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Bone Resorption Around Pedicle Screws After Pedicle Screw Plate Fixation[1]

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Purpose: To determine the frequency, level, distribution, onset, and pattern of progression of bone resorption that occurring around pedicle screws after pedicle screw plate fixation.

Materials and Methods: Bone resorption around 902 pedicle screws was analyzed in post-operative, and follow-up radiographs obtained from 156 patients who underwent pedicle screw plate fixation. To determine the resorption degree, categorized arbitrarily as grade 1 (less than 1 mm), grade 2 (1 mm or more, but less than 2 mm), or grade 3 (2 mm or more), the width of radiolucent zones was measured. In 39 patients in whom resorption was graded 1, 2, or 3, the pattern of progression of 78 screws was evaluated.

Results: Resorption occurred around 78 (8.6%) screws in 39 (25%) patients, 26 of whom had more than one lesion. For 99% of screws, there was evidance of resorption within 12 weeks of pedicle screw plate fixation. During follow-up, 61.5% of screws (48/78) remained stable, while 38.5% (30 screws) showed progression to higher grades. The possibility of progression to a higher grade is less when the initial grade is lower.

Conclusion: An understanding of the radiographic patterns of bone resorption is useful for monitoring a patient after pedicle screw plate fixation.

Index words : Spine, radiography
Spine, bone resorption
Pedicle screws, instability

Pedicle screws are widely used to provide stable fusion of the spine and to restore its alignment (1 - 5). To minimize the area of vertebral fusion, rods or plates are used for screw fixation, though hardware motion may lead to loosening and repeated movements of loose appliances can lead to bone resorption around a screw (1, 2). This is manifested as a radiolucent zone that can be easily assessed at plain radiography. Bone resorption may, however, also occur in the normal course of events.

In this retrospective study, we analyzed the radiographic patterns of bone resorption occurring around pedicle screws after pedicle screw plate fixation of thoracic, lumbar and sacral spine, and assessed its frequency, level, distribution, onset, and progression.

Materials and Methods

Pre-operative, post-operative, and follow-up radi-

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ographs of 902 screws in 156 patients (55 men and 101 women aged 16 - 82 (mean, 49) years) who underwent pedicle screw plate fixation of the thoracic, lumbar and sacral spine were analyzed retrospectively to evaluate bone resorption around pedicle screws. The indications for pedicle screw plate fixation were spinal trauma with associated fracture, instability caused by degenerative disease, spondylolisthesis, and scoliosis correction. The system applied included the Diapason spinal system (Stryker Spine, Bordeaux, France).

Follow up radiographs of anteroposterior (AP), lateral and oblique projections were obtained weekly during the first six weeks, biweekly thereafter up to 12 weeks and then monthly until follow up, lasting 91 - 382 (mean, 236) days, was lost. All radiographs were retrospectively reviewed by two radiologists (J. - H. L., S. - W. P) whose conclusions were reached by consensus ($k = 0.834$, index of interobserver agreement, $p = 0.0001$). The presence or absence of a radiolucent zone at the screw-bone interface was noted, and immediate post-operative and follow-up radiographs were compared. If equivocal radiolucency around pedicle screws was observed on immediate post-operative radiographs but did not progress to overt radiolucency during follow-up, this was regarded as an absence of bone resorption. Of 902 screws in 56 patients, 78 screws in 39 showed overt radiolucent zones around screws. Where maximal width was observed, this zone was measured at the screw- bone interface by one experienced radiologist (J. - H. L.), using a caliper, and the degree of bone resorption was thus determined. This was graded according to the width of the radiolucent zone, as follows: grade 1: less than 1 mm; grade 2: 1mm or more but less than 2 mm; grade 3: 2 mm or more (Figs. 1, 2). Grade 3 was considered to be abnormal (6 - 8). For 78 screws in 39 patients in whom bone resorption was observed, the level, distribution, onset, and pattern of progression were analyzed. A total of 254 pedicle screws had been inserted at multiple levels in these patients : at two levels in five, three levels in 22, four levels in nine, and five levels in three (Table 1). Lesions were described as single, bilateral at a single, or multiple (more than two) at multiple (two or more) levels. The level of bone resorption was classified according to its location: cranial, caudal, or intermediate. When resorption was noted at proximal parts among pedicle screws, it was classified as cranial; if at distal parts, as caudal. When the radiolucent zone around the screw appeared on follow-up radiographs, it was considered to indicate the onset of bone resorption. Resorption during follow-up was classified as stable or progressive.

Results

Among 902 screws in 156 patients, bone resorption was seen in 78 (8.6%) in 39 (25%) patient. When resorp-

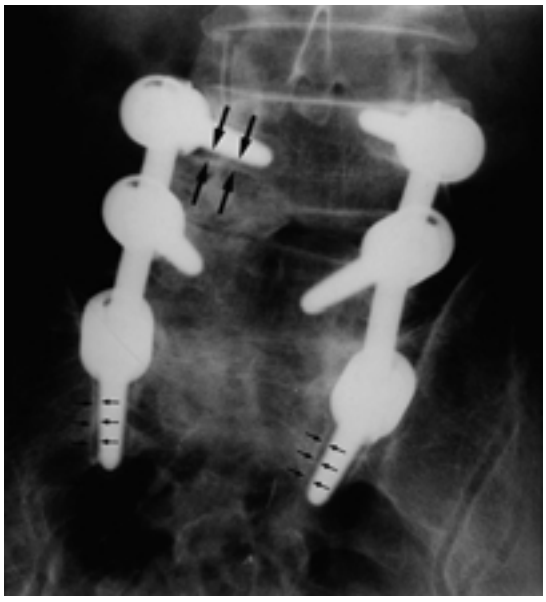


Fig. 1. AP radiograph of bone resorption around pedicle screws (63-year-old man). Both grade 1 (between small arrows) and grade 2 (between large arrows) bone resorption were noted at L4 and the sacral levels.

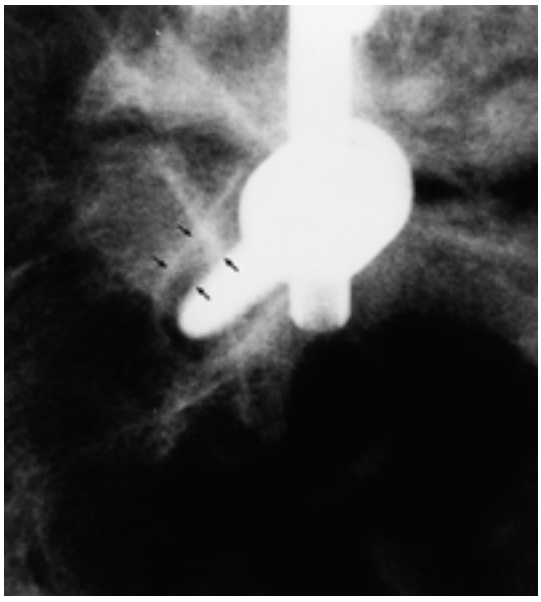


Fig. 2. AP radiograph of loose pedicle screw (74-year-old woman). Grade 3 bone resorption (between arrows) is seen at the sacrum.

tion initially appeared, 68 (7.5%) of 902 screws were classified as grade 1, eight (0.9%) as grade 2, and two (0.2%) as grade 3. In these 39 patients in whom resorption occurred, no evidance of infection was noted. Resoption manifested as a single lesion in 13 patients (13 screws); bilateral, single-level lesions in 18 (36 screws); and multiple lesions at multiple levels in eight patients (29 screws) (Fig. 1). The location of bone resorption was cranial in 33% of the cases (26 of 78 screws), caudal in 43.6% (34 screws), and intermediate in 23.1% (18 screws) (Table 2). For 14 screws distributed among five patients, resorption was both cranial and caudal. As shown in Fig. 3, resorption first occurred within six weeks of pedicle screw plate fixation in 78.2% of cases (61 of 78 screws) and within 12 weeks of this in 98.7% (77 of 78 screws). It first appeared at between 2 and 3 weeks (5.1%, 4 screws); most frequently, initial onset was between 3 and 4 weeks (30.8%, 24 screws).

As shown in Table 3, 61.5% (48 of 78 screws) remained in stable condition, while in 38.5% (30 screws), resorption pregressed. Of the 68 screws showing grade 1 resorption, 42 (61.8%) remained in stable condition, 14

Table 1. Level of Pedicle Screws in Patients with Bone Resorption

Level	No. of Patients (n=39)	No. of Inserted Screws (n=254)
2 Levels		
L3, L4	1	4
L4, L5	4	6
3 Levels		
T12, L1, L2	1	6
L2, L3, L4	1	6
L3, L4, L5	11	66
L4, L5, S1	9	54
4 Levels		
L2, L3, L4, L5	4	32
L3, L4, L5, S1	5	40
5 Levels		
L2, L3, L4, L5, S1	3	30

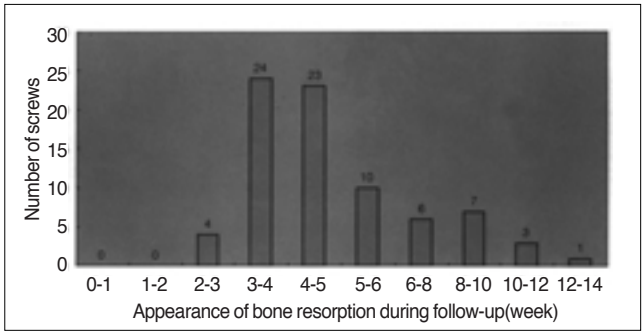


Fig. 3. Bar graph shows 99% of bone resorption was appeared within 12 weeks after pedicle screw plate fixation. Bone resorption began to appear between 2 and 3 weeks, and the peak onset was between 3 and 4 weeks.

Table 2. Location of Bone Resorption

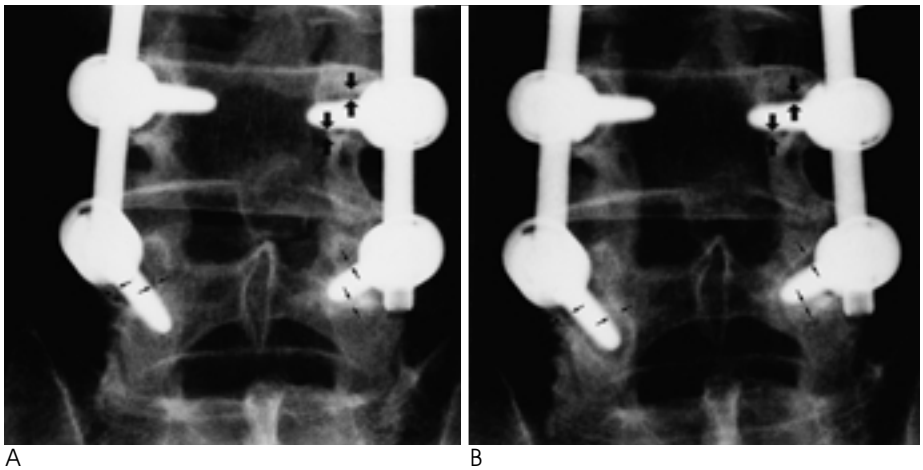
Location	Multiplicity* Single (n=13)	Bilateral (n=36)	Multiple (n=29)	Total (n=78)
Cranial		18	8	26
Intermediate	7	4	7	18
Caudal	6	14	14	34

* Data are the number of screws.

Table 3. Progression of Bone Resorption during Follow-up.

Initial Grade	Follow-up Grade* Grade 1 (n=42)	Grade 2 (n=18)	Grade 3 (n=18)	Total (n=78)
Grade 1	42	14	12	68
Grade 2		4	4	8
Grade 3			2	2

* Data are the number of screws.
Grade 1: bone resorption less than 1 mm in width
Grade 2: bone resorption less than 2 mm in width
Grade 3: bone resorption more than 2 mm or more in width.



A B

Fig. 4. Progression of bone resorption (A) AP radiograph of bone resorption (62-year-old man). Grade 1 bone resorption in L5 (between thin arrows) and grade 2 bone resorption in L4 (between thick arrows) are noted. (B) AP radiograph of the same patient obtained 7 months later. Progression of bone resorption in L5 to grade 2 (between thin arrows). The grade 2 bone resorption in L4 remained stable (between thick arrows).

(20.6%) pregressed to grade 2, and 12 (17.6%) progressed to grade 3 (Fig. 4). Of the eight screws showing grade 2 resorption, the condition of four (50%) remained stable, while the other four (50%) progressed to grade 3. Both screws showing grade 3 resorption remained stable during follow-up. Overall, 18 of 902 screws (2.0%) in seven of 156 patients (4.5%) showed abnormal, grade 3 bone resorption. No screws were removed.

Discussion

Pedicle screws together with plate and rod systems have been employed to create stability in thoracolumbar spine. They are attached posteriorly to rods or plates by threaded nuts. When firmly anchored into intact bone, pedicle screws resist loads in all directions (9), but when a screw becomes loose, hardware may fail at the site of attachment to the spine. Loosening of screws that are in direct contact with bone is caused by inadequate fixation, or infection (6, 10 - 16). Repeated movements of loose hardware produce bone resorption or erosion around instruments (2, 6, 17, 18). Bone resorption is seen on plain radiographs as a radiolucent zone, though the development of such zones is not always due to loosening; it may also be a normal event. Such normal resorption can be caused by surgical trauma, the interpositioning of soft tissue or blood, and micromotion (17, 18). Analysis of sequential films can be used to distinguish physiologic change from loosening (19). The width and appearance of bone resorption are important predictors of the possibility of screw loosening.

The incidence of such loosening according to earlier reports, varies from 0.6% to 11% (8, 12 - 16). The frequency of abnormal (grade 3) bone resorption (4.5%; 7 of 156 patients) encountered during follow-up was within the range of previous reports. In the majority (82%, 32 of 39 patients) of our cases with bone resorption, this was less than 2 mm in width.

Bone resorption took the form of a solitary lesion in one-third of our cases and more than two lesions in two-thirds. Because of the decreased mobility of fused segments, spinal motion most significantly occurs just above and below the fused segments. In 77% of our cases, resorption occurred cranially, caudally, or both ends, where motion was marked.

The development and progression of bone resorption seem to be rapid, appearing within 12 weeks of pedicle screw plate fixation in 99% of our cases. The possibility of progression to higher grades is low when the initial grade is low. Only 7.6% of screws showing grade 1 resorption progressed to grade 3, while 50% of those showing grade 2 progressed to grade 3.

When abnormal bone resorption occures, differential diagnosis should include the possibility of infection. In our cases, no clinical sign of infection was noted, though screws were not removed because stability was maintained with the help of bony fusion in the supposedly loosened 18 screws.

Two limitations of our study are the relatively short follow-up periods and lack of surgical confirmation. Bone resorption occuring during the late postoperative period could thus not be evaluated.

In conclusion, bone resorption can occur around both pedicle screws and other similar screws or instruments applied to long bones. When spinal stability was maintained with the help of bony fusion and without evidence of infection, it was not always necessary to remove loosened screws. We believe that an understanding of the radiographic patterns of bone resorption aids in monitoring a patient after pedicle screw plate fixation.

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척추경 나사 고정술 후 발생하는 나사 주위 골흡수[1]

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목적: 척추의 안정성을 유지시키기 위해 시행되는 척추경(spinal pedicle) 나사 고정술(screw plate fixation) 후 척추경 나사 주위에 생기는 골흡수의 빈도, 위치, 분포, 발생 시기, 골흡수의 진행 양상을 평가하고자 한다.
대상과 방법: 척추경 나사 고정술을 시행 받은 156명 환자의 902개 척추경 나사를 대상으로 수술 직후와 추적 관찰 기간 동안 척추경 나사 주위에 발생한 골흡수 여부를 분석하였다. 골흡수의 정도를 평가하기 위하여 방사선 투과성 부위(radiolucent zone)의 폭을 측정하여 Grade 1(1 mm 미만), Grade 2(1 mm 이상 2 mm 미만), Grade 3(2 mm 이상)으로 등급화 하였다. 골흡수가 관찰된 39명의 78개의 척추경 고정 나사에서 골흡수의 정도, 위치, 분포, 발생 시기 및 진행 양상을 평가하였다.
결과: 척추경 나사 고정술을 시행받은 156명 902개의 척추경 중 39명(25%) 환자의 78 개(8.6%)의 척추경에서 골흡수가 관찰되었다. 39명 중 26명에서 두 곳 이상의 척추경 고정 나사 주위에서 골흡수를 보였다. 척추경 고정 나사 중 99%에서 수술 후 12주 이내에 골흡수가 관찰되었다. 추적 기간 중 62%(78 개중 48개의 척추경 고정 나사)에서 병변의 정도는 진행하지 않았으나 38%에서는 더 높은 등급으로 골흡수의 정도가 진행하였다. 초기의 골흡수 등급이 낮은 경우에서 높은 등급으로 골흡수가 진행하는 정도가 낮았다.
결론: 척추경 나사 고정술 후 발생하는 나사 주위의 골흡수의 방사선학적 소견에 대한 이해는 수술 후 환자의 경과를 관찰하고 이해하는 데 도움이 될 것으로 기대한다.