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Comparison between functional bracing and locked intramedullary nailing in isolated and closed humeral shaft fractures

İzole, kapalı humerus şaft kırıklarında fonksiyonel breys ile kilitli çivilemenin karşılaştırılması

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Objectives: We retrospectively compared the treatment results of functional bracing and locked intramedullary nailing for humeral shaft fractures in two similar patient groups.

Patients and methods: Sixty-seven patients were treated conservatively with a prefabricated functional brace (group 1, n=35, mean age 34 years) or surgically with a locked intramedullary nail (group 2, n=32, mean age 37 years) for acute, isolated, and closed humeral shaft fractures. The average time from injury to treatment was five days (range 2 to 11 days) in group 1, and four days (range 1 to 7 days) in group 2. The results were assessed according to the Constant-Murley shoulder scoring system. The mean follow-up was 15.2 months in group 1 and 16.3 months in group 2.

Results: Hospitalization was significantly shorter in group 1 (mean, 7 days *versus* 21 days; p=0.001). The average time to union was 13.4 weeks in group 1, and 13.9 weeks in group 2 (p=0.5). Eleven patients (31.4%) and two patients (6.3%) developed an average varus angulation of 8.5° and 5° in group 1 and 2, respectively. Three patients (8.6%) had apex-anterior angulation (mean 7°), and one patient (2.9%) had 4° apex-posterior angulation in group 1. Three patients (8.6%) in group 1, and two patients (6.3%) in group 2 had abduction losses of less than 10°. External rotation of the shoulder decreased by less than 10° in two patients (5.7%) in group 1 and in two patients (6.3%) in group 2. Shortening (range 5 to 20 mm) developed in four patients in group 1. One patient (2.9%) with a transverse fracture developed nonunion in group 1. Prominence of the proximal end of the nail was seen in two patients (6.3%), one of which required removal. The results were all excellent or good in both groups, with an average score of 86.5 in group 1, and 85.9 in group 2 (p=0.7).

Conclusion: Although both methods offer satisfactory results in the treatment of humeral shaft fractures, we recommend functional bracing as the method of choice unless it is contraindicated.

Key words: Bone nails; braces; fracture fixation, intramedullary/ methods; fractures, closed; humeral fractures; range of motion, articular.

Amaç: Humerus şaft kırıklarının tedavisinde fonksiyonel breys ya da kilitli intramedüller çivi uygulamalarının sonuçları benzer iki hasta grubunda geriye dönük olarak karşılaştırıldı.

Hastalar ve yöntemler: Akut, izole ve kapalı humerus şaft kırığı olan 67 hastanın 35'i (grup 1; ort. yaş 34) özel hazırlanmış fonksiyonel breys ile, 32'si (grup 2; ort. yaş 37) kilitli intramedüller çivilemeyle tedavi edildi. Yaralanmadan tedaviye kadar geçen süre grup 1'de ortalama beş gün (dağılım 2-11 gün), grup 2'de dört gün (dağılım 1-7 gün) idi. Tedavi sonuçları Constant-Murley omuz skorlama sistemine göre değerlendirildi. Ortalama izlem süresi grup 1'de 15.2 ay, grup 2'de 16.3 ay idi.

Bulgular: Grup 1'de hastanede kalış süresi anlamlı derecede kısa bulundu (sırasıyla, ort. 7 gün ve 21 gün; p=0.001). Kaynama grup 1'de ortalama 13.4 haftada, grup 2'de 13.9 haftada gerçekleşti (p=0.5). Grup 1'de 11 hastada (%31.4) ortalama 8.5°, grup 2'de iki hastada (%6.3) 5° varus açılanması meydana geldi. Grup 1'de üç hastada (%8.6) ortalama 7° apeks-anterior açılanması, bir hastada (%2.9) 4° apeks-posterior açılanması görüldü. Grup 1'de üç hastada (%8.6), grup 2'de iki hastada (%6.3) 10 dereceden az abdüksiyon kaybı meydana geldi. İki grupta da ikişer hastada omuz dış rotasyonunun 10 dereceden düşük olmak üzere azaldığı görüldü. Ekstremite kısalığı (dağılım 5-20 mm) sadece grup 1'de dört hastada gelişti. Grup 1'de transvers kırığı olan bir hastada (%2.9) kaynama elde edilememesi üzerine cerrahi uygulandı. İki hastada (%6.3) çivinin proksimal ucunda çıkıntı oluştu ve birinde çivinin çıkarılması gerekti. Sonuçlar her iki grupta da tüm hastalarda mükemmel ya da iyi bulundu; ortalama omuz skoru grup 1'de 86.5, grup 2'de 85.9 idi (p=0.7).

Sonuç: Humerus şaft kırıklarında her iki yöntemle de tatmin edici sonuç alınmasına karşın, kontrendikasyon olmadıkça, fonksiyonel breysin ilk tedavi seçeneği olması gerektiğini düşünüyoruz.

Anahtar sözcükler: Kemik çivisi; breys; kırık fiksasyonu, intramedüller/yöntem; kırık, kapalı; humerus kırığı; hareket açıklığı, eklem.

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Humeral shaft fractures can be treated both by conservative and surgical techniques. Some conservative options such as U-splint, hanging-cast, and Velpeau bandage have disadvantage of long-term immobilization of the adjacent joint(s), resulting in transient inferior subluxation and adhesive capsulitis of the shoulder, and elbow stiffness, which require long-term physical therapy after fracture union.[1,2] After Sarmiento et al.[1] described and used functional bracing for humeral shaft fractures, immobilization of the adjacent joints became unnecessary and most of the problems associated with long-term immobilization were solved.

Most of the humeral shaft fractures can be treated successfully by conservative methods.[1-6] However, in case of contraindication or lack of experience with conservative techniques, surgery may be required. Among several surgical options, the most appropriate technique should be chosen taking into account the need for an anatomic reduction, rigid fixation with minimal soft tissue injury, and early mobilization of the adjacent joints. Interlocking intramedullary nailing seems to meet these necessities.[7-11]

In this retrospective study, we compared functional bracing and interlocking intramedullary nailing to determine the advantages and disadvantages of these two methods in similar patient groups.

PATIENTS AND METHODS

In our institution, fractures of the humeral shaft are treated either conservatively with functional bracing or surgically with locked intramedullary nailing. The choice of treatment is made depending on the general medical status of the patient, the characteristics of fractures, cooperation level of the patient, and experience of the surgeon with the two treatment methods.

The study reviewed the results of treatment in 67 patients who underwent conservative or surgical treatment for acute, isolated, and closed humeral shaft fractures. Of these, 35 patients (group 1; 28 males, 7 females; mean age 34 years; range 19-75 years) were treated with a functional brace, and 32 patients (group 2; 24 males, 8 females; mean age 37 years; range 20-83 years) were treated with a locked intramedullary nail. The localization and type of fractures are summarized in Table I. Patients with multiple injuries, open fractures, neurovascular lesions, and undisplaced fractures were excluded from the study.

In group 1, following resolution of acute pain and swelling and removal of the primary stabilization device (a splint or cast), a prefabricated functional brace was applied (Fig. 1a, b). The average time from injury to the application of brace was five days (range 2 to 11 days). After the application of brace, the patients were taught and encouraged to perform pendulum motion exercises of the shoulder and flexion/extension exercises of the elbow. An arm sling was applied to hold the elbow in 90 degrees of flexion. For the first week, the patients were asked to remove the arm sling at least five times a day and perform passive motion exercises for adjacent joints. At the end of the first week, the arm sling was removed except for bed time, and the patients were asked to perform active shoulder and elbow motion exercises as much as possible. In order to avoid angular deformities especially varus angulation at the fracture site, resting elbow on a surface and shoulder flexion/abduction were not allowed until clinical and radiographic signs of fracture healing were observed. The brace was worn at all times except for personal hygiene. With the exception of one patient, formal physical therapy was not employed after completion of fracture healing.

In group 2, the average time from injury to surgery was four days (range 1 to 7 days) (Fig. 2a). A closed, non-reamed, antegrade nail was applied via the proximal entrance of the portal under image intensifier control. An 8-mm (n=25) or 9-

TABLE I

Localization and type of fractures

			Localization			Type			
	No. of patients	Mean age (years)	Proximal	Middle	Distal	Transverse (AO-A3)	Oblique (AO-A2)	Spiral (AO-A1)	Three-part (AO-B1 and B2)
Group 1	35	34	2	18	15	7	2	11	15
Group 2	32	37	5	18	9	8	5	7	12

mm (n=7) intramedullary nail (Biomet Inc, Warsaw, Indiana) was used. The nail was locked in place with four interlocking screws, two at the proximal and two at the distal end. Distal locking screws were applied with limited open approach in order to avoid injury to the radial nerve. Passive range of motion exercises of the shoulder and elbow were initiated on the first postoperative day without immobilization. Active exercises were allowed on the seventh postoperative day while active resistive exercises in the forth postoperative week.

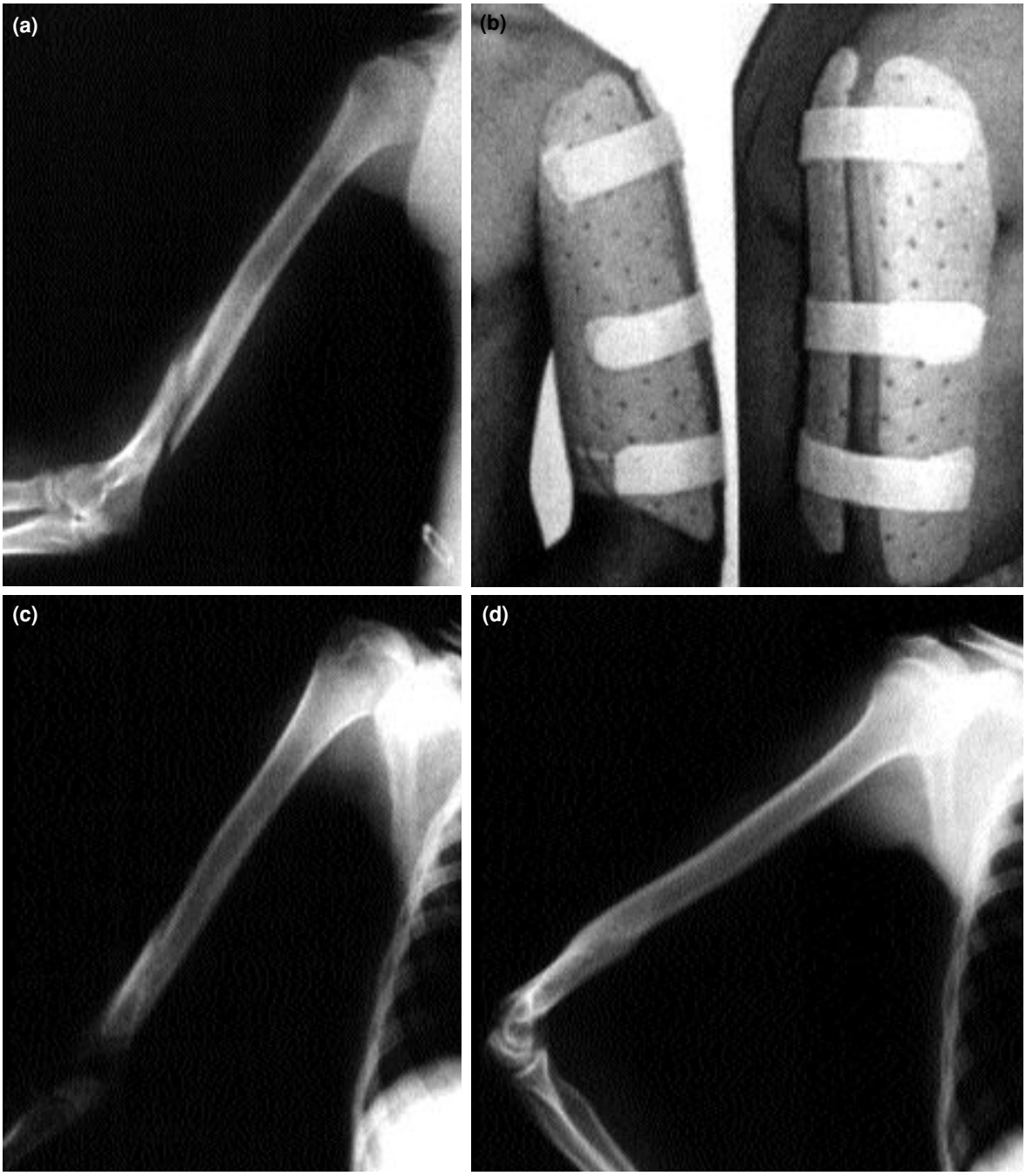

Fig. 1. (a) Radiograph of a patient in group 1 showing a spiral distal third humeral shaft fracture. **(b)** The application of the prefabricated functional brace causing no limitation in shoulder and elbow movements; soft tissue compression is adjustable with Velcro straps. **(c)** Anteroposterior and **(d)** lateral radiographs of the patient after solid union was completed, showing no mediolateral and no anteroposterior angulation, respectively.

The results were assessed in the light of radiographic, functional, and clinical findings, and according to the Constant-Murley shoulder scoring system (excellent 80-100, good 60-79, moderate 40-59, fair 20-39, poor 0-19).[12] The mean follow-up period was 15.2 months (range 13 to 22 months) in group 1 and 16.3 months (range 14 to 22 months) in group 2.

Statistical evaluations were made using SPSS 11.0. The independent samples t-test was used for analysis of data that had appropriate range of samples ($n \geq 4$). The results were examined in a confidence interval of 95% and with a significance level of $p<0.05$.

RESULTS

There was a statistically great difference between the two groups with respect to the mean hospitalization time, which was 7±1.4 days (range 5 to 11 days) in group 1, and 21±3.6 days (range 17 to 25 days) in group 2 ($p=0.001$). The longer hospitalization in group 2 was mainly due to preoperative preparation and postoperative follow-up of patients for surgical wounds. The brace was used for an average of nine weeks (range 7 to 11 weeks) in group 1.

Radiographic evaluation. The average time to solid union was 13.4±2.5 weeks (range 9 to 19 weeks) in group 1 (Fig. 1c, d), and 13.9±2.3 weeks (range 8 to 17 weeks) in group 2 (Fig. 2b, c) ($p=0.5$). Both mediolateral and anteroposterior plane angulations were assessed at the time union was completed. In the mediolateral plane, there was an average varus angulation of 8.5° (range 2° to 13°) in 11 patients (31.4%) in group 1, and 5° (3° and 7°) in two patients (6.3%) in group 2.

In the anteroposterior plane, three patients (8.6%) had an average of 7° (range 5° to 11°) apex-anterior angulation, and one patient (2.9%) had 4° apex-posterior angulation in group 1. There was no anteroposterior angulation deformity in group 2.

Functional evaluation. For functional evaluation, shoulder and elbow movements were assessed. Three patients (8.6%) in group 1, and two patients (6.3%) in group 2 had abduction losses of less than 10°. External rotation of the shoulder joint decreased by less than 10° in two patients (5.7%) in group 1 and in two patients (6.3%) in group 2. Limitation in elbow motion did not occur in any group.

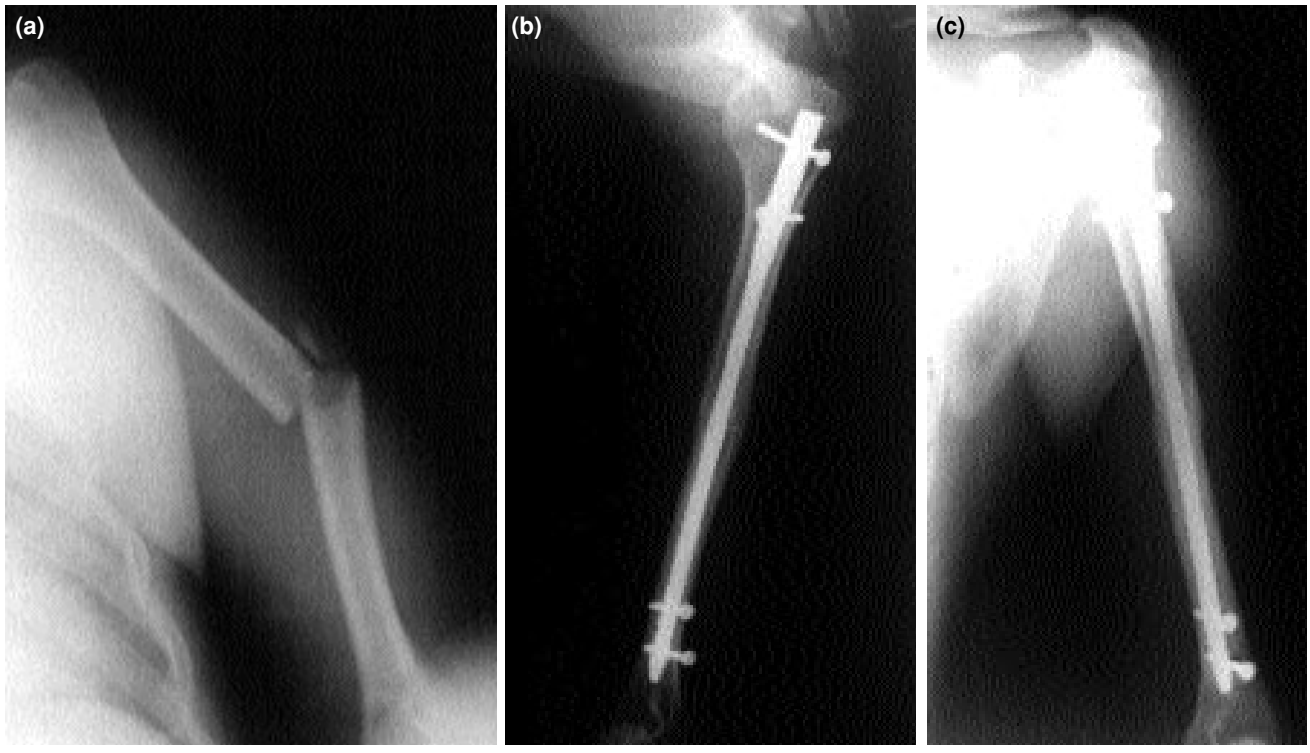

Fig. 3. (a) Radiograph of a patient in group 2 showing a transverse middle third humeral shaft fracture. **(b)** Anteroposterior and **(c)** lateral radiographs of the patient after solid union was completed.

Formal physical therapy was required in only one patient (2.9%) in group 1. Shortening of the fractured side (range 5 to 20 mm) was detected in four patients in group 1, whereas there was no limb length discrepancy in group 2. It was observed that a varus angulation up to 13° and shortening up to 20 mm did not have any adverse effect on functional outcome.

Clinical evaluation. All the patients were satisfied with the cosmetic appearance and the treatment results in both groups, with none having any restriction in performing preinjury jobs.

One patient (2.9%) with a transverse fracture developed nonunion in group 1 and was treated with open reduction, autologous bone grafting and plate-screw fixation. Neither nonunion nor infections were encountered in group 2. There was prominence of the proximal end of the nail in two patients (6.3%), one of which required removal of the nail after union was completed. None of the patients experienced radial nerve palsy.

According to the Constant-Murley shoulder scoring system, the results were all excellent or good in both groups, with an average score of 86.5±8.3 (range 65 to 100) in group 1, and 85.9±9.8 (range 61 to 100) in group 2 (p=0.7).

DISCUSSION

This is a retrospective study designed to compare the results of conservative and operative treatment of humeral shaft fractures. Our treatment protocol involved functional bracing for conservative approach and closed reduction and intramedullary nailing for operative approach.

It is now widely accepted that the treatment of choice for isolated closed humeral shaft fractures is conservative methods. With closed methods, a high rate of union can be obtained with good functional results and without surgery-associated risks (infection, nerve injury, rotator-cuff damage, implant loosening, etc.).[1,4,5,7,13-15] On the other hand, treatment of fractures of long bones with intramedullary nailing has become increasingly common in the past two decades and noticeably good results have been reported.[11,16,17]

Fractures of the humeral shaft can be treated successfully with both conservative and surgical methods. Functional bracing and locked intramedullary nailing are the most popular conservative and surgical methods, respectively.[1-3,5-10] Wallny et al.[15] compared the results of bracing and locked nailing for humeral shaft fractures and found no significant differences between these two methods with respect to functional outcome, radiographic findings, and complications. In our study, we also did not find any significant difference between the two methods in this respect, and all the patients had a satisfactory functional outcome.

The most common problem with functional bracing is the risk for axial deviations at the fracture site, which mostly tend to develop in the presence of varus angulation.[1-3,18] In group 1, 11 patients (31.4%) developed varus angulation at the fracture site. However, we found that varus angulation up to 13° did not affect either functional outcome or the cosmetic appearance. It is accepted that angulatory deformities of the humeral shaft up to 25° can be tolerated both functionally and cosmetically because of the existing large soft tissue mass around the humerus and wide range of movement of the adjacent joints.[1,2,6] Similarly, our clinical observations showed that shortening of the humerus up to 20 mm had no adverse effect on functional outcome and was hard to detect cosmetically. It is accepted that shortening of the humerus within a range of 5 cm is of no clinical importance.[2,6]

The patient who developed nonunion in group 1 had a transverse, two-part fracture with a minimal contact area between fracture fragments. Zuckerman and Koval[19] stated that there was a potential risk for nonunion in transverse fractures. It seems that the chance to close the gap between fracture fragments is greater by surgical methods.

In conclusion, both techniques in the present study provided a high rate of union within a similar length of time, good functional results, a high rate of patient satisfaction, and a low complication rate. Our clinical experience shows that functional bracing should be the first choice of treatment in isolated, closed humeral shaft fractures because of shorter hospitalization, cost-effectiveness, avoidance of surgery-associated risks. Since bracing requires a high patient compliance, patients who cannot cooperate are not candidates for bracing. Patients with pathologic fractures, fractures with multiple or vascular injuries, and bedridden patients should also be considered for surgery.[6,13,20] We prefer locked intramedullary nailing in

patients requiring surgery because it offers a rigid stabilization, a low complication rate, a vast indication spectrum, a high union rate within a short time, a satisfactory functional outcome, and no residual angular deformities.

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