



In Which Conditions is Conservative Treatment Likely to Fail in Humeral Shaft Fractures? A Retrospective Analysis of 67 Patients

Humerus Cisim Kırıklarında Hangi Durumlarda Konservatif Tedavinin Başarısız Olma İhtimali Vardır? 67 Hastanın Retrospektif Analizi

✉ Mehmet ALBAYRAK¹, ✉ Fatih UĞUR²

¹*İstanbul Rumeli University Health Services Vocational School Therapy and Life Department Physiotherapy Program, İstanbul; Tekirdağ Yaşam Hospital, Clinic of Orthopedics and Traumatology, Tekirdağ, Turkey*

²*Kastamonu University Faculty of Medicine, Department of Orthopedics and Traumatology, Kastamonu, Turkey*

ABSTRACT

Aim: Humeral shaft fractures are one of the most common fractures of the upper extremity. Most humeral shaft fractures can be treated conservatively, but in some cases, surgical treatment is required. In this study, the characteristics of patients who needed surgical intervention due to unsuccessful conservative treatment and inability to achieve union were investigated.

Materials and Methods: Data of 67 patients [female (n=41) and male (n=26)] in whom conservative treatment was initiated due to humeral shaft fracture were evaluated retrospectively. The data of the patients in whom treatment had to be switched to surgery during the follow-up period were analyzed. Age, gender, trauma type, fracture site and vitamin D levels on the day of the fracture were noted.

Results: At the end of 54 (42-77) days, the treatment was switched to surgery due to nonunion in 14 patients. All of these patients were female, over the age of 60 years, and the humeral fractures in these patients were in the middle third of the humerus. The mean 25(OH) vitamin D [25(OH) D] level of these patients was 14 mg/dL (4-22 mg/dL).

Conclusion: It is concluded that the conservative treatment is prone to fail if humeral shaft fracture is a proximal oblique or a mid-shaft one, if the patient is over the age of 60 years and female, and if 25(OH)D level of the patient is low.

Keywords: Conservative, humerus fracture, surgery

ÖZ

Amaç: Humerus shaft kırıkları üst ekstremitenin sık görülen kırıklarından biridir. Humerus shaft kırıklarının büyük bir kısmı konservatif yöntemlerle tedavi edilebilir ancak bazı durumlarda cerrahi tedavi gereksinimleri mevcuttur. Bu çalışmada konservatif tedavinin başarısız olduğu ve kaynamanın elde edilememesi nedeniyle cerrahi girişime ihtiyaç doğan hastaların özellikleri araştırıldı.

Gereç ve Yöntem: Humerus cisim kırığı nedeniyle konservatif tedavilerine başlanan 67 hastanın [kadın (n=41) ve erkek (n=26)] verileri retrospektif olarak değerlendirildi. Takip sürecinde cerrahi tedaviye geçiş yapılmak durumunda kalan hastaların verileri incelendi. Yaş, cinsiyet, travma tipi, kırık yeri ve kırığın olduğu gündeki D vitamini düzeyleri not edildi.

Bulgular: On dört hastada 54 (42-77) gün sonunda kaynamama nedeniyle cerrahi tedaviye geçiş yapıldığı saptandı. Bu hastaların tamamı 60 yaş üzeri kadın hastalardı ve bu hastalardaki humerus kırıkları humerusun orta üçte birlik kısmındaydı. Cerrahi tedaviye geçiş yapılan hastaların 25(OH) vitamin D [25(OH)D] seviyeleri ortalama 14 mg/dL (4-22 mg/dL) idi.

Sonuç: Bu çalışma neticesinde humeral cisim kırığının proksimal yerleşimli ve oblik olması veya orta shaft yerleşimli olması, hastanın 60 yaş üstü kadın hasta olması ve hastanın 25(OH)D seviyesinin düşük olması durumlarında konservatif tedavinin başarısız olmaya daha yatkın olduğu sonucuna varıldı.

Anahtar Kelimeler: Konservatif, humerus kırığı, cerrahi

Address for Correspondence: Mehmet ALBAYRAK MD, İstanbul Rumeli University Health Services Vocational School Therapy and Life Department Physiotherapy Program, İstanbul; Tekirdağ Yaşam Hospital, Clinic of Orthopedics and Traumatology, Tekirdağ, Turkey

Phone: +90 533 660 50 13 **E-mail:** doktorm.albayrak@gmail.com **ORCID ID:** orcid.org/0000-0002-4074-7024

Received: 03.05.2023 **Accepted:** 22.06.2023



©Copyright 2023 by Tekirdağ Namık Kemal University / Namık Kemal Medical Journal is published by Galenos Publishing House. Licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 (CC BY-NC-ND) International License.

INTRODUCTION

Humerus shaft fracture (HSF) is a common upper limb injury that makes up for 1-5% of all fractures^{1,2}. In terms of incidence, HSFs usually show a bimodal distribution—the first peak is seen in young males aged 21-30 years mostly due to high-energy trauma, and the second peak is in older females aged 50-80 years due to low-energy trauma (most commonly due to fall from a standing height)³.

Although there is a lack of consensus regarding the most appropriate treatment for HSFs—conservative⁴ versus surgical intervention⁵, conservative methods, which include applying a coaptation splint followed by a Sarmiento functional brace⁶ or directly applying the functional brace⁷, are preferred more in the literature. Regarding the surgical treatment of HSFs, there is a list of absolute and relative indications that are commonly accepted by trauma surgeons (Table 1)⁸⁻¹⁰.

Age, gender, severity of trauma, presence of an open fracture and accompanying metabolic diseases are the factors that affect the union of the fracture^{2,3}. In means of fracture type, some fracture patterns like short oblique fractures of humerus have relative indication for surgery, which means conservative treatment can be initiated primarily in these cases. In case of failure, such as nonunion in the follow-up, these fracture types may need surgical intervention. Throughout the follow-up period of conservative treatment, it is well known that patient compliance gradually decreases, and in case of necessity for a further surgical intervention when conservative treatment fails, surgery becomes much more demanding and technically challenging.

In this study, the characteristics of patients who needed surgical intervention due to unsuccessful conservative treatment and inability to achieve union were investigated. It was hypothesized that conservative treatment had a tendency to fail in proximal oblique shaft fractures. The effects of sex, age and vitamin D levels on the success or failure of conservative treatment were also evaluated.

MATERIALS AND METHODS

The study was approved by the Tekirdağ Namık Kemal University of Local Ethics Committee (protocol no: 2023.77.04.13, date: 25/04/2023).

In this retrospective study, we evaluated 84 patients treated for HSFs between January 2008 and December 2018 in Tekirdağ Yaşam Hospital by reviewing archive and radiology files. Among these, 17 patients who were operated on for absolute indications were excluded from the study. The remaining 67 patients were conservatively managed at the beginning of the treatment before surgical intervention. All patient characteristics are presented in Table 2.

On the day of admission, 25(OH) vitamin D levels were measured for all patients using a blood test. After radiologic investigations [anteroposterior (AP) and lateral view radiographs of the shoulder and arm], all included patients were initially managed conservatively using a coaptation splint, which was applied in the emergency room. The next day, a custom brace was made for each patient according to the dimensions taken from the uninjured arm. After one week, the coaptation splint was removed and the custom-manufactured brace was applied. All

Table 2. Data of the patients

Data	Number of patients
Male	26
Female	41
Total	67
Location on the shaft	
Proximal third	16
Middle third	39
Distal third	12
Total	67
Trauma type	
Major	11
Minor	56
Total	67

Table 1. Absolute and relative indications for surgical treatment of humerus shaft fractures

Absolute indications	Relative indications
<ul style="list-style-type: none"> - Open fracture - Vascular injury requiring repair - Brachial plexus injury - Ipsilateral forearm fracture (floating elbow) - Compartment syndrome - Periprosthetic humeral shaft fractures at the tip of the stem 	<ul style="list-style-type: none"> - Bilateral humerus fracture - Polytrauma or associated lower extremity fracture - Pathologic fractures - Burns or soft tissue injury that precludes bracing - Fracture characteristics <ul style="list-style-type: none"> - Distraction at fracture site - Short oblique or transverse fracture pattern - Intraarticular extension

patients were followed up for the next two weeks using serial weekly X-rays. Criteria for acceptable alignment were listed as less than 20° apex anterior or posterior angulation, less than 30° varus/valgus angulation, maximum 15° malrotation and 3 cm of shortening². The data of the patients in whom treatment had to be switched to surgery during the follow-up period were analyzed. Age, gender, trauma type and fracture site were noted.

In Figure 1, the radiograph of a 67-year-old female patient at the time of first admission is seen and in Figure 2, the radiograph of the same patient is seen, showing deterioration in the fracture alignment and nonunion on the 29th day. In Figure 3, the radiograph of the patient taken at the end of 4 weeks after the operation is seen.

In Figure 4, the radiograph of another 64-year-old female patient at the time of first admission is seen. Figure 5 shows the radiograph of the same patient, demonstrating deterioration in the fracture alignment and nonunion. AP and lateral radiographs of the same patient 3 weeks after the operation are seen in Figure 6 and in Figure 7, respectively.

Statistical Analysis

A binary logistic regression model was used to examine the effects of age, sex, fracture site, and fracture type on the union status of fractures, and the Wald test was performed to evaluate the collective significance of the aforementioned variables. Furthermore, to determine the differences in

fracture healing according to sex, fracture type, and age, the Fisher's exact test was employed. A p value of <0.05 was used to determine statistical significance.

RESULTS

Sixteen of the fractures were located in the proximal third of the humerus, 39 in the middle third and 12 in the distal third. Eleven patients had fractures after major trauma like falling from height and the rest had fractures due to simple trauma or falls from a standing height. Out of the 67 patients, 53 healed without any complications and attained fracture union by the



Figure 2. The radiograph of the same patient, taken on the 29th day, showing deterioration in the fracture alignment and nonunion



Figure 1. The radiograph of a 67-year-old female patient at the time of first admission



Figure 3. Follow-up radiograph of the patient at the 4th week postoperatively

end of the 8-10-week period conservatively. Radiographically, callus formation was visible between 4 and 6 weeks for all 53 patients, and bony alignment was within the acceptable range in both AP and lateral radiographs.

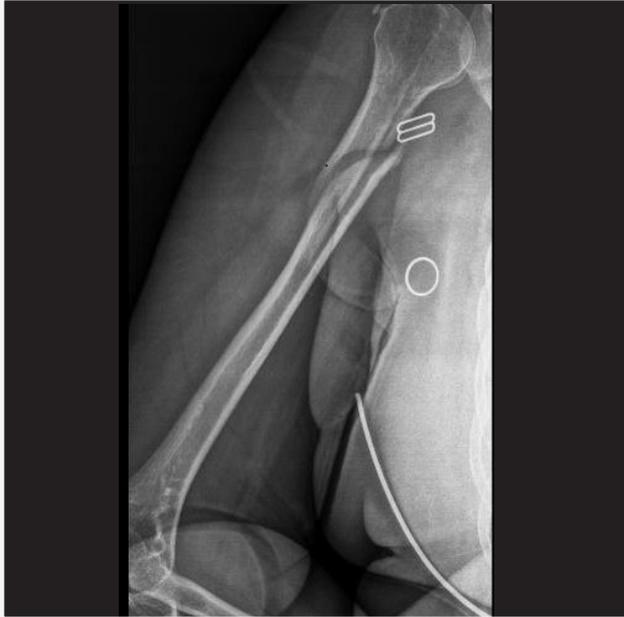


Figure 4. The radiograph of a 64-year-old female patient at the time of first admission



Figure 5. The radiograph of the same patient, taken on the 32nd day, showing deterioration in the fracture alignment and nonunion

The remaining 14 patients (20.89%), in whom conservative treatment had failed, were subsequently treated surgically. The average duration for determining the failure of conservative management and opting for surgery was 41 days (38 ± 14 days).



Figure 6. Follow-up AP radiograph of the patient at the 3rd week postoperatively

AP: Anteroposterior



Figure 7. Follow-up lateral radiograph of the patient at the 3rd week postoperatively

The reasons for failure were malalignment and lack of adequate callus formation in the follow-up radiographs. Eventually, all 14 patients were treated with open reduction and internal fixation using plate and screws. Postoperatively, the patients were followed for 2 weeks, all fractures healed and showed radiographic union at the end of 10 weeks postoperatively. As for the complications, superficial wound infections, which were healed with a 15-day antibiotic treatment and dressings, were detected in two patients. In three patients, 30° of decrease in elbow total arc range of motion, which recovered with a 20-day physical therapy conducted at home and in the hospital, developed.

In terms of fracture location, 25% of the proximal one-third ($n=4/16$), 89.74% of the middle third ($n=35/39$), and 100% of the distal third ($n=12/12$) fractures were united using a functional brace. There was a statistically significant difference between the healing rates in the proximal and middle third fractures ($p=0.039$) and the proximal and distal third fractures ($p=0.043$) but the difference in the healing rates for the middle and distal third fractures was statistically not significant ($p=0.051$).

When comparing the conservatively treated ($n=53$) and surgically treated ($n=14$) groups, we found that the former had relatively younger patients (44 ± 12 years), while the mean age for the surgically treated ones was 61 ± 11 years, which was statistically significant ($p=0.040$). On the other hand, the mean vitamin D3 levels at the time of admission were significantly low in the surgically treated group compared to the conservatively treated group [14 mg/dL (16 ± 8 mg/dL) versus 29 mg/dL (44 ± 14 mg/dL); $p=0.036$].

When stratified according to sex, all male patients had bony unions while 33.3% of women had nonunion. On comparing different age groups, we found that all patients in age group of 16-59 years had union while 35% of the patients aged >60 years had no union. Additionally, there was no significant relationship between union status and trauma type, such as major or minor ($p=0.061$).

The Wald test performed to determine the effects of age, sex, and vitamin D levels revealed that a one-year increase in the age variable reduced the probability of fracture union by 0.836 times ($\beta=-0.18$, odds ratio=0.836, $p=0.048$). Furthermore, we found a significant relationship between fracture union status and sex ($p=0.011$) and age ($p=0.044$).

DISCUSSION

Functional treatment (in the form of splinting/bracing) is an integral part of the conservative management of HSFs, which usually yields satisfactory results by allowing appropriate stabilization to ensure fracture healing and

patient compliance¹¹. Although obesity and nonconformity of the patient to brace therapy are the primary impediments to conservative treatment^{10,11}, functional bracing is the first choice of treatment for HSFs¹⁰⁻¹². In our study sample, all patients were first started with conservative treatment with splints followed by functional bracing, unless absolutely indicated for surgery. However, Denard et al.⁵ stated that closed treatment of humerus fractures had a significantly higher rate of nonunion and malunion, and surgical treatment was better than conservative treatment without significant complication. In contrast, only 20.89% of our patients had nonunion or malunion with conservative management, which corroborates the choice of conservative treatment as the first-line treatment for HSF.

However, despite the success of conservative treatment for HSFs, many studies have pointed out that oblique fractures of the humerus, especially in the proximal one-third, require surgical intervention^{4,12,13}. In our study, all of our patients who underwent surgery due to malunion or nonunion had oblique fractures in the proximal humerus. Furthermore, Koch et al.¹⁴ stated that transverse fractures of the humerus are more prone to nonunion and often require surgery. However, in our study, transverse fractures healed adequately with conservative treatment, whereas the oblique fracture group required surgery.

Notably, previous studies with concurring evidence about proximal oblique HSFs being more prone to nonunion with conservative methods have also highlighted the role of the patient's age as important for nonunion^{15,16}. In contrast, Ali et al.⁴ found that nonunion could occur in this particular fracture type, irrespective of the patient's age. In our study, patients over the age of 60 years were particularly prone to nonunion after sustaining a proximal oblique HSF.

It has also been reported that the only criterion to ensure union in an HSF, regardless of its type according to the AO classification¹⁶, is the fracture location within the shaft-proximal or not¹¹. We also observed that patients with fractures in the proximal third of the humerus were likely to go into nonunion. It is uncertain why proximal third humerus fractures, especially the oblique type, do not unite conservatively and require surgery. Walker et al.¹⁰ reasoned that this area was between the insertion points of two strong muscles, deltoid and pectoralis major, which tend to distract the fracture site by pulling in different directions. Therefore, if rotational alignment is maintained but there is a gap between the fracture ends, muscle interposition must be taken into consideration. It is well established that if there is a significant gap between fracture ends, the fracture tends to go into atrophic nonunion.

Similar to our study, Decomas and Kaye¹⁷ also performed a multifactorial analysis of nonunion in HSF patients and confirmed that obesity, a history of cigarette smoking, metabolic bone disease, cardiovascular disease, short oblique fractures, open fractures, and fractures of the proximal third of the shaft were potential risk factors. Accordingly, they claimed that handling these patients by conservative treatment increased the risk of nonunion; hence, they should be managed surgically and directly¹⁷. Our results also corroborate these findings that HSFs in the proximal one-third tend to go into nonunion when managed conservatively, especially in older patients.

Study Limitations

We did not account for the patient's medical history, such as accompanying illnesses that can impair fracture healing, namely diabetes mellitus, hypothyroidism, obesity, and smoking habits. A lack of information about these information limits the applicability of our results. Furthermore, the fractures were not classified according to the AO classification. Larger studies comparing the nonunion cases by their fracture classifications and incorporating more factors related to the patient's personal characteristics are required to verify these results.

CONCLUSION

Our results confirm that oblique HSFs (short or long) in the proximal or middle one-third regions tend to become absolute indications for surgical management, especially if the patient is female and above the age of 60 years. In such patients, clinicians can promptly opt for surgery without using conservative methods to ensure bony union and recovery.

Ethics

Ethics Committee Approval: The study was approved by the Tekirdağ Namik Kemal University of Local Ethics Committee (protocol no: 2023.77.04.13, date: 25/04/2023).

Informed Consent: Retrospective study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: M.A., Concept: M.A., Design: M.A., Data Collection or Processing: M.A., Analysis or Interpretation: F.U., Literature Search: F.U., Writing: M.A.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

REFERENCES

1. Cole PA, Wijdicks CA. The operative treatment of diaphyseal humeral shaft fractures. *Hand Clin.* 2007;23:437-48.
2. Spiguel AR, Steffner RJ. Humeral shaft fractures. *Curr Rev Musculoskelet Med.* 2012;5:177-83.
3. Tytherleigh-Strong G, Walls N, McQueen MM. The epidemiology of humeral shaft fractures. *J Bone Joint Surg Br.* 1998;80:249-53.
4. Ali E, Griffiths D, Obi N, Tytherleigh-Strong G, Van Rensburg L. Nonoperative treatment of humeral shaft fractures revisited. *J Shoulder Elbow Surg.* 2015;24:210-4.
5. Denard A Jr, Richards JE, Obremesky WT, Tucker MC, Floyd M, Herzog GA. Outcome of nonoperative vs operative treatment of humeral shaft fractures: a retrospective study of 213 patients. *Orthopedics.* 2010;33.
6. Sarmiento A, Kinman PB, Galvin EG, Schmitt RH, Phillips JG. Functional bracing of fractures of the shaft of the humerus. *J Bone Joint Surg Am.* 1977;59:596-601.
7. Zagorski JB, Latta LL, Zych GA, Finnieston AR. Diaphyseal fractures of the humerus. Treatment with prefabricated braces. *J Bone Joint Surg Am.* 1988;70:607-10.
8. Latta LL, Sarmiento A, Tarr RR. The rationale of functional bracing of fractures. *Clin Orthop Relat Res.* 1980;28-36.
9. Ekholm R, Tidermark J, Törnkvist H, Adami J, Ponzer S. Outcome after closed functional treatment of humeral shaft fractures. *J Orthop Trauma.* 2006;20:591-6.
10. Walker M, Palumbo B, Badman B, Brooks J, Van Gelderen J, Mighell M. Humeral shaft fractures: a review. *J Shoulder Elbow Surg.* 2011;20:833-44.
11. Toivanen JA, Nieminen J, Laine HJ, Honkonen SE, Järvinen MJ. Functional treatment of closed humeral shaft fractures. *Int Orthop.* 2005;29:10-3.
12. Rutgers M, Ring D. Treatment of diaphyseal fractures of the humerus using a functional brace. *J Orthop Trauma.* 2006;20:597-601.
13. Ring D, Chin K, Taghinia AH, Jupiter JB. Nonunion after functional brace treatment of diaphyseal humerus fractures. *J Trauma.* 2007;62:1157-8.
14. Koch PP, Gross DF, Gerber C. The results of functional (Sarmiento) bracing of humeral shaft fractures. *J Shoulder Elbow Surg.* 2002;11:143-50.
15. Gallusser N, Barimani B, Vauclair F. Humeral shaft fractures. *EFORT Open Rev.* 2021;6:24-34.
16. Kehtari S, Gallusser N, Vauclair F. Mise au point sur les fractures diaphysaires de l'humérus [Update on humeral shaft fractures]. *Rev Med Suisse.* 2020;16:2421-5.
17. Decomas A, Kaye J. Risk factors associated with failure of treatment of humeral diaphyseal fractures after functional bracing. *J La State Med Soc.* 2010;162:33-5.