Volume: 23, Issue: 4, October 2012 pp.: 295-306 ORIGINAL ARTICLE / ORJİNAL MAKALE

PERCUTANEOUS AND OPEN PEDICLE SCREW FIXATION FOR TRAUMATIC SPINE FRACTURES

TRAVMATİK OMURGA KIRIKLARINDA PERKÜTAN İLE AÇIK PEDİKÜL FİKSASYONUNUN KARŞILAŞTIRILMASI

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SUMMARY:

Objective: To present the short-term results of 24 patients treated by percutaneous pedicle screw fixation for traumatic thoracolumbar fractures, compared to 24 matched patients treated by open pedicle screw fixation.

Summary of Background Data: Although pedicle screw implants provide quick and reliable stabilization, extensive soft tissue dissection is necessary. Screws inserted percutaneously may reduce surgical trauma.

Materials and Methods: A total of 24 patients from the percutaneous pedicle screw group (PPSG) were compared to 24 matched patients treated in the open pedicle screw group (OPSG). Both types of screws were inserted with a freehand technique. The parameters compared were operation time, blood loss, duration of hospital stay and complications.

Results: Both groups consisted of 58% males; the mean age was 48.7 years in the PPSG and 47.1 years in the OPSG. The groups were not statistically different. The mean follow-up period was 14.0 months (PPSG) and 17.3 months (OPSG). In both groups, most of the fractures were type B injuries (flexion/distraction/extension according to the AO classification) without neurological deficit. A significant difference in median blood loss was found (50 mL in the PPSG; 500 mL in the OPSG; $p<0.001$). The operation duration in the PPSG was 103.2 ± 24.6 (68–169) minutes, in the OPSG it was 142.0 ± 45.4 (95–270) minutes ($p<0.001$). Three malpositioned screws and one dural perforation occurred in the PPSG, and one malpositioned screw with a dural tear occurred in the OPSG. Five deep infections developed in the OPSG, all requiring surgical debridement. The postoperative hospital stay was 12.7 ± 9.3 days for the PPSG and 17.7 ± 14.5 days for the OSPG (not significant). During follow-up, loss of correction occurred five times in the PPSG, and three times in the OPSG.

Conclusion: Using percutaneous pedicle screw fixation resulted in less blood loss, shorter surgical duration and a lower number of infections compared to the open technique. Percutaneous pedicle screw fixation is a promising technique to stabilize traumatic spine fractures in selected cases.

Key words: Percutaneous pedicle screw fixation, trauma, surgical treatment.

Level of Evidence: Retrospective case- control study, Level II.

ÖZET:

Amaç: Bu çalışmada travmatik torakolomber kırığın, perkütan pedikül vida fiksasyonu ile tedavi edilen 24 hasta ve bunlarla eşleştirilmiş aynı patolojiye yönelik açık pedikül vida fiksasyonu ile tedavisi yapılmış 24 hastanın kısa dönem sonuçları karşılaştırılmıştır.

Geçmiş Bilgiler: Pedikül vida implantları hızlı ve uygun stabilizasyonlar sağlamalarına karşın, geniş yumuşak doku diseksiyonu gerektirmektedirler. Perkütan olarak konulan vidalar cerrahi travmayı azaltabileceklerdir.

Araç ve Yöntem: Karşılaştırma toplam 24 hastadan oluşan perkütanöz pedikül vida grubu(PPVG) ile bu gruba eşleştirilmiş yine 24 hastadan oluşan açık pedikül vida fiksasyonu grubu (APVG) arasında yapılmıştır. Cerrahi süresi, kan kaybı, hastanede kalış ve komplikasyon parametreleri karşılaştırılmıştır.

Bulgular: Her iki grupta erkek cinsiyeti %58 iken, ortalama yaş PPVG de 48.7 ve APVG de 47.1 olmuştur. Gruplar arasında istatiksel olarak anlamlı fark bulunmamıştır. Ortalama takip süresi PPVG'de 14.0 ay ve APVG'de 17.3 aydır. Her iki grupta kırıkların çoğunluğu nörolojik defisit olmayan tip-B (AO sınıflandırmasına göre fleksiyon/distraksiyon/ekstansiyon) yaralanma şeklinde görülmüştür. İstatiksel olarak anlamlı ortalama kan kaybı tespit edilmiştir (50 ml PPVG'de, 500ml APVG'de; $p<0.001$). PPVG'de cerrahi süre 103.2 ± 24.6 (aralığı 68-169) dakika ve APVG'de 142.0 ± 45.4(aralığı 95-270) dakika şeklinde olmuştur ($p<0.001$). PPVG'de üç vidada yanlış yerleştirilme ve bir dura delinmesi gelişirken, APVG'de bir vida yanlış yerleştirilmesi ve bir dura yırtığı gelişmiştir. Beş derin enfeksiyon APVG de görülürken tamamına cerrahi debridman uygulanmıştır. Postoperatif hastanede kalış süresi PPVG de 12.7 ± 9.3 gün ve APVG de 17.7 ± 14.5 gün şeklinde olmuştur(istatiksel olarak anlamlı değildir). Takip boyunca koreksiyonda kayıp PPVG de beş kez, APVG de üç kez gerçekleşmiştir.

Sonuç: Açık teknik ile karşılaştırıldığında perkütan pedikül vida fiksasyonu kullanımı daha az kan kaybına, daha kısa cerrahi süresine ve daha düşük enfeksiyon oranlarına sahiptir. Perkütan pedikül vida fiksasyonu seçilmiş travmatik omurga kırığı vakalarının stabilizayonunda umut vaad eden bir sistemdir.

Anahtar Kelimeler: perkütanöz pedikül vida fiksasyonu, travma, cerrahi tedavi
Kanıt Düzeyi: Retrospektif vaka-kontrollü çalışma, Düzey II

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Received: 6th July, 2012
Accepted: 26th July, 2012

INTRODUCTION:

Although thoracic and lumbar spinal fractures have been treated for many years, there is no consensus on which surgical treatment type should be employed[27,28]. Internal pedicular screw fixation was described by Magerl and Dick in the 1980s and has become the most commonly used technique for spinal fixation[14,28]. Minimally invasive techniques have also been developed for spinal surgery, in parallel with other surgical areas. The first minimally invasive procedures (in addition to the short-lived external pedicular fixators of Magerl et al.) were vertebroplasty and balloon kyphoplasty, which allow the vertebral body to be reached by percutaneous and transpedicular ways[16,17,21]. The next step in minimally invasive surgery was the development of implant systems depending on the use of percutaneous pedicle screws, as described by Foley et al. in 2001 for degenerative indications[1]. Initially, this technique was combined with anterior lumbar interbody fusion[1,13]. The use of percutaneous pedicular screw stabilization alone was then also defined[2-5,11,18-20]. This technique has been accepted as relatively safe, with a replacement rate of incorrect screws between 6% and 30%, and below 10%[4,12,22,25,29]. This technique, by using stab incisions instead of a midline approach and paraspinal muscle dissection, provides a decrease in the blood loss and shortens the surgery and hospitalization periods. The first experiences with this technique have been published, but there are few publications comparing percutaneous pedicular screw fixation and conventional open pedicular screw fixation for traumatic indications[4,5,10]. Therefore, the aim of this study was to evaluate any superiority of the percutaneous technique to the standard open technique for traumatic spinal fractures. In this study, the aim was to compare the paired short-term results of 24 patients who received percutaneous pedicle screw fixation and 24 patients who received open pedicle screw fixation. Our hypothesis was that the percutaneous technique would result in less blood loss, a shorter duration of both surgery and hospitalization and fewer complications, when compared to the standard open technique.

PATIENTS AND METHODS:

We have been using a percutaneous screw fixation technique in our center, particularly for type B fractures, since December 2005. For this study, we have taken the results of the first 25 patients who received this technique. One patient, who died due to traumatic brain injury during the hospitalization period, was excluded from the study since no follow-up could be made. The information in our spinal trauma information network (that includes all spinal trauma patients between 2003 and 2008) was scanned to compare the 24 patients in the percutaneous pedicle screw group (PPSG) and 24 patients who received open pedicle screw fixation (OPSG). The patients from our database who were most appropriate to compare with the patients who received the percutaneous method were determined by evaluating the gender, age, fracture type, trauma seriousness and ASIA scale. Those paired 24 patients were the ones who received routine open pedicle screw fixation, and all were treated in the first three weeks of the trauma and received stabilization with only a posterior approach. Three different fracture levels were determined: thoracic (T1–10), thoracolumbar (T11–L2), and lumbar (L3–5). At least two different injuries also required hospitalization as they were detected as polytrauma or high-energy trauma due to an acceleration/deceleration of a

speed difference of at least 40 km/h, or falling from a 2 m height. Short- or long-segment instrumentation was used as appropriate, and long-term instrumentation was described as that bridging more than two disc areas[24,28].

Surgical Technique:

All the patients in the PPSG were treated by two experienced surgeons under fluoroscopy with a free hand technique, using the system developed for percutaneous pedicle screw fixation (CD Horizon Longitude, Medtronic Sofamor Danek). All the patients were given 2 g of cefacidal as antibiotic prophylaxis, and were operated on in a facedown position and under general anesthesia by using thoracic and pelvic supports to provide postural fracture reduction. When the correct vertebral and pedicular levels were determined with C-arm fluoroscopy, stab incisions were performed. Jamshidi bone needles followed by K-wires were placed in the pedicles of the spinal bodies successive to the fracture. Screws, bonded to the screw lengtheners by drilling above the K-wires, were placed into the pedicles. Pedicle screws with diameters of 5.0 and 7.5 mm and lengths of 30 and 50 mm were used. The slopes of the rods were determined by the surgeon and prepared accordingly. The rods were placed from cephalic to caudal with administered stabilizations (Figure-1).

After placement, the rods were immobilized and the accuracy of the implants' positions was checked. The skin was then closed with suture material (Figure-2).

After postural reduction, in cases with multi-sectional displaced last plaque fractures, the defined technique and the last plaque reduction with balloon (BAER) technique were combined for the reduction of the last plaque fractures and for filling the gap in the spinal body[17].

The patients in the OPSG received the routine open pedicle screw instrumentation technique, including the bone grafting procedure and appropriate BAER procedures, when necessary, under antibiotic prophylaxis. While all the patients in the OPSG were protected with a brace for 6 and 8 weeks postoperatively, no brace was used for stabilization for most of the patients in the PPSG.

Figure-1. The placement of the rod by a cephalic way, eight screw lengtheners can be observed.

Figure-2. View of the incision after rod placement.

The mean follow-up period was 14.0 months in the PPSG (range: 6–27 months) and 17.3

months in the OPSG (range: 1–35 months). The parameters determined before the study were age, gender, fracture level, accompanying disease, prescribed drug use, blood loss during the operation, operation duration, hospitalization period, complications, re-operation, neurological condition and radiological evaluation (Table-1). The preoperative and postoperative Cobb angles were measured independently by two authors by using the PACS (picture archiving communication system) software.

Statistics:

For the comparison of the continuous result measurements of the two groups, an independent sample t-test was used, and for the determination of the statistical difference of variables separated into two parts, Fisher's Exact test was used. Statistical significance was determined as $p<0.05$.

RESULTS:

The male ratio of both groups was 58%. The mean age of the PPSG was 48.7 (range: 19–85) and the mean age of the OPSG was 47.1 (range: 21–75) (Table-2).

In the preoperative neurological examination, in the PPSG, 21 patients were ASIA E (87.5%) and three patients were ASIA A (12.5%)[15]. In the OPSG, 19 patients were ASIA E (79.1%), three patients were ASIA D (12.5%), one patient was ASIA C (4.2%), and one patient was ASIA A (4.2%).

The fracture levels of the PPSG patients were detected as thoracic for six patients, thoracolumbar for 17 patients, and thoracolumbar and lumbar fractures together for one patient (T12 and L3). In the OPSG, the fracture levels were thoracic for six patients, thoracolumbar for 15 patients, lumbar for one patient, and both thoracolumbar and lumbar vertebral fractures were detected in two patients. While 79% of the PPSG patients were injured by high-energy trauma, 75% of the OPSG patients were detected to have high-energy trauma. Multiple injuries were detected in 62.5% of the PPSG patients and 41.7% of the OPSG patients.

While the fracture types of the PPSG patients, according to the AO classification, were 29% A, 67% B and 4.0% C, the AO fracture types in the OPSG patients were 41.6% A, 54.2% B and 4.2% C. On evaluation with the Fisher's exact test, no statistically significant differences were found between the preoperative parameters of the two groups. On average, four screws (4–10) were placed in both groups (Figures-3 and 4).

The BAER procedure was administered to seven patients in both of the groups. While the mean blood loss was 50 ml with the percutaneous method, it was 500 ml with the open pedicular screw method ($p<0.001$).

The mean operation duration was 103.2 ± 24.6 (range: 68–169) minutes in the PPSG, including seven percutaneous BAER procedures and one mini open decompression procedure.

Table-1. Previously determined working parameters

Age	Years
Gender	Male/Female
Fracture Level	Thoracic: T1–10, Thoracolumbar: T11–L2, Lumbar L3–5
Accompanying Disease	Relevant, for instance diabetes, cardiovascular disease, spinal diseases
Drug Use	Analgesic, cardiovascular drugs, drugs affecting bone formation and destruction
Blood Loss	Milliliters, the amount indicated by the spinal surgeon in the surgical report
Operation Duration	Minutes, the time passed from the first incision to the closure of the wound indicated by the anesthesiologist in the surgical report
Complications	Postoperatively reported all complications, for instance infections, cardiovascular /respiratory problems
Revisions	Surgeries after the first spinal stabilization (screw re-localization or surgery for infections)
Radiological Evaluation	The follow-up radiographies were evaluated at 1, 6 and 12 weeks postoperatively and the Cobb angles in the 1st year. The changes in the Cobb angle were summarized in four categories:
	• No change • <10° increase • 10–15° increase • >15° increase

Table-2. Base Data Table

	PPSG (n=24)	OPSG (n=24)
Percentage of males	58	58
Age in years (range)	48.7 (19–85)	47.5 (21–75)
ASIA-scale (A/B/C/D/E)	3/0/0/0/21	1/0/1/3/19
High energetic trauma (%)	79	75
Multi-trauma (%)	62.5	41.7
Fracture Level (Th/TL/L)*	6/18/1	6/17/3
AO-Classification (A/B/C)	7/16/1	10/13/1

* Total is greater than 24 due to patients with multiple fracture levels.

The mean operation duration for the OPSG was 142.0 ± 45.4 (range: 95–270) minutes, and it included seven additional BAER procedures and ten decompression procedures. While long-segment instrumentation was administered to 33% of the PPSG patients, this rate was 29% for the OPSG (Table-3).

Complications:

Three screws were malpositioned in the PPSG and one possible dura puncture was observed. One screw was revised during surgery and the other two were left in the same position. The incorrect screw localization was 2.5% (3/119 screws). The dural puncture did not require any surgical evaluation in the follow-up and did not cause any clinical findings. One screw was incorrectly localized in the OPSG and there was a laceration in the dura. The dural lesion was recovered surgically, while no procedure was administered to the screw.

Five deep infections were detected in the OPSG in the postoperative period, and surgical treatment was required (removal of the implant to control infection in one patient), while no infection was observed in the PPSG (Table-4).

The postoperative hospitalization period was 12.7 ± 9.3 (range: 3–34) days for the PPSG, and 17.7 ± 14.5 (range: 5–83) days for the OPSG. No secondary neurological worsening was detected in any of the patients. During the follow-up, pain developed in one patient due to the implants, and the implants were removed with minimally invasive surgery. The implants of all other PPSG patients remained *in situ*.

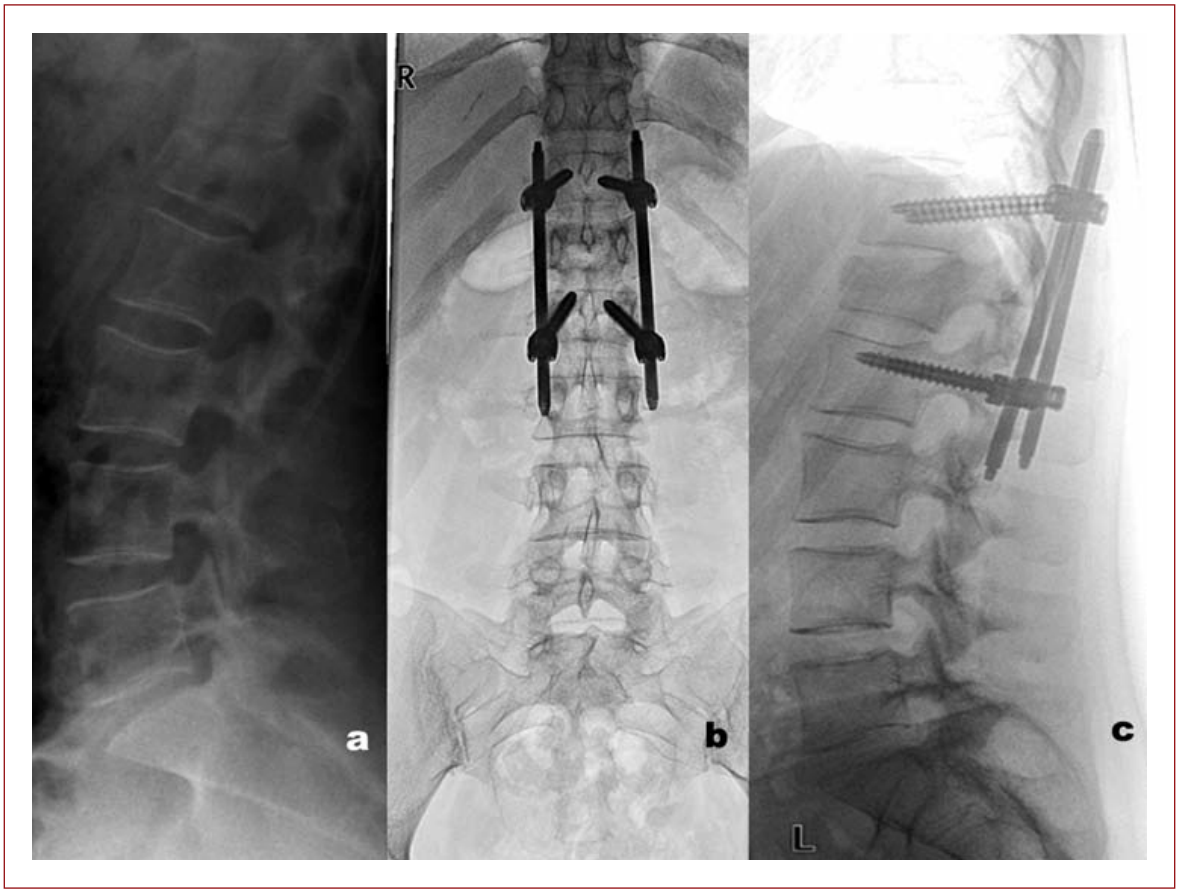

Figure-3.a. Preoperative lateral radiography of a patient with a Magerl Type-A.3 fracture in L1 **b.** AP radiography after T12–L2 percutaneous short instrumentation, **c.** Lateral radiography after T12–L2 instrumentation.

In the OPSG, the implant of one patient was removed due to a deep infection, and the implants of five patients were removed electively.

Radiological Evaluation:

Comparison of the radiographies of the two groups was performed. First year radiographic follow-ups were not performed for twelve patients (six from each group).

From the remaining 18 patients in the PPSG (75%), a fixed Cobb angle was detected for five patients, and a worsening Cobb angle was detected for 13 patients.

Figure-4.a-b. The view of long percutaneous screw instrumentation performed for T12 and L3 fractures (T11-L4). Seven screws in total were placed into the pedicles.

In the OPSG, on the other hand, while a fixed Cobb angle was observed for two patients, a worsening Cobb angle was detected for 16 patients, of which 13 had less than 10° of worsening and three had 10–15° of worsening. The reasons for Cobb angle worsening were analyzed radiographically, and it was detected that the worsening in the PPSG was due to an increased angle in the screw-rod joint for three patients, the migration of lower screws for one patient, and the pull-out of the upper screws for one patient.

The reasons for the worsening of the Cobb angle in the OPSG were detected as the pull-out of the lower screws for two patients, and the deformation of the rod without an increase in the screw-rod angle for one patient.

DISCUSSION:

In this short-term study, a group of 24 patients treated with percutaneous pedicle screw fixation were compared to a group of 24 patients treated with conventional open pedicle screw fixation for traumatic spinal fractures, to determine which group had a shorter operation duration, fewer complications and a shorter hospitalization period. The results suggest that the percutaneous method may be superior to the standard method in terms of blood loss, operation duration, and postoperative infections. No neurological worsening or implant deficiency developed in any patients. However, when comparing the two groups, no significant difference was found in the hospitalization period or complications.

In previous publications, it has been reported that percutaneous pedicle screw fixation has been used for degenerative and traumatic indications.

In most studies, combined posterior and anterior interbody fusion was used as the treatment for patients with traumatic fractures, and it was concluded that an open approach is required, and therefore the potential advantage of the method decreased[1,3,9,12,13,22]. The difference in operation duration between our groups can be explained due to the important role of neural decompression and iliac autografting, which are the procedures causing time loss with large muscle dissection in the open group. In the OPSG, nine more decompressions and 24 more iliac autografts were performed than in the PPSG. If we compare our groups with other published surgical durations, there is a need to evaluate seven additionally-performed kyphoplasty procedures.

Table-3. Surgical Information

	PPSG (n=24)	OPSG (n=24)
Mean blood loss (ml)	50	500
Mean blood loss (ml)	52.3 ± 10.4 (50–100)	603.1 ± 471.8 (150–2000)
Operation duration min. BAER	103.2 ± 24.6 (68–169)	142.0 ± 45.4 (95–270)
Procedure	7	7
Decompression	1	10
Long Segment Instrumentation (%)	33	29.2
Mean screw number	4 (4–8)	4 (4–10)

Table-4. Complications

	PPSG (n=24)	OPSG (n=24)
Incorrectly localized screw	3	1
Dura Puncture/Laceration	1	1
Superficial Infection	0	1
Prolonged Wound Area Leakage	1	2
Deep Infection	0	5
Pneumonia	3	4
Urinary System Infection	1	6
Decubitus Ulcer	0	2
Bladder Retention	1	3
ARDS	0	2
Dyspnea	3	0
Bacteremia	1	1
Ileus	0	2
Constipation	1	0
Renal Failure	1	1
Delirium	1	1
Unknown	3	8

Oner et al. reported that this procedure extends the operation time by 20 minutes[17].

Additionally, long instrumentation and more screws were used in a high number of patients (n=8) in the PPSG, which increased the operation time. One patient in the PPSG also received decompression, leading to the longest operation time in the group (169 minutes). This increased the mean operation time to 103 minutes. While the mean published operation time is between 42 and 120 minutes, the duration has a range of between 14 and 275 minutes[1,3-7,10,15,18-22,25,29].

Early stabilization of the spinal fracture is advantageous and is recommended[23,26]. As there was spinal injury in 13% and 30% of the traumas, fast and early stabilization with minimally invasive surgery is seen to be a promising treatment choice, and by administering this successfully in injury-controlled surgery, it can be used as part of the ATLS instruction[26].

The limited blood loss seen in the PPSG was because paraspinal muscle dissection of a large area was generally not performed, and this provides a comparison, particularly with positive data, for near-time systematic evaluation. Our results show consistency with the blood loss values of 40 ml and 70 ml that are frequently indicated in the literature[4,6,9,10,20,22,31].

While the number of infections seen in the PPSG was zero, there were five infections in the OPSG (20.8%). We consider this rate (which is not statistically significant) of deep infection seen in the open group to be higher than expected (the published rate is <3%), and we still do not have a satisfactory explanation for this phenomenon. Since this study is a case-control study consisting of small groups, and is not a randomized controlled trial, the infection rates may show deviations. If our groups were larger, the difference in the infection rate would be smaller. We believe that the lack of infection in the PPSG has a clinical importance[4,18,20,30].

The fact that the number of multi-trauma patients was high in the two groups blocked evaluation of the success of the percutaneous method in giving a shorter hospitalization period (there was no statistically significant difference between the hospitalization period or the postoperative hospitalization period). The multi-trauma patient rate was different in each of the two groups: 41.7% in the OPSG and 62.5% in the PPSG (however, this difference was not statistically significant). Most of the multi-trauma patients required additional surgical procedures, which increased the hospitalization period and complication rates. This explains the long hospitalization periods for both groups, which was 12.7 days for the PPSG and 17.7 days for the OPSG.

Multiple complications developed in one patient in each group, a total of two patients. However, while there were no complications for most of the patients in both groups, infections (such as bladder retention/infection or pneumonia) were generally seen in the OPSG.

A certain disadvantage of this stabilization technique is that it does not allow neural decompression and/or spondylodesis with direct fracture reduction. This limits the number of indications which the method is suitable for, and also explains the preoperative neurological status of the patients in our experimental group (those chosen without deficit or with full deficit). Decompression can be administered by the mini open method (this formed in one patient in the PPSG). The same fracture reduction is not possible using the open technique, but there is a possibility of positioning the patient on the operating table and making the reduction[11]. Although there were no statistically significant differences between the two groups, the neurological status of the groups shows homogeneity.

This makes a good evaluation difficult and is one of the limitations of the study. Although generally seen less frequently, most of the patients in the PPSG were treated for AO type-B fractures, and this was attributed to our habit of administering conservative treatment to most AO type-A fractures. This limited the generalization of our results. In addition to the limitations of this study, the fact that it is a retrospective study, the short follow-up period for the percutaneous pedicular group, the small size of the compared groups and the lack of follow-up for six patients in each group might be added. Evaluation of the Cobb angles of each group in the follow-up showed that the

postoperative values were more constant for the OPSG than for the PPSG.

An increase in the Cobb angles was determined for five patients in the PPSG and in three patients in the OPSG, a total of eight patients. There are different reasons for this situation. Most of the increases in the PPSG were due to the deterioration of the screw-rod connection angle, while most in the OPSG were found to be due to screw pull-out or loosening.

The reason was not secondary vertebral collapse for any of the patients with an increase in the Cobb angle of greater than 10°.

In conclusion, the percutaneous pedicular screw fixation method displayed promising results in terms of blood loss and operation duration. The appropriate indications and long-term clinical follow-up results should be evaluated in future randomized clinical studies. This minimally invasive method, which saves time, will be able to be used as part of damage-controlled surgery.

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