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Comparison of plate and compression screw in the treatment of hallux rigidus with arthrodesis: a retrospective study

Ahmet Yurteri[1], Numan Mercan[2], Ahmet Yıldırım[3]

[1]Department of Orthopaedics and Traumatology, Konya City Hospital, Konya, Türkiye, [2]Department of Orthopaedics and Traumatology, Necip Fazıl City Hospital, Kahramanmaraş, Türkiye, [3]Department of Orthopedics and Traumatology, University of Health Sciences, Health Application and Research Center, Konya, Türkiye

ABSTRACT

Objectives: Although numerous surgical techniques and fixation methods have been described for the treatment of hallux rigidus (HR) with arthrodesis, consensus on the gold standard treatment has not been reached. The aim of this study is to retrospectively compare the clinical and radiological outcomes of compression screw fixation and plate fixation in the treatment of HR with arthrodesis.

Methods: Patients who underwent arthrodesis surgery due to HR between January 2021 and December 2023 at a single center were retrospectively reviewed. Patients who met the inclusion criteria were divided into two groups: those who underwent arthrodesis with plate fixation (PLATE) and those who underwent arthrodesis with compression screw fixation (SCREW). Demographic data including age, gender, affected side, operative time, hallux valgus angle (HVA), dorsiflexion angle, AOFAS scores, and implant irritation data were compared among patients with at least 3 months of follow-up.

Results: It was observed that all patients included in the study had successful bone union without any complications. There were no significant differences between the two groups in terms of age, gender, affected side, preoperative HVA, and preoperative AOFAS scores (P= 0.970, P= 0.426, P= 0.694, P= 0.216, and P= 0.905, respectively). The mean operation time and postoperative AOFAS score were lower in the PLATE group compared to the SCREW group (P=0.006 and P=0.004, respectively). However, in the SCREW group, the dorsiflexion angle and the rate of implant irritation were lower compared to the PLATE group (P=0.016 and P=0.01, respectively).

Conclusions: In the surgical treatment of HR, both plate fixation arthrodesis and compression screw arthrodesis are reliable surgical techniques. While plate fixation arthrodesis is a faster and more practical method, arthrodesis with a compression screw results in fewer complaints related to the implant and provides a more functional recovery.

Keywords: Hallux rigidus, arthrodesis, treatment, plate, compression screw

Corresponding author: Ahmet Yurteri, MD.,
Phone: +90 332 310 50 00, E-mail: op.drahmetyurteri@gmail.com

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Hallux rigidus (HR) presents as a clinical condition characterized by limited mobility and pain due to arthrosis of the first metatarsophalangeal joint (MPJ1) [1-3]. The MPJ1 actively participates in the propulsion phase of the gait cycle. However, in various pathological conditions, often painful conditions, this joint can be completely disrupted, leading to a decrease in range of motion (ROM) and restriction of function. At this point, first metatarsophalangeal arthrodesis (MPA1) emerges as a long-standing surgical technique [4-6]. This surgical procedure is preferred to alleviate pain and restore functional activity. It is particularly effective in the treatment of various pathologies, such as HR and severe hallux valgus (HV). However, the success and outcomes of this surgery may vary depending on the techniques employed [7-9].

The MPA1 procedure can vary depending on the type of joint surface resection and fixation method. For instance, these surgeries may rely on different types of joint surface resections, such as flat, concave, or convex, and various fixation methods, including screws, plates, or staples [10-12]. These different techniques can affect the effectiveness and outcomes of the surgical procedure. In most cases, equipment containing a compression system, such as dorsal plates or compression screws, is used for performing MPA1 procedures. However, there is still a lack of widespread consensus among surgeons specializing in foot surgery regarding which method should be considered the gold standard. This situation demonstrates ongoing debates and various perspectives concerning the practical applications of the gold standard [11, 13, 14].

We aim to evaluate the clinical and radiological outcomes by comparing patients undergoing arthrodesis with dorsal plate versus compression screw fixation for MPA1.

METHODS

Ethics Committee Approval and Study Design

The study was initiated after obtaining approval from the Necmettin Erbakan University Ethics Committee with decision number 2023/4836 and conducted in accordance with the principles outlined in the Helsinki Declaration. A retrospective study design was developed to compare the clinical and radiological outcomes of patients undergoing arthrodesis with either a plate or compression screw for MPJ1. Patients diagnosed with symptomatic MPJ1 osteoarthritis between January 2021 and December 2023, who subsequently underwent arthrodesis surgery, were examined. Among these patients, demographic data including age, gender, follow-up duration, affected extremity side, and operation duration were recorded. Patients meeting the inclusion criteria were divided into two groups: those who underwent arthrodesis with plate

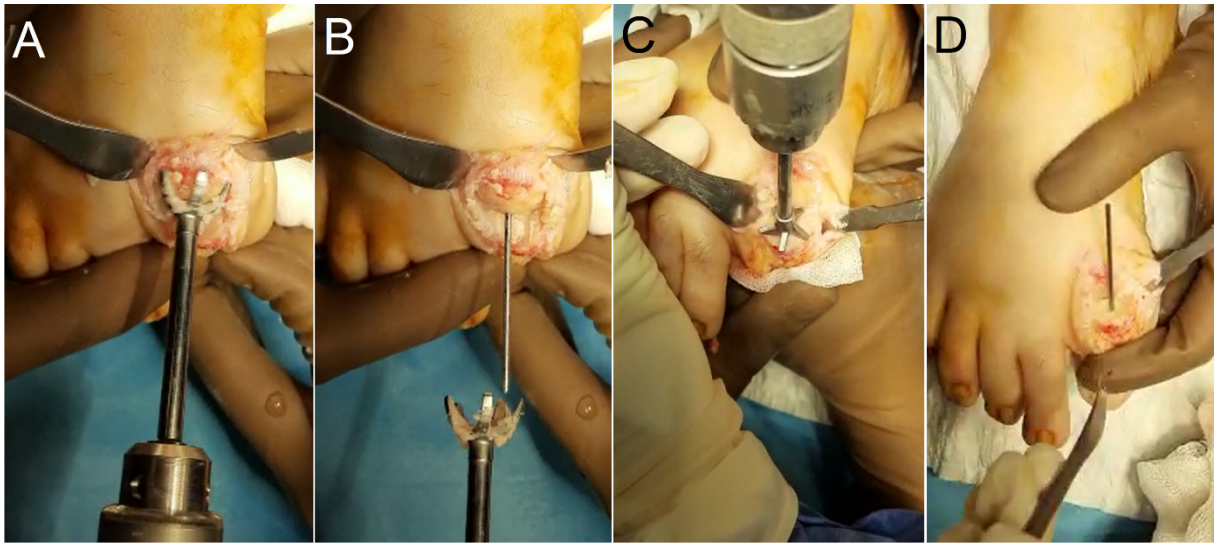

Fig. 1. Preparation of ball-cup (convex-concave) arthrodesis surfaces in the screw group.

fixation (PLATE) and those who underwent arthrodesis with screw fixation (SCREW).

Inclusion and Exclusion Criteria

Patients with severe HV defined by an M1/P1 angle greater than 40°, inflammatory diseases (rheumatoid arthritis), or recurrence of HV deformity (secondary surgery), as well as patients with intellectual or mental disorders and those lost to follow-up, were determined as exclusion criteria.

Surgical Procedure

All surgical procedures were performed by a surgeon following antibiotic prophylaxis (1 gram IV cefazolin) and ensuring necessary sterile conditions. After applying a tourniquet to the patient's thigh, an incision was made approximately 0.5- 1 cm above the junction of the dorsal and plantar surfaces at the level of the MPJ1, from the superomedial aspect of the toe. Capsulotomy of the MPJ1 was performed, and osteophytes around the joint were excised. Up to this point, the surgical procedure was similar for both techniques.

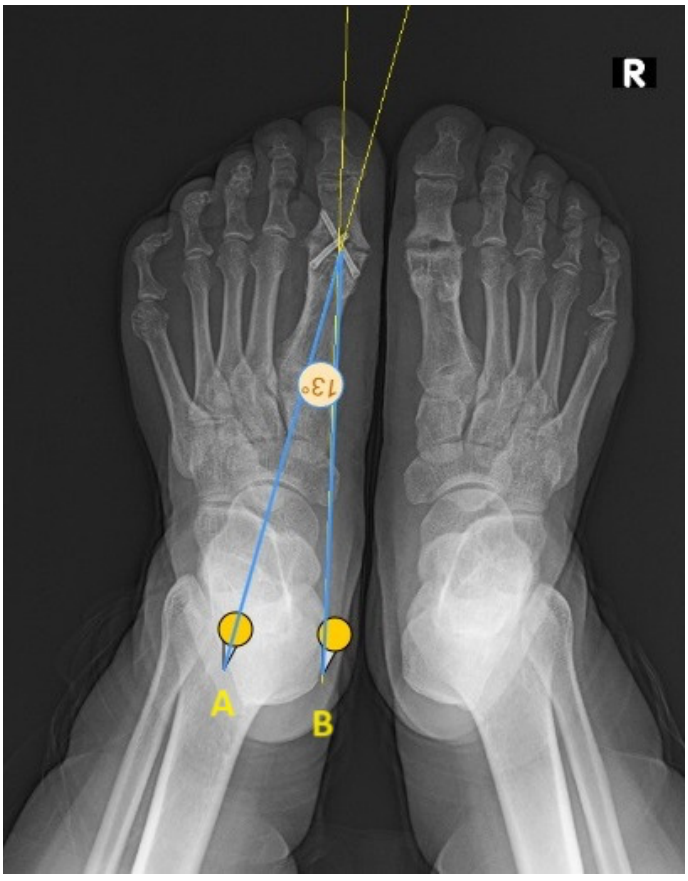

Fig. 2. Hallux valgus angle measurement. (A) 1. Metatarsal diaphyseal axis; (B) Proximal phalanx diaphyseal axis.

For the PLATE group, the distal articular surface of the first metatarsal and the proximal phalanx were excised with osteotomy, and stabilization for osteosynthesis was achieved by placing a plate and locking screws on the dorsal surface under fluoroscopic guidance. In the SCREW group, the articular surfaces were prepared using a motorized concave-convex drilling technique, guided by a previously aligned K-wire, which was aligned with the diaphyseal axis of the first metatarsal and the first phalanx of the hallux. Reamirization of the articular surface continued until pinpoint bleeding was observed in the subchondral bone (Fig. 1A-D). Subsequently, fixation for osteosynthesis was achieved under fluoroscopy with two compression screws. In both surgical procedures, arthrodesis was applied with neutral rotation, 5°-15° valgus, and a dorsiflexion angle of a 5°- 15° according to the ground (20°- 25° relative to the first metatarsal).

After confirming the position of arthrodesis and fixation material under radioscopic control, the skin was closed with 4.0 monofilament sutures, and a compressive bandage was applied to the foot and ankle. The same rehabilitation program was applied for both surgical procedures; patients were advised to use a splint for three weeks postoperatively and were instructed not to bear weight on the operated extremity during this period. After this time, they were allowed to bear weight with the assistance of rigid-soled shoes for four weeks, followed by gradually transitioning to normal shoes with weight-bearing allowed thereafter.

Radiological and Clinical Evaluation

X-ray images were taken with weight-bearing on the affected toe to measure the preoperative and postoperative hallux valgus angle (HVA) and postoperative dorsiflexion angle (DFA). The HVA measurement is determined as the angle formed between the line indicating the longitudinal axis of the first metatarsal bone and the line indicating the longitudinal axis of the proximal phalanx on the dorsoplantar radiograph (Fig. 2). The DFA is determined as the angle formed between the line indicating the longitudinal axis of the first metatarsal bone and the line indicating the longitudinal axis of the proximal phalanx on the lateral radiograph (Fig. 3). To evaluate patients' functional capacities, preoperative and postoperative AOFAS

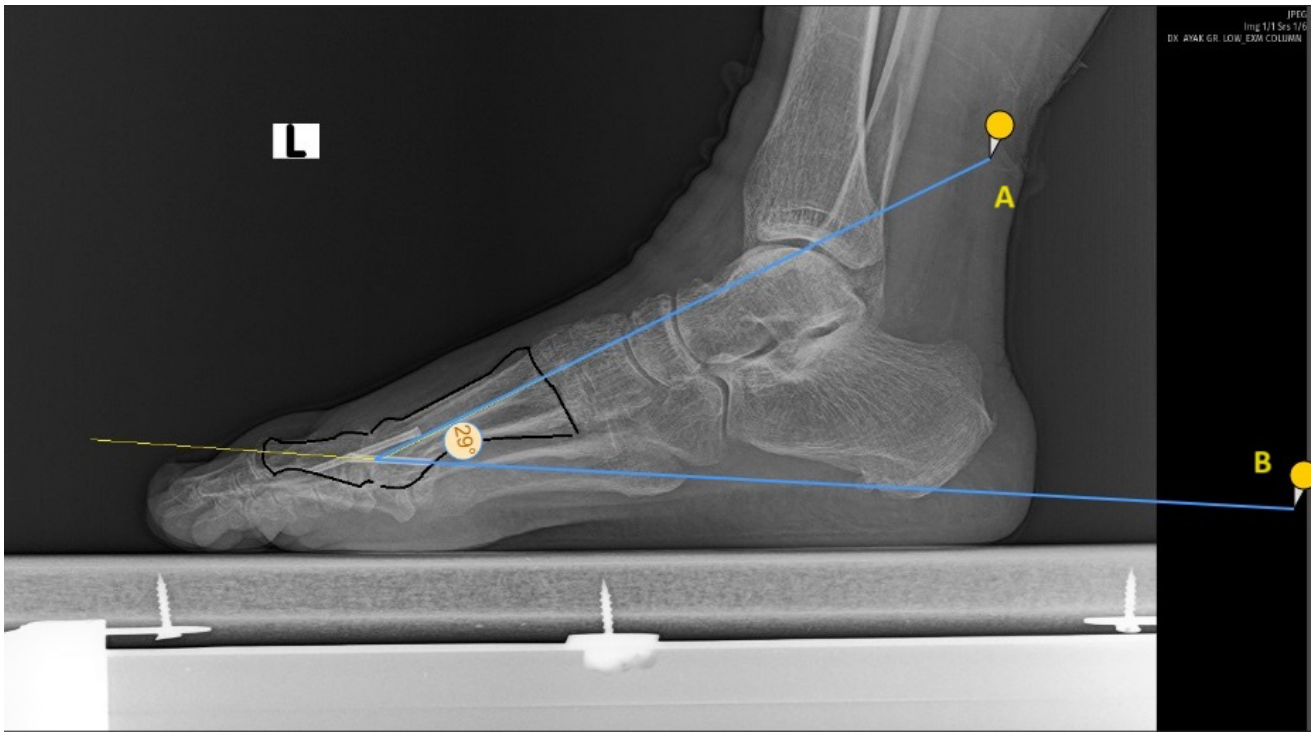

Fig. 3. Dorsiflexion angle measurement. (A) 1. Metatarsal lateral diaphyseal axis; (B) Proximal phalanx lateral diaphyseal axis.

scores (American Orthopaedic Foot & Ankle Society) were examined. Additionally, patients were questioned about whether the implant used in the postoperative period caused any irritation during their latest follow-up appointments.

Statistical Analysis

The data were analyzed using Stata version 16 statistical software (StataCorp LLC, College Station, TX, USA). All samples were examined together, and the two groups were compared with each other based on the treatment type received. For quantitative variables, the Student's t-test was used, and for qualitative variables, the Chi-square test was employed. A significance level of $P<0.05$ was considered statistically significant.

RESULTS

Out of 47 operated patients, 32 toes (from 31 patients) meeting the inclusion criteria were included in the evaluation. Among them, 14 toes underwent arthrodesis with a plate, while 18 toes underwent arthrodesis with a compression screw. It was observed that all evaluated patients had successful bone union, and there were no major complications such as nonunion, implant failure, or reoperation. Only one patient in the SCREW group experienced intraoperative guide wire breakage, resulting in an intramedullary guide remaining in the first metatarsal, which could not be removed. However, this situation did not cause pain complications in the patient, and successful bone union was observed, so it was considered a minor complication.

The average follow-up duration was 8.42±4.55 (range: 3-19) months in the PLATE group and 7.83±5.84 (range: 3-28) months in the SCREW group, with no significant difference observed between the two groups (P=0.434). In the PLATE group, the mean age was 55.71±12.16 years (range: 38- 74), while in the SCREW group, it was 55.50±8.35 years (range: 42-72), with no significant difference observed between the two groups (P=0.970). The male/female ratio in the PLATE group was 2/12 (14.3%/85.7%), while in the SCREW group, it was 5/13 (27.8%/72.2%), with no significant difference observed between the two groups (P=0.426). The af-

fected extremity side (left or right) in the PLATE group was 3/11 (21.4%/78.6%), while in the SCREW group, it was 6/12 (33.3%/66.7%), with no significant difference observed between the two groups (P= 0.694). The mean operation duration was 37.14±11.03 minutes (range: 25-64) in the PLATE group and 50.44±13.72 minutes (range: 28-71) in the SCREW group, with a significant difference observed between the two groups (P=0.006) (Table 1).

In radiological measurements, the preoperative HVA was 16.29±6.7 (range: 9-29) in the PLATE group and 13.72±8.98 (range: 3-32) in the SCREW group, with no significant difference observed between the two groups (P=0.216). The postoperative HVA was 4.71±2.36 (range: 1-9) in the PLATE group and 3.61±2.38 (range: 0-8) in the SCREW group, with no significant difference observed between the two groups (P=0.206). The change in HVA (preoperative-postoperative) was 11.57±6.81 (range: 3-23) in the PLATE group and 10.11±8.91 (range: 0-31) in the SCREW group, with no significant difference observed between the two groups (P=0.350). The postoperative DFA was 28.79±6.81 (range: 14-36) in the PLATE group and 22.89±6.23 (range: 12-33) in the SCREW group, with a significant difference observed between the two groups (P= 0.016) (Table 1).

In the PLATE group, the preoperative AOFAS score was 28.57±4.58, while in the SCREW group, it was 27.66±6.49, with no significant difference observed between the two groups (P=0.905). The postoperative AOFAS score was 72.14±13.40 in the PLATE group and 85.83±6.47 in the SCREW group, with a significant difference observed between the two groups (P= 0.004). Complaints related to implant irritation were observed in 5 patients (35.7%) in the PLATE group, while none were observed in the SCREW group, indicating a significantly higher rate of implant irritation in the PLATE group (P=0.01) (Table 1).

Table 1. Comparison of parameters of PLATE and SCREW group

Parameter	PLATE group	SCREW group	P value
Age (years)	55.71±12.16 (38-74)	55.50±8.35 (42-72)	0.970[a]
Gender (Male/female)	2/12 (14.3%/85.7%)	5/13(27.8%/72.2%)	0.426[b]
Side (Left/right)	3/11 (21.4%/78.6%)	6/12 (33.3%/66.7%)	0.694[b]
Operation time (minutes)	37.14±11.03 (25-64)	50.44±13.72 (28-71)	**0.006[a]**
Follow-up duration (months)	8.42±4.55 (3-19)	7.83±5.84 (3-28)	0.434[b]
Preoperative HVA	16.29±6.7 (9-29)	13.72±8.98 (3-32)	0.216[a]
Postoperative HVA	4.71±2.36 (1-9)	3.61±2.38 (0-8)	0.206[a]
HVA change	11.57±6.81 (3-23)	10.11±8.91 (0-31)	0.350[a]
DFA	28.79±6.81 (14-36)	22.89±6.23 (12-33)	**0.016[a]**
Preoperative AOFAS score	28.57±4.58	27.66±6.49	0.905[a]
Postoperative AOFAS score	72.14±13.40	85.83±6.47	**0.004[a]**
Implant irritation	5 (35.7%)	0 (0%)	**0.010[b]**

Data are shown as mean±standard deviation (minimum-maximum) or n (%). HVA=Hallux valgus angle, DFA=Dorsiflexion angle, AOFAS=American Orthopaedic Foot & Ankle Society

[a]Mann-Withney U test, [b]Fisher's exact test

DISCUSSION

Both plating and compression screw procedures are reliable surgical treatments for treating HR with arthrodesis. Although plating is a quicker and more convenient method, it has been shown that compression screw arthrodesis leads to fewer issues connected to the implant and offers superior functional recovery. Similarities were observed between the two groups in terms of age, gender, follow-up duration, preoperative and postoperative HVA, HVA change, and preoperative AOFAS scores. The only advantage that could be considered for those undergoing arthrodesis with a plate was the shorter operation duration. The main advantages observed for those undergoing arthrodesis with a compression screw compared to those with a plate were higher postoperative AOFAS scores, fewer complaints related to implant irritation, and DFA being closer to the optimal angle range. These results not only support the safe use of both surgical techniques in the treatment of HR with arthrodesis but also suggest that patient satisfaction is higher in arthrodesis with a compression screw prepared with ball-cup reaming.

In our study, the mean age of the included patients was 55 years, and the predominance of female gender was consistent with previous studies [14-16]. Furthermore, prior studies have demonstrated high fusion rates for MPA1, with Coughlin *et al*. [17] reporting 98%, Flavin *et al*. [18] reporting 100% fusion rates, and Goucher *et al*. [19] reporting 92%. Our study's finding of 100% fusion in the included patients aligns with these previous findings in the literature. However, Besse *et al*. reported a fusion rate of 74% in a series of 54 MPA1 cases using pure titanium staple fixation with ball and cup reamers [20]. This result suggests that both compression screws and plates provide more stable fixation in MPA1 compared to staples.

Various arthrodesis techniques have been reported in the literature, including cross-screw fixation, staple fixation, single interfragmentary screw fixation, dorsal compression plating, and combined plate and screw fixation [11, 13, 14, 21]. Additionally, differences exist in the preparation of joint surfaces for arthrodesis, such as plane cuttings or conical reaming. Curtis and Politi reported in their cadaver study that conical preparation with interfragmentary screw fixation provides more rigid stabilization compared to both dorsal plating with plane resection and interfragmentary screw fixation [22, 23]. However, Neri *et al*. [16] indicated in their study that joint surfaces prepared with plane resection offer the possibility of arthrodesis in the optimal position without shortening of the first ray. In our study, successful fusion was observed in both types of arthrodesis, indicating that both treatment methods can be safely applied. However, the gold-standard technique remains controversial. Our study suggests that the SCREW technique (conical preparation + interfragmentary screw fixation) is advantageous, as it is associated with fewer complaints related to implant irritation and better AOFAS scores. A disadvantage of this technique is that placing two compressive screws in the appropriate position for the MPJ1 is more challenging and time-consuming compared to plating for arthrodesis.

Postoperatively, there was an average increase of approximately 44 points in the AOFAS score for the PLATE group and 58 points for the SCREW group compared to preoperative scores. Goucher *et al*. [19] reported a 31-point increase in AOFAS score after MPA1 based on conical preparation and dorsal plating fixation. While the increase in AOFAS score in our PLATE group was close to 44 points postoperatively, the notable increase of 58 points in the AOFAS score in the SCREW group in our study is worth mentioning. We believe there are two reasons for this discrepancy. Firstly, Goucher *et al*.'s [19] study included a variety of indications for arthrodesis (such as HV and HR), whereas our study focused solely on patients diagnosed with isolated HR. This is significant because the symptom of pain in HR patients is more prevalent than the deformity seen in HV. Another factor is that Goucher *et al*. [19] performed arthrodesis solely with plating, which inevitably increases the likelihood of implant irritation and decreases satisfaction rates.

In our radiological evaluation, the change in HVA was 11.5° in patients undergoing arthrodesis with plates and 10.1° in those with compression screws, showing a lower angle change compared to the literature. The angle change was larger in studies by Pydah *et al*. [24] (22.6°), Besse *et al*. [20] (25°), and Neri *et al*. [16] (23.2°- 20.4°). We attribute the larger angle change in these studies to the inclusion of patients with severe HV undergoing arthrodesis, whereas in our

study, only patients with MPJ1 osteoarthritis were included. Postoperative DFA was 28.7° in patients with plate arthrodesis and 22.89° in those with compression screw arthrodesis. In a study by Jarabo *et al*. on MPA1, DFA was 21.15° in patients using compression screws along with plates, while it was 28.44° with only plate usage. These values are similar to those obtained in our study. Another important point here is that DFA was higher only in patients undergoing arthrodesis with plates in both our study and the study by Garcia-Jarabo *et al*. [25]. We believe this is due to the compression forces generated between the dorsal surface of the bone and the plate during arthrodesis with plates, resulting in tensile forces on the plantar surface and thus an increased DFA. In contrast, on surfaces prepared with ball cup reaming, compression screws act as interfragmentary screws along the osteotomy line, resulting in less significant increases in DFA.

Limitations

Our study has some limitations. Being retrospective, lack of recording of intraoperative fluoroscopy time, surgeries performed by multiple different surgeons, and the use of implants from different brands are factors that limit the study.

CONCLUSION

In the treatment of HR with arthrodesis, both plating and compression screw techniques are reliable surgical methods. While plating is a faster and more practical approach, it has been observed that compression screw arthrodesis results in fewer implant-related complaints and provides better functional recovery.

Authors' Contribution

Study Conception: AY; Study Design: AY; Supervision: NM; Funding: N/A; Materials: NM; Data Collection and/or Processing: AY; Statistical Analysis and/or Data Interpretation: AYıldırım; Literature Review: NM; Manuscript Preparation: AY and Critical Review: AYıldırım.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

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