous bone by screws caused by the flexion-extension movement of the lumbar vertebra was decreased, and thus the concerned screw relaxation could be prevented. Zindrick et al.[16] have reported that in experimental studies using the lumbar spine with osteoporosis, during the insertion of a transpedicular screwing, if the fixation strength were weak, cement enforcement could be performed in the vicinity of screws. But, Hu has reported that to use exothermic materials such as bone cement in the vicinity of nerve roots was not desirable[6]. Moreover, Soshi et al. have reported that in the biomechanical experiments using the vertebra of cadavers in severe osteoporosis cases the pull-out strength of spinal perpendicular screws could not mediate a positive effect on the pull-out strength of spinal pedicular screws despite of the reinforcement of screws with bone cement and thus effective fixation could not be obtained using screws in any cases[12]. Nonetheless, it was the outcome of the reinforcement with bone cement of the entrance of pedicle, and thus it was different from our study that bone cement was injected directly to the cancellous bone in the vicinity of screws, and indeed, we made a bulk of screws with bone cement by injecting bone cement to the spinal cancellous bone, and thus it is considered to prevent the "teeter-totter" motion of screws based on the spinal pedicles until bone fusion[14]. However, other factors that may depend on screw fixation strength such as screw diameter or insertion tehnique. Moreover, many patients with severe osteoporosis are elderly patients, hence, more attentions have to be paid on the selection of surgery indications since respiratory, cardiovascular, or endocrinal diseases, may be accompanied, and general weakness after surgery may be shown in some cases. Therefore, considering the loss and gain after surgery carefully, more attentions have to be paid on the selection of such surgery patients. In addition, as in our study, osteoporotic compression fracture may be developed in the adjacent level by minor trauma, and thus even after surgery, efforts should

be made to treat and prevent osteoporosis through diet or medications.

CONCLUSION

Posterior lumbar interbody fusion and the bone cement augmented pedicular screwings in spondylolisthetic patients accompanying severe osteoporosis can be an effective treatment.

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COMMENTARY

Osteoporotic spine that needs screw fixation is the difficult situation to spine surgeon. The patient population mean age was 62.3 years. Average T-score was -3.62. The osteoporotic spine has handicap itself, which the screw could be loosened due to the weak bony trabecula when it is introduced. There is the possibility that the screw could be pulled out or loosened. The authors tried to overcome the weak point with bone cement augmentation. Bone cement augmentation is good idea. Despite of the poor population of these cases, its significant role of enhancing the fusion rate gives us the additional weapon to solve it.

First, bone cement augmentation can accelerate the bony collapse or disc degeneration later. If this serious situation occurs in the adjacent level, there is few next solution in the elderly. Therefore the authors should carefully consider the adjacent segment condition before this augmentation.

Second, this procedure must be done by the one who is technically familiar with 'the screwing'. And it can have successful result if a surgeon has excellent skill. The operators would have burden to conduct the procedure within fixed time and just one trial. If the bone cement augmentation by biopsy needle is failed by trajectory, subsequent screwing will be impossible because of hardness of cement. Of course the authors well pointed out its delicate importance of the bone cement viscosity. The skill and consuming time are the key of this procedure. In other words, the procedure has some risks.

We all hope that more safe solution in this situation could be found in the future.

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