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CLINICAL OUTCOMES OF ASEPTIC THORACOLUMBAR PSEUDOARTHROSIS THAT OCCURRED AFTER POSTERIOR SPINAL INSTRUMENTATION

POSTERİOR SPİNAL ENSTRUMANTASYON SONRASI OLUŞAN ASEPTİK TORAKOLOMBER PSÖDOARTROZDA KLİNİK SONUÇLARIMIZ

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SUMMARY:

Objective: In this study, we aimed to retrospectively evaluate the clinical and radiological findings and the mid to long-term results of aseptic pseudoarthrosis that emerged after posterior thoracolumbar segmental instrumentation surgery for spinal deformities and vertebral fractures, based on surgeries in the Department of Orthopedia and Traumatology, Istanbul Training and Research Hospital, from February 1999 to February 2010.

Materials and Methods: The 32 patients with spinal pseudoarthrosis that were included in this study were divided into two groups (Group-1 consisted of 11 vertebral fractures and Group-2 of 21 spinal deformities). The mean follow-up period was 36 months (range: 6–110 months). The records of our patients were reviewed retrospectively and the final follow-up results of the patients were taken into account in the data preparation process. The predisposing factors and radiological findings of pseudoarthrosis were assessed in light of the literature. The clinical results of the patients were measured using the Scoliosis Research Society-30 (SRS-30) questionnaire. Categorical data were provided by conducting analyses using Pearson's chi-square and Fisher's Exact Test to assess the relationship with pseudoarthrosis. Numerical values were analyzed with the Mann-Whitney U Test and Pearson-Spearman Correlation Test.

Results: The most common complaint was pain at the pseudoarthrosis site (26 patients, 81.3%). Diabetes mellitus, smoking, osteoporosis and non-steroidal anti-inflammatory drug use were not risk factors for spinal pseudoarthrosis in our patients. Rod or implant failure was recorded as the most common radiological finding of pseudoarthrosis in both groups (Group-1: 10 patients, 90.0%; Group-2: 18 patients, 85.7%). Progression of the deformity was a specific finding for Group-2 patients (14 patients, 66.6%), and middle column damage was only seen for Group-1 patients (3 patients, 27.3%). The number of fused vertebrae, halo signs around the screws, and number of non-fused vertebrae at the fusion level were significantly correlated with pseudoarthrosis ($p<0.001$; $r=0.725$). Patients had similar SRS-30 scores at the final follow-up (Group-1 average: 3.30; Group-2 average: 3.39) ($p=0.984$).

Conclusion: The number of fused vertebrae correlates with pseudoarthrosis. In this study, co-morbidities were not found to be significantly correlated with pseudoarthrosis.

Key words: Scoliosis, thoracolumbar spine fractures, spine fusion, pseudoarthrosis, revision surgery.

Level of evidence: Retrospective clinical study, Level III

ÖZET:

Amaç: Şubat 1999 – Şubat 2010 tarihleri arasında İstanbul Eğitim ve Araştırma Hastanesi Ortopedi ve Travmatoloji Kliniği' nde, spinal deformite veya vertebra kırığı sonrası posterior torakolomber segmental enstrümantasyon uygulanmış hastalarda ortaya çıkan aseptik psödoartrozun klinik ve radyolojik değerlendirilmesi ve orta-uzun dönem fonksiyonel sonuçların retrospektif olarak değerlendirilmesi amaçlanmıştır.

Gereç ve Yöntem: 11' i kırık (Grup-1), 21'i deformite (Grup-2) sebebiyle opere olmuş 32 psödoartroz hastası çalışma gruplarını oluşturmaktadır. Ortalama takip süresi 36 (dağılımı 6-110) aydır. Hastalarımızın dosyaları geriye dönük olarak gözden geçirilmiş ve son kontrolleri dikkate alınarak veriler hazırlanmıştır.

Hastalarımızın psödoartroz sebepleri literatürdeki araştırmalar ışığında araştırılmış, psödoartrozun radyolojik bulguları irdelenmiş ve klinik sonuçları Skolyoz Araştırma Derneği – 30 (SRS-30) skorlama sistemi ile değerlendirilmiştir. Elde edilen kategorik veriler, psödoartrozla ilişkisi yönünden, Pearson k2 ve Fisher Exact Test ile; sayısal değerler Mann- Whitney U Test ve Pearson Spearman Korelasyon Testi ile değerlendirilmiştir.

Bulgular: Çalışmaya alınan hastaların en sık başvuru şikayetinin psödoartroz sahasında ağrı (26 hastada, % 81,3) olduğu kaydedilmiştir. Diyabet, sigara kullanımı, osteoporoz ve non steroid ve anti enflamatuvar ilaç kullanımının hastalarımızda spinal psödoartroz risk faktörü olarak anlamlı olmadıkları görülmüştür. Her iki grupta en sık radyolojik psödoartroz bulgusunun rot veya implant kırığı (Grup1 10 hasta, % 90.9, Grup2 18 hasta, % 85.7) olduğu tespit edilmiştir. Deformite hastalarında deformitenin ilerlemesi (14 hasta, % 66.6), kırık hastalarında orta kolon hasarı (3 hasta, % 27.3) gruplara özel bulgular olarak saptandı. Füzyona katılan vertebra sayısı, vida çevresinde hale gözükmesi ve füzyon sahasında olup vida konmayan vertebra sayısı ile psödoartroz sayısı arasında anlamlı bir ilişki olduğu görülmüştür ($p<0.001$, $r: 0.725$). Hastaların son kontrol SRS-30 toplam değerleri, Grup-1 için ortalama 3.30; Grup2 için ortalama 3.39 ($p: 0,984$) olduğu belirlenmiştir.

Sonuç: Füzyona katılan vertebra sayısı psödoartroz sayısı ile yakından ilişkilidir. Bu çalışmada, diğer komorbiditelerle psödoartroz arasında anlamlı ilişki bulunamamıştır.

Anahtar kelimeler: Skolyoz, torakolomber vertebra kırığı, spinal füzyon, psödoartroz, revizyon cerrahi.

Kanıt Düzeyi: Retrospektif klinik çalışma, Düzey III

INTRODUCTION:

Spinal fusion is an approach that is commonly used in spinal surgery, although not every aspect is completely understood. Pseudoarthrosis is one of the most important reasons for failed spinal surgery. If there are any signs of continuous pain, correction loss or implant failure 9–12 months after spinal surgery, pseudoarthrosis should be suspected. Unfortunately, it is not easy to diagnose pseudoarthrosis[1,7]. While pseudoarthrosis should be suspected with continuous and persistent pain for patients that have received spinal arthrodesis, a lack of symptoms has been reported in half of patients with pseudoarthrosis[3,6].

The possibility of pseudoarthrosis after spinal arthrodesis should be kept in mind when considering surgery on a continuous fusion mass. The absence of fusion after spinal arthrodesis has been found at various ratios in different studies. This ratio has decreased with the development of spinal fixation and graft techniques. The ratio can vary due to non-homogenous studies containing different patient groups, different results for anterior, posterior or combined surgeries, and the diversity of the spinal instruments used[4,8,15].

In direct radiographs, spinal pseudoarthrosis can be encountered as rod or screw fracture, displacement of screw or hook (pull-out) or halo formation around them, progression of deformity if present, collapse of the disc space or damage to the middle column, and changes in deformity angles in curvature X-rays[4,8,15]. In addition, the involvement of increased activity in whole-body bone scintigraphy with technetium supports pseudoarthrosis, although it has been shown in one study to have low reliability[2]. The presence of localized pain on fusion, progression of deformity or disease, and localized movement of the fusion mass in bilateral curvature X-rays are helpful for a diagnosis of pseudoarthrosis. An absolute diagnosis can be performed by observation of movement in the fusion area during surgery[5]. Although many studies show pseudoarthrosis in varying ratios after vertebral surgery, there are limited studies concerning the diagnosis and treatment of pseudoarthrosis.

This study aims to retrospectively evaluate the clinical and radiological results of patients diagnosed with spinal aseptic pseudoarthrosis.

MATERIALS AND METHODS:

Between February 1999 and February 2010, patients who applied to our clinic with posterior spinal fusion of the thoracolumbar region due to vertebral fracture or spinal deformity, and who had received surgery at least once due to the development of aseptic pseudoarthrosis, were retrospectively evaluated. 32 patients who could be contacted gave their consent and were included in the study. Two patients who died during the follow-up period due to other diseases were excluded.

The patients were evaluated in two groups, based on whether they had a fracture or deformity. 11 of the patients (34.4%) received surgery due to a vertebral fracture (Group-1) and 21 (65.6%)

received surgery due to spinal deformity (Group-2).

The distributions of vertebral fracture levels and spinal deformity types are listed in Table-1 and Table-2, respectively. 14 of the patients (43.8%) were male and 18 (56.2%) were female. while in Group-2, these were 7 (33.3%) and 14 (66.7%), respectively.

The mean age of the patients was 38.3 years (range: 16–69 years). While the mean age was 44.2 ± 10.0 years (range: 25–62 years) in Group-1, it was 35.3 ± 16.3 years (range: 16–69 years) in Group-2.

Our patients were diagnosed with spinal pseudoarthrosis an average of 37.8 ± 27.6 months (6–96 months) after their last operation. Their complaints were retrospectively evaluated from forms completed during their examinations.

The patients were questioned in terms of risk factors causing spinal pseudoarthrosis, such as diabetes, smoking, osteoporosis, use of NSAIDs, chronic diseases and drug use. The direct radiography and orthoroent-genography results of the patients taken before surgery were evaluated for pseudoarthrosis findings. The presence of screw or rod fracture, progression of deformity, disc space collapse, a halo around the screw or hook, and middle column damage were investigated in the patients.

The vertebral numbers joined by fusion and the levels at which the screw, hook or sublaminar fiber were placed were evaluated after examination of the preoperative X-rays of the patients, and the relationship between them and pseudoarthrosis was investigated. CT, scintigraphy and MRI examinations of the patients taken before surgery were evaluated, and any pseudoarthrosis findings were noted.

Table-1. Level distribution of fractures

Broken vertebra	T12	L1	L2	L3	L4
Patient number	2 (18.1%)	4 (36.2%)	1 (9.1%)	3 (27.3%)	1 (9.1%)

Table-2. The distribution of deformity patients

Deformity type	**Patient Number**	**Patient Number (%)**
Adolescent idiopathic scoliosis	10	47.6
Degenerative adult scoliosis	6	28.6
Kyphosis	3	14.3
Congenital kyphoscoliosis	2	9.5

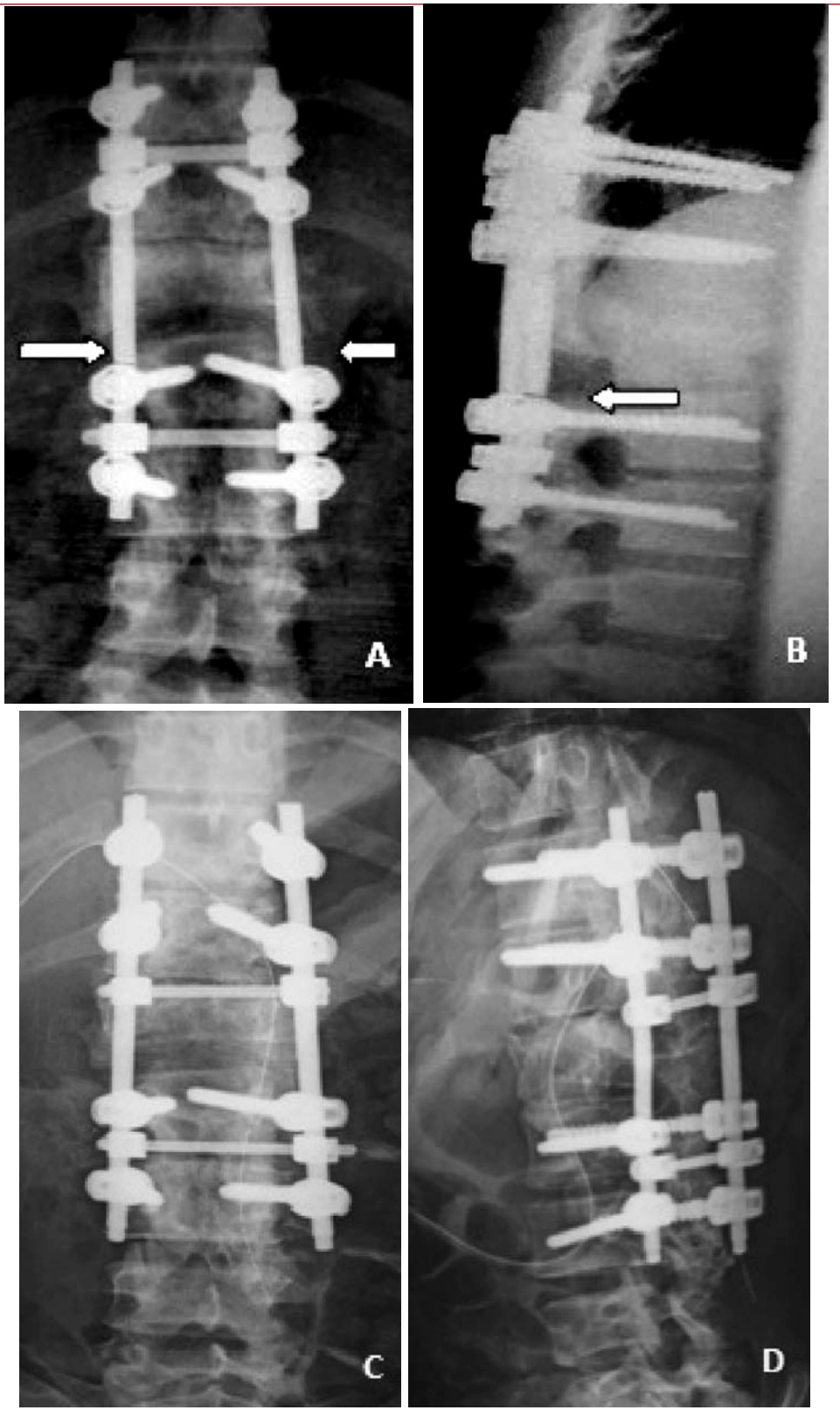

Figure-1. T.P., female aged 24, Group-1, **A-** preoperative AP X-ray, **B-** preoperative lateral X-ray, **C-** postoperative AP X-ray, **D-** postoperative lateral X-ray.

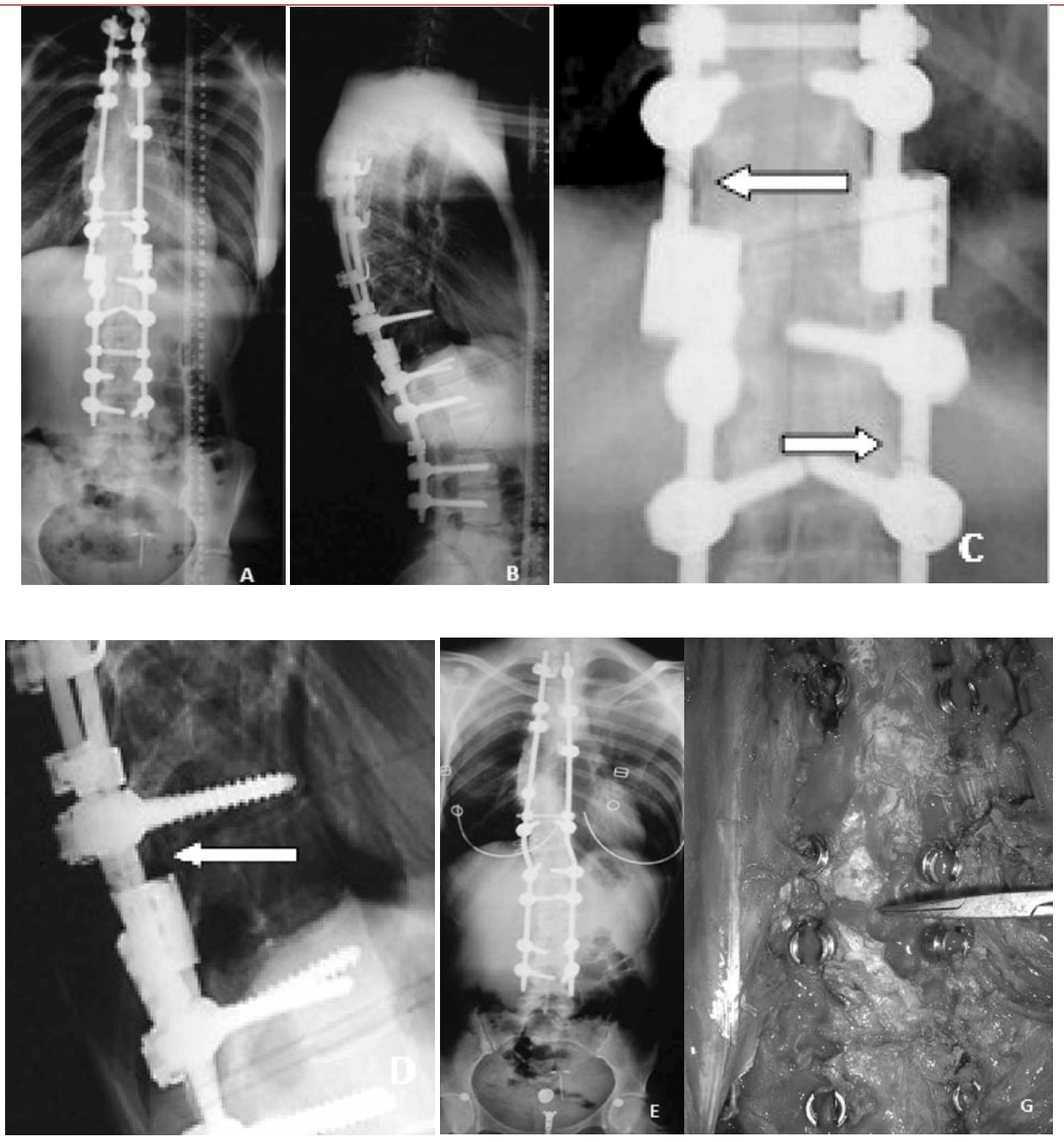

Figure-2. E.A, female aged 26, Group-2, **A-** preoperative AP X-ray, **B-** preoperative lateral X-ray, **C** and **D-** close image of rod fractures, **E-** postoperative AP X-ray, **F-** postoperative lateral X-ray, **G-** intraoperative image pseudoarthrosis area, **H-** intraoperative image of the patient after grefonage and re-implantation.

The surgical decision was evaluated by the anesthesia and reanimation clinic after consulting the relevant fields in terms of the current internal diseases. After deciding that the patients were suitable from an internal perspective, they were included on the operation list. Thirty minutes before all surgeries, prophylaxis was applied with first-generation cephalosporin. The patients received general anesthesia and were prepared in a prone position on a radiolucent operation table. An incision, starting from the proximal and distal borders of the vertebrae to be included in the fusion area and longitudinally extending in the midline, was performed. The posterior elements and previous fusion area were revealed, and the pseudoarthrosis line was determined by protecting the medullary canal. The presence of pseudoarthrosis, at which level and which vertebrae, the relationship between pseudoarthrosis and the implants, and movement in the pseudoarthrosis area were evaluated and noted.

Some implants were revised and new screw, hook and sublaminar fibers were placed into planned sites. Some instruments were reserved and a hybrid system was connected with connectors and dominos. Third-generation posterior instruments were used in all patients. The tips of the pseudoarthrosis were refreshed by decortication, and an autograft taken from the patient, and/or an allograft if necessary, were placed into the fusion area. After surgery, the patients immediately began breathing exercises, and they were raised if there was no hypotension on sitting after 24 hours. No corsets were used for any patients. Other patient exercises were performed by a service physiotherapist. The patients were discharged on average on postoperative day 10.

The patients were followed up for an average of 36 ± 26.7 months (range: 6–110 months). In the last follow-up, they were evaluated with orthoroentgenography, CT and whole-body bone scintigraphy examinations. Hemogram, sedimentation and C-reactive protein were used for evaluating any infection. The function, pain, internal view, mental health and satisfaction of the patients were evaluated using the SRS-30 form prepared by the Scoliosis Research Society (SRS). A score of 1 was accepted as the worst, and 5 as the best.

The Pearson chi-square and Fisher Exact tests were used for comparison of the categorical data of the patients. P-values less than 0.05 were accepted as significant. For comparison of numerical data, the Mann-Whitney U test was used. For the comparison of the relationships of numerical data, the Pearson Spearman correlation test was used. The r and p-values were calculated by linear regression analysis. The absolute p-values of variables were determined by backward elimination. Linear relationship constants were calculated. Finally, the values related by a linear relationship were evaluated in terms of a cubic relationship.

RESULTS:

No significant differences were observed between the groups in terms of gender distribution. When we examined the clinical findings of the patients, the most common complaint was pain in the pseudoarthrosis area (26 patients, 81.3%). Neurological complaints such as muscle loss, paresthesia, paresis, stool and enuresis (8 patients, 25%), and deformity (7 patients, 21.9%) were also among the most common complaints. In addition, complaints were recorded about skin damage due to the implant in three patients (9.4%) and voice changes due to the implants in two patients (6.3%). While pain and neurological complaints were observed in both groups, deformity was only detected in the patients with pseudoarthrosis that developed after scoliosis.

When co-morbidity factors were examined, these were found to be diabetes in four of the patients (12.5%), smoking in three patients (9.4%) and osteoporosis in eight patients (25%). It was detected that when 21 patients (65.6%) were admitted due to pseudoarthrosis, they had been using NSAIDs. Also, cirrhosis was detected in one patient (3.1%), hypothyroidism in one patient (3.1%), and a previous history of polio in one patient (3.1%). These co-morbidities were not found to be associated with pseudoarthrosis alone.

When the radiographs of the patients with pseudoarthrosis were evaluated, rod and/or screw fracture was detected as the most common direct radiological sign (10 patients in Group-1 (90.9%), 18 patients in Group-2 (85.7%)).

No significant difference was found between the groups (p=1.00).

When the preoperative radiographies and orthoroentgenographies were evaluated, progression of deformity was detected in 14 patients in Group-2 (40.6%), while no progression was observed in Group-1. The difference between the groups was found to be significant (p=0.01).

Collapse of disc space, another sign that was evaluated in the preoperative radiographies, was observed in one patient in Group-1 (9.1%) and six patients in Group-2 (28.6%). This difference was not found to be significant, due to the patient number (p>0.374).

When halo formation around the screw and hook was evaluated in the preoperative radiographies, it was observed in one patient in Group-1 (9.1%) and four patients in Group-2 (19.0%). The p-value between the groups was not found to be significant (p=0.637). Implant displacement was observed in one patient in Group-1 (9.1%) and four patients in Group-2 (19.0%), and the p-value was not significant (p=0.637). Middle column damage was detected in three patients in Group-1 (9.4%). Although there was no middle column damage in Group-2, the p-value was not significant (p=0.03).

The vertebrae of the patients that were joined by fusion were evaluated. In Group-1, the L1, L2 and L3 vertebrae were joined by fusion in nine patients (81.8%), and the fusion space varied between T10 and S1. In Group-2, while the vertebrae joined by fusion were spread over a wider range (T1–S1), T11, T12 and L1 were joined by fusion in 17 patients (81%).

When the vertebral numbers of the patients that developed pseudoarthrosis, and patient factors such as age, gender, extra disease, the properties of implants previously placed (at how many levels screw, hook and sublaminar fiber were placed; no placement of implant), progression of deformity, displacement of implant, halo formation around screws, and middle column damage were compared with the Mann-Whitney U test, it was observed that all these data may be related. However, when linear regression analysis was performed, associations to a good degree were only seen in our group for the number of vertebrae involved in fusion and halo formation around screws ($r=0.725$; $p<0.001$). The r^2 of the linear relationship between the number of vertebrae joined by fusion and pseudoarthrosis was found to be 0.525, and the r^2 of the cubic relationship was found to be 0.599.

The ratio between the number of vertebrae joined by fusion but having no implant and the number of all vertebrae joined by fusion was found to be significantly associated with the pseudoarthrosis ratio (corrected $r^2=0.557$), and the r value was not found to be significant in the linear regression analysis due to the low number of cases.

Although the last operation time and the amount of erythrocyte suspension in the last operation of the patients were found to be low in Group-1, the p-value was not significant. In Group-1, an average of 38 cc of allograft was used, and an average of 52 cc of allograft was used in Group-2. In terms of the allograft amounts used, no significant difference was found between the two groups.

According to the SRS-30 forms completed in the last follow-ups of the patients, no significant differences between the two groups were found in terms of function ($p=0.917$), pain ($p=0.145$), internal view ($p=1.000$), mental health ($p=0.693$), satisfaction ($p=0.346$) or total value ($p=0.984$) in the evaluation scored out of 5.

When the results of the whole-body bone scintigraphy in the last follow-up and the preoperative results were compared, a loss of activity was observed. However, no statistical analysis could be carried out, because some patients had no preoperative scintigraphy.

No early or late postoperative infections developed in any of the patients. No sign of pseudoarthrosis progression was detected in any of the patients in the last follow-up, and they were considered to be fused.

DISCUSSION:

The majority of studies on spinal pseudoarthrosis are retrospective studies about adolescent idiopathic scoliosis, adult scoliosis, ankylosing spondylitis and pseudoarthrosis after surgery of the cervical region[1,10-14]. In our study, patients with vertebral fractures were also included in addition to patients with vertebral deformities, with the aim of evaluating the risk factors that have an effect on the development of pseudoarthrosis after spinal fusion surgery, and more accurate pseudoarthrosis diagnosis and complications.

Spinal pseudoarthrosis can depend on local parameters or properties of general mechanical stabilization. Local problems are the use of insufficient live graft, vascular failure, smoking, fusion-retardant medications (such as NSAIDs, methotrexate etc.), metabolic problems and infection. General problems that depend on stabilization are insufficient sagittal or coronal balance, insufficient compression force affecting the fusion area, excessive stretching of the fusion area and insufficient stabilization of the fusion region. The risk of pseudoarthrosis is higher in patient groups with a risk of neurofibromatosis, neuromuscular scoliosis or ankylosing spondylitis[17].

Kim et al. investigated the biological risk factors of pseudoarthrosis and questioned cardiovascular diseases, osteoporosis, endocrine disease, neurological disease, gastrointestinal disease history, and smoking and alcohol use. The p-values for smoking and associated diseases were not found to be significant for the risk of pseudoarthrosis[12]. Also, Pateder et al. stated that smoking alone was not a risk factor for spinal pseudoarthrosis[14]. In our study, smoking was detected in 9.4% of the patients (3 patients), and other diseases in 53.1% of the patients. No statistically significant relationships between any of these risk factors and the pseudoarthrosis ratio were found.

The clinical signs of spinal pseudoarthrosis at diagnosis change according to the patient[17]. In the literature, no clinical diagnostic criteria have been fully elucidated. Kim et al. examined the complaints of patients admitted due to pseudoarthrosis, and detected that seven patients (58.3%) had pain in the pseudoarthrosis area while five patients (41.7%) did not. They saw neurological complaints in four patients (33.33%) during admission[11]. In our study, as in the literature, the most common complaint was pain in the area of pseudoarthrosis, with 26 of the 32 patients (81.25%) having this complaint. It was detected that only eight patients (25%) had neurological complaints such as muscle loss, paresthesia/paresis or stool and urine incontinence. Therefore, we suggest that spinal pseudoarthrosis should be eliminated in cases of non-regressive pain in the fusion area after spinal surgery.

The radiological evaluation of spinal pseudoarthrosis also varies according to the patient[9,17]. In one study, they detected rod fracture in 62.5%, progression of deformity in 50%, collapse of disc space in 19%, displacement

of hook in 12.5% and halo formation around the screw in 12.5% of patients with pseudoarthrosis who received surgery due to spinal deformity[5].

In our study, there was rod or screw fracture in 28 patients (87.5%), progression of deformity in ten patients (31.3%), collapse of disc space in seven patients (21.9%), displacement of implant in five patients (15.6%), and halo formation around the screw in four patients (12.5%). While deformity progression was observed only in the patients who received surgery due to spinal deformity, middle column damage was observed only in the patients who received surgery due to fractures.

Forces affecting the spine biomechanics and fusion area have effects on the levels at which pseudoarthrosis is observed in the spine[17]. In one study, it was stated that the risk of pseudoarthrosis was higher in the thoracolumbar region. This was thought to be because this region is an area of transition from the stable thoracic vertebral region to the mobile lumbar vertebral region, and is highly exposed to biomechanical forces. In this study, they stated that 50% of pseudoarthrosis was observed between T9 and L1[12]. Pateder et al. stated that pseudoarthrosis was observed in the thoracolumbar region (T9–L1) of 77 patients (58.3%), in the thoracic region (T1–9) of 16 patients (12.1%), and in the lower levels (L2–S1) of 39 patients (29.5%)[14]. In another study, pseudoarthrosis was reported in the thoracolumbar region (T9–L1) of eight patients (66.7%)[11]. In our study, pseudoarthrosis was observed between T9 and L1 in 18 patients (56.2%).

In patients with long-level fusion, joining of levels into the fusion, especially the lumbosacral level, increases the pseudoarthrosis rate[17].

In one study, it was stated that 13 or more levels joined fusion in 11 patients (69%) with pseudoarthrosis, and the number of vertebrae joining the fusion was directly proportional to the risk of pseudoarthrosis[12]. In our study, the average number of vertebrae joining the fusion was 11.7 (5–18). A significant relationship was revealed between the pseudoarthrosis rate and the number of vertebrae joining the fusion ($p<0.001$).

Kuklo et al. compared patients who received only a hook or a hybrid system with patients who received only a posterior approach, and stated that the revision rate was lower in the second group[13]. In a study conducted by Richards et al., the patients who received only a posterior approach needed more revision than the patients who received only an anterior approach[16]. In our study, posterior instrumentation alone was applied to the patients, and the number of hook and screws and the number of vertebrae without screws were investigated. The ratio between the number of vertebrae without screws and the number of vertebrae joining the fusion was found to be related to the pseudoarthrosis number, but it was not found to be statistically significant, due to a low patient number ($p=0.657$).

Complications can arise with pseudoarthrosis surgery due to operation time, high bleeding amount, and need for surgical experience[17]. Pateder et al. observed pulmonary complications in 12 patients (3.75%) after pseudoarthrosis surgery, with three patients (2.27%) with shortness of breath, eight patients (6.06%) with pneumonia, and one patient (0.76%) with hemothorax. They stated the neurological complication rate as 6.06% (8 patients)[14].

In another study, intradural rupture was reported in three patients (25%), and it was observed by CT that the L3 root was.

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