ACTA
ORTHOPAEDICA
et
TRAUMATOLOGICA
TURCICA

Author's translation
Acta Orthop Traumatol Turc 2007;41(1):15-20

The role of functional bracing in the treatment of humeral shaft fractures

Humerus cisim kırıklarında fonksiyonel breys tedavisinin yeri

Bulent OZKURT, Murat ALTAY, Cem Nuri AKTEKIN, Ali TOPRAK, Yalcin TABAK

Ankara Numune Training and Resarch Hospital, Fifth Orthopaedics Clinic

Amaç: Bu çalışmada humerus cisim kırığı nedeniyle fonksiyonel breys uygulanan hastaların klinik, radyografik ve fonksiyonel sonuçları değerlendirildi.

Çalışma planı: Humerus cisim kırıklı 30 hasta (19 erkek, 11 kadın; ort. yaş 34; dağılım 18-64) uzun kol alçı atel ve sonrasında fonksiyonel breys ile tedavi edildi. Kırıkların 18'i sağ, 12'si sol taraftaydı. Tümü kapalı kırık idi. Kırıkların 10'u spiral, dokuzu parçalı, altısı transvers, beşi oblik olarak değerlendirildi; 16'sı humerus 1/3 orta, sekizi 1/3 üst, altısı 1/3 alt kesimde idi. Fonksiyonel breys uygulamasına ortalama altıncı günde (dağılım 0-16 gün) başlandı. Breys tedavi süresince günde 24 saat kullanıldı ve radyografik olarak yeterli kaynama dokusu oluşumu, kırık hattında belirgin iyileşme olması ile sonlandırıldı. Fonksiyonel değerlendirme Hunter ölçütlerine göre yapıldı. Hastalar ortalama 20 ay (dağılım 10-58 ay) takip edildi.

Sonuçlar: Yirmi dört hastada (%80) ortalama 14 haftada (dağılım 11-21 haftada) tam kaynama elde edilirken, altı hastada (%20) kaynama görülmemesi üzerine cerrahi tedaviye başvuruldu. Hunter ölçütlerine göre, 24 hastada (%80) iyi (G3-4), altı hastada (%20) mükemmel (G5) sonuç alındı. Fonksiyonel breys ile kaynama elde edilen hastalarda ortalama 6 derece varus-valgus açılanması, ortalama 8 derece ön-arka açılanma gelişti. Dört hastada breys nedeniyle ciltte maserasyon görüldü. Kaynama elde edilen bir hastada (%3.3) 1.7 cm'lik kısalık gelişti.

Çıkarımlar: Klinik ve radyografik sonuçlarımız, endikasyonun uygun konması durumunda, ödemin gerilemesi sonrası uygulanan fonksiyonel breys tedavisinin humerus cisim kırıklarında ilk tedavi seçeneği olabileceğini göstermektedir.

Anahtar sözcükler: Breys; kırık iyileşmesi; kırık tespiti/yöntem; humerus kırığı/tedavi.

Objectives: We evaluated clinical, radiographic, and functional results of patients treated with functional bracing for humeral shaft fractures.

Methods: Humeral shaft fractures of 30 patients (19 males, 11 females; mean age 34 years; range 18 to 64 years) were treated with functional bracing. Fractures were on the right in 18 patients, on the left in 12 patients. All were closed fractures, being spiral in 10, comminuted in nine, transverse in six, and oblique in five patients. Humeral fractures were in the upper third, middle third, and distal third in 16, 8, and 6 patients, respectively. Functional brace was applied after a mean of six days (range (0 to 16 days) and was worn throughout day and night until radiographic signs of sufficient union and healing was observed. Functional assessment was made according to the Hunter criteria. The mean follow-up was 20 months (range 10 to 58 months).

Results: Union was achieved in 24 patients (80%) after a mean of 14 weeks (range 11 to 21 weeks). Six fractures (20%) failed to unite and were subsequently treated with surgery. According to the Hunter criteria, 24 patients (80%) were evaluated as good (G3-4), and six patients (20%) as excellent (G5). The mean varus-valgus rotation was 6°, the mean anterior-posterior translation was 8° in patients who had union with functional bracing. Four patients developed skin macerations secondary to brace use. Limb shortening of 1.7 cm occurred in one patient whose fracture was united with bracing.

Conclusion: Our clinical and radiographic results suggest that, based on proper indications, functional bracing applied after regression of edema may be the treatment of choice in humeral shaft fractures.

Key words: Braces; fracture healing; fracture fixation/methods; humeral fractures/therapy.

Correspondence to: Dr. Bulent Ozkurt. Ankara Numune Training and Resarch Hospital, Fifth Orthopaedics Clinic, Ankara- Turkey.
Phone: +90 312 - 343 64 08 Fax: +90 312 - 362 48 39 e-mail: drbulentozkurt@yahoo.com

Received: 23.01.2006 **Accepted:** 07.12.2006

There is no commonly accepted opinion for the ideal treatment option for humeral shaft fractures .[1] In contrast to the compressing forces in lower extremity fractures resulting from the body weight and ground reaction forces, reduction can be achieved easily in humeral fractures thanks to the effect of the muscle tissue surrounding the humerus, and consequently, conservative treatment can be possible most of time.[2,3] For most of these fractures, selection of suitable patients and a functional brace can allow the proper positioning of the fragments to be maintained, rapid bone structuring and healing can be ensured, and it can be possible to move shoulder and elbow joints even before complete healing in the fracture line.[4] It has been reported that higher rates of healing, lower rates of complications, and better functional results can be achieved as compared to surgical treatment.[2,5-7]

Application of surgery is accepted in general for fractures with vascular and nerve injury, patients with multiple fractures, bilateral humeral shaft fractures, pathological fractures, comminuted segmental fractures, open fractures, fractures that vascular and nerve complications develop during conservative treatment, fractures with poor patient compliance like mental retardation and in those with neurological disorders like parkinsonism or epilepsy.[8-13] Humeral fractures in cases other than mentioned above can be successfully treated with conservative methods.

Hanging cast, U-splint, shoulder-trunk cast, Sarmiento cast, abduction device, shoulder fixing bandage (velpeau) bandage, and skeletal traction are used as methods of conservative traction. Movements of shoulders and elbow can be set free in early stages with brace treatment, and complications like stiffness in elbow and shoulder joints, and subluxation of the shoulder as a result of atrophy of the deltoid muscle can be prevented.

It has been reported that higher rates of healing and better functional results are obtained with functional brace treatment as compared to surgical treatment.[2,5-7] However, it the articles that results of treatment with functional brace are reported, it is also reported that all the patients have not been followed up till the end of the treatment. Results of the patients lost during follow-up, how did their treatments continued, and whether or not a different treatment modality has been applied, are all unknown.

In this study, clinical, radiographic, and functional results of the patients that functional braces were applied to because of humeral fractures were evaluated and efficacy of the conservative treatment in these patients was investigated.

Patients and method

Total thirty patients with humeral shaft fractures (19 males, 11 females; mean age 34 ± 4.8 ranges 18-64) were treated with long arm cast splint followed by functional brace. Patients that did not came to control visits and continued their treatment in other centers, or those treated with surgery were not included in the study. Eighteen patients that satisfactory follow up could be performed till the completion of the treatment out of 30 (60%) had their fractures in the right humerus, and 12 (40%) in the left. Causes of fractures were traffic accidents in 18 (60%), falling in 10 (33.3%), and sport injury in 2 (6.6%). There were accompanying injuries in 4 patients (13.3%) (Injuries of thorax, abdomen, or head).

Clinical and radiographic evaluations of the patients were performed at presentation. According to the form of the fractures, 10 (3.3%) were evaluated as spiral, 9 (30%) were comminuted, 6 (20%) transverse, and 5 (16.7%) oblique. According to anatomical location, 16 (54.6%) were in one-thirds middle portion, 8 (26.6%) were one-thirds upper,

Table 1. Distribution of levels and types of the fractures

Level of the fracture	Number of fractures	Transverse		Oblique		Spiral		Comminuted	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
1/3 proximal	8	1	12.5	2	25.0	3	37.5	2	25.0
1/3 middle	16	3	18.7	2	12.5	5	31.3	6	37.5
1/3 distal	6	2	33.3	1	16.7	2	33.3	1	16.7
Total	30	6	20.0	5	16.7	10	33.3	9	30.0

and 6 (20%) were in one-thirds lower portion of the humerus (Table 1).

All the patients included in the study had closed fractures. Two patients (6.7%) had radial nerve palsy at presentation. After applying long arm split cast with epaulet for an average period of 6 ± 0.8 day (range 0-16) with elbow in flexion of 90°, the treatment was shifted to functional brace with the reducing of acute symptoms and swelling. Brace was used for 24 hours a day throughout the treatment. Patients were followed for an average period of 20 ± 3.7 months (range 10-58). Braces manufactured from thermoplastic polyethylene extending in the medial aspect from a level of 2.5 cm below the axilla to a level of 1.3 cm over the medial epicondyl, and extending in the lateral aspect from immediately over the acromion to the lateral epicondyl of the humerus as described by Sarmiento[2] were applied to all the patients with the help of the measures taken from the intact arm, so as to leave the antecubital region open, and to allow flexion of the elbow up to 120°. Adhesive bands were arranged according to the swelling in the soft tissues and brace was used continuously. Active and passive exercises of the hand, wrist, elbow and shoulder were immediately started with the use of functional brace; however, abduction and active lifting of the shoulder was not allowed till satisfactory healing tissue was observed in order to avoid angular deformities. The patients were recommended to sleep in head-up position with the purpose of preventing varus deformity that might develop particularly in transverse fractures. Arm-neck sling was applied for the first two weeks continuously except for the periods that patient was exercising. Clinical and radiographic evaluations were performed weekly for the first four weeks after the start of brace application, and then every two weeks. Functional brace application was terminated with the appearance of satisfactory healing tissue, disappearing of pathologic movement and pain in the fracture line with marked improvement. Patients with radial nerve palsy were followed with ENMG (electroneuromyography) taken after the third week. Dynamized radial splint was applied to these patients immediately, and passive hand and wrist exercises were started.

Table 2. Hunter criteria

G1	Complete absence of shoulder and elbow movements and complete impairment in daily activities
G2	Lesser degree of movement and important impairment in daily activities
G3	Small impairment in daily activities because of restricted movement
G4	Mild restriction in movement not affecting daily activities
G5	Full range of motion in shoulder and elbow

Functional and radiographic evaluation was performed in the follow-up of the patients. Functional evaluation was performed according to Hunter criteria[14] by comparing to the intact side (Table 2). Radiographic evaluation was performed by taking the formation of healing tissue, anteroposterior, lateral, and rotational angulations, and shortening into consideration.

Statistical evaluation

Mean values were expressed as mean ± standard deviation. All statistical analyses were performed using Windows SPSS 11.5 (SPSS Inc IL, ABD) program.

Results

While full healing was seen in 24 patients (80%) out of 30 treated with functional brace after a mean follow-up period of 20 ± 3.7 (range 10-58) months, 6 patients (20%) (cases that considered no healing would occur, that marked motion was found in clinical examination and parting between fragment exceeding 1 cm were seen in radiograms) were treated with surgery upon seeing no signs of healing despite an adequate period had passed. Surgery because of loss of reduction was applied to none of the patients. Lockable screws and autogenic iliac grafting were applied to four patients treated with surgery; DCP/screws and autogenic iliac grafting were applied to the remaining two. Problems of the arrangement of fragments and healing were not encountered in any of the patients. Of the fractures in patients that were treated with conservative treatment previously and then treated with surgery due to non-union, were transverse in four cases, and oblique in two, as regards form of the fracture; and were located in mid-portion in three cases, in lower one-thirds in two cases and upper one-thirds in one, as regards anatomical location. While the mean healing period was 14 ± 2.2 (range 11-21) weeks for those treated with functional brace, the mean healing period was 13 ± 2.6 (range 12-14) weeks postoperatively for those treated with lockable screwing, and

13.5 ± 3.0 (range 12-16) weeks postoperatively for those treated with DCP/screws.

Varus-valgus and posteroanterior angulations were measured in patients that healing was obtained with functional brace in last control x-rays. Varus-valgus angulation was measured as 6 ± 0.7 degrees averagely (range 0-18) and posteroanterior angulation was measured to be 8 ± 2.1 degrees averagely (range 0-21). No significant rotational deformation was seen in patients. None of these angulations were regarded to be important problems functionally and cosmetically. In patients with radial nerve palsy, nerve functions improved spontaneously after third month. Vitamin B complex (B1 259mg, B6 250mg vitamin complex, bid, for three months) orally were administered with the purpose of contributing to nerve healing. Maceration developed in four patients related to the irritation of the skin by the brace. For these macerations, skincare and dermatologic agents were used without stopping the use of the brace. The most frequently seen functional losses were restriction in shoulder abduction in five patients (16.7%) and restriction in external rotation in four (13.3%), respectively. While the range of motion could be obtained in two patients (6.6%) with physical therapy, satisfactory results could be obtained in others without any need for additional treatment. Shortening of 1.7cm developed in only one patient (3.3%) in patients treated with functional brace, full length could be obtained in all the remaining cases. In the functional evaluation according to Hunter criteria following the healing of the fracture, there was mild restriction of motion in 24 patients (80%) that did not affect the daily activities (Hunter G3-4), and full range of motion (Hunter G5) was seen in 6 (20%) (Figure 1 a-f).

Discussion

Humeral shaft fractures are seen with a rate of 5% in all the fractures.[15] Since humerus does not bear the body weight like bones of the lower extremity, it is under traction forces rather than compressing forces. Therefore, fractures of the humerus can be treated mostly with conservative methods.[16] Treatment with surgical methods is accepted in general in patients with multiple injuries, fractures in more than one extremities, in those under the risk of pulmonary embolism, fractures with vascular injury, fractures that nerve complications develop during conservative treatment, fractures extending to the joint, bilateral humeral shaft fractures, pathological fractures, comminuted segmental fractures, open fractures accompanied by serious soft tissue damage, fractures with poor patient compliance like mental retardation and in those with neurological disorders like parkinsonism or epilepsy, lack of healing or mal-union with conservative treatment.[8-13] In the literature, it has been reported that treatment with brace of the humeral shaft fractures is more successful than surgical treatment with high rates of healing and good functional results.[2,5-7] Therefore, there is consensus that the treatment should be conservative in cases other than the indication of surgery is absolute.

Stability of the fracture with functional brace is ensured by peripheral compression on the soft tissues surrounding the fracture. In addition, together with the stability ensured by the brace, spontaneous reduction is ensured with the effect of gravity. With the stable reduction ensured with the brace, active movement is started in early period, blood circulation is increased in the fracture area, micro movements enhance bone production, and range of motion can be conserved in the neighboring joints. Not draining of the haematoma of the fracture positively contributes to the healing of the fracture.[17,18]

In the U-splint, which is another frequently used mode of conservative treatment, cotton wool is wrapped around the arm after giving the proper position to humerus, and elbow is brought to 90 degrees flexion. Splint is applied with a width of 10cm an in 8-10 layers, to get hold of the shoulder and while the forearm is in neutral position.[19] Since shoulder and elbow joints are fixated in this method and shoulder fixing bandage (velpeau) bandage applications, complications like stiffness in the elbow joint, or atrophy of the deltoid muscle, and temporary downwards subluxation of the shoulder develop and require a long rehabilitation period.[15,20] In addition, these two methods have the disadvantages like not fully removing the pain and partially preventing body care.[21]

Healing in humeral fractures occur within the first 3 months in general. Healing occurred in four to six months is called delayed union, and healing has not occurred till six months is called nonunion.

Transverse fractures, soft tissues interposition to the fracture line, infection, presence of macro motion in the fracture line, obesity, alcoholism, or inappropriate treatment techniques can cause delayed union or nonunion.[22] Healing time is reported between 6 and 10.6 weeks in various studies. The average healing time was found 14 weeks in our study. We believe that causes of the longer period of healing time as compared to the literature are the incomplete patient compliance in our cohort and failure in the application of home rehabilitation program.

There are no detailed information in the literature concerning the location of the fracture and rates of no healing; however, fractures in the middle one-thirds of the humerus are less risky as compared to fractures in other localizations.[23] The non-union

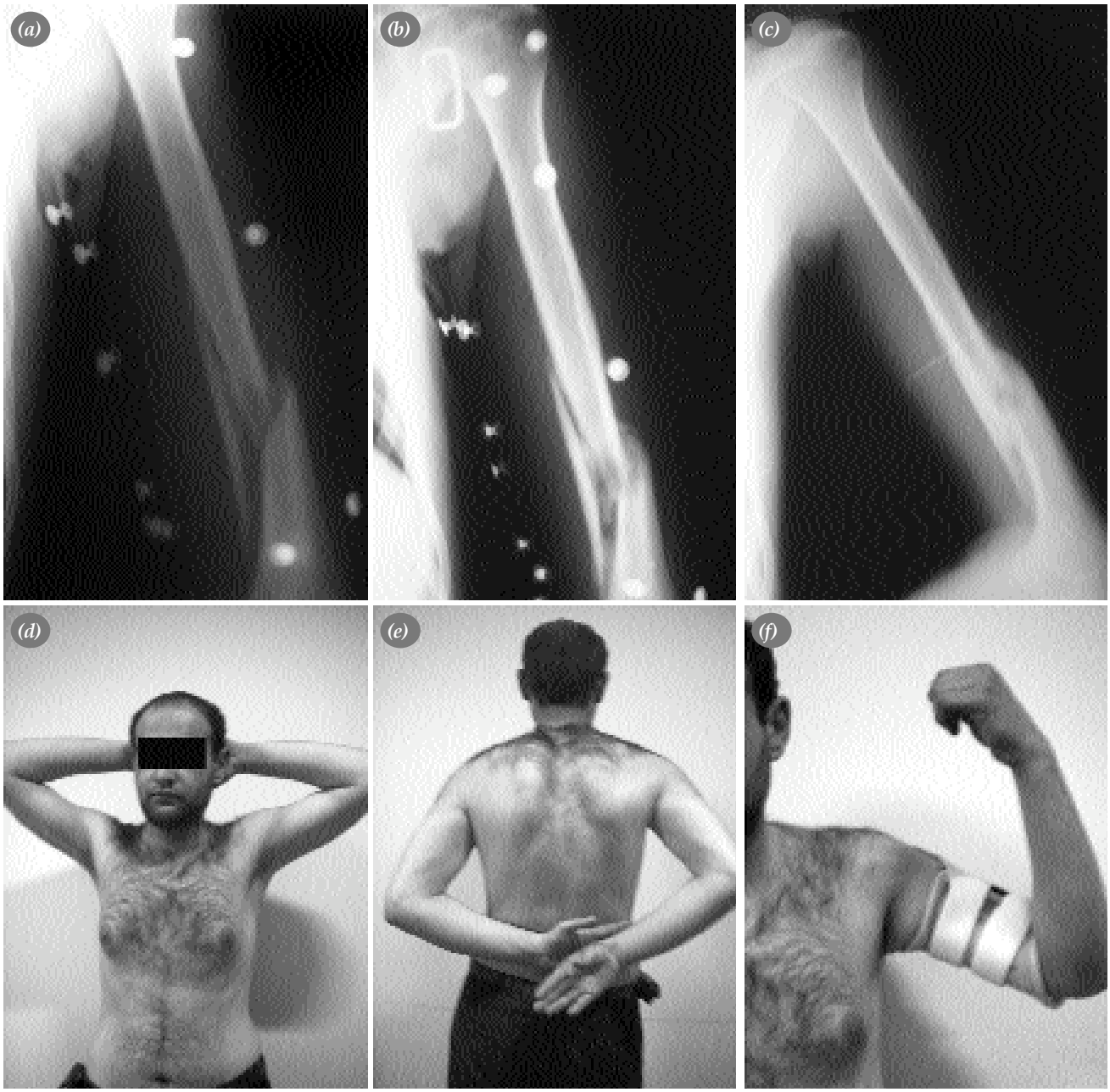

Figure 1. **(a)** Third-week x-ray of the patient followed up with Sarmiento brace. **(b)** Arrangement of bones in the sixth-week x-ray is appropriate, and callus formation can be seen. **(c)** Full healing was obtained according to the sixth-month control x-ray. **(d)** Anterior, and **(e)** posterior view of the functional results of the patient. **(f)** It is observed here that movement is full when the brace is on.

case in our study was related to the form of the fracture, as seen frequently in transverse fractures, rather than the location of the fracture.

It is known that posteroanterior angulations up to 20° and varus angulations up to 30° do not cause significant functional impairment.[10,22] Posteroan-terior angulations in this study were found to be 8° in the average, and a varus angulation was found to be 60 in the average. Shortening of 1.7cm developed in only one patient. Functional loss or cosmetic problems were seen in none of our patients.

Rate of non-union in humeral shaft fractures is reported between 2-20% in the literature.[3] Nonunion was observed with a rate of 20% also in this study. Treatments of two-thirds of the patients that treatment was initiated with functional brace are continuing in the same center; however, modes of treatment for those leaving the follow-up are unknown. Even in the study of Sarmiento et al.[24] only 620 patients out of 922 (67%) could be followed up till healing. In the study of Zagorski et al[7] however, only 170 patients out of 233 could be followed till the end of treatment. Results of the patients lost to follow-up, and whether or not a different treatment modality has been applied to them are unknown. A lower union rate of 80% supports this suggestion.

We believe that treatment with functional brace maintains its property of being the first option in humeral shaft fractures with its advantages like bearing no surgical risks, ease of application, not causing of loss of work power, being economically advantageous and healing with good functional results, provided that indication is established well.

References

1. Sarmiento A, Waddell JP, Latta LL. Diaphyseal humeral fractures: treatment options. Instr Course Lect 2002;51:257-69.
2. Sarmiento A, Horowitch A, Aboulafia A, Vangsness CT Jr. Functional bracing for comminuted extra-articular fractures of the distal third of the humerus. J Bone Joint Surg [Br] 1990;72:283-7
3. Balfour GW, Mooney V, Ashby ME. Diaphyseal fractures of the humerus treated with a ready-made fracture brace. J Bone Joint Surg [Am] 1982;64:11-3.
4. 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.
5. Osterman PAW, Ekkernkamp A, Muhr G. Functional bracing of shaft fractures of the humerus-an analysis of 195 cases. Orthop Trans 1993-1994;17:937-46.
6. Sharma VK, Jain AK, Gupta RK, Tyagi AK, Sethi PK. Nonoperative treatment of fractures of the humeral shaft: a comparative study. J Indian Med Assoc 1991;89:157-60.
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. Wallny T, Westermann K, Sagebiel C, Reimer M, Wagner UA. Functional treatment of humeral shaft fractures: indications and results. J Orthop Trauma 1997;11:283-7.
9. Calderone RR, Ghobadi F, McInerney V. Treatment of shoulder dislocation with ipsilateral humeral shaft fracture. Am J Orthop 1995;24:173-6.
10. Sarmiento A, Latta LL. Functional fracture bracing. J Am Acad Orthop Surg 1999;7:66-75.
11. Redmond BJ, Biermann JS, Blasier RB. Interlocking intramedullary nailing of pathological fractures of the shaft of the humerus. J Bone Joint Surg [Am] 1996;78:891-6.
12. Tome J, Carsi B, Garcia-Fernandez C, Marco F, Lopez-Duran Stern L. Treatment of pathologic fractures of the humerus with Seidel nailing. Clin Orthop Relat Res 1998;(350):51-5.
13. Thomsen NO, Mikkelsen JB, Svendsen RN, Skovgaard N, Jensen CH, Jorgensen U. Interlocking nailing of humeral shaft fractures. J Orthop Sci 1998;3:199-203.
14. Hunter SG. The closed treatment of fractures of the humeral shaft. Clin Orthop Relat Res 1982;(164):192-8.
15. Bell MJ, Beauchamp CG, Kellam JK, McMurtry RY. The results of plating humeral shaft fractures in patients with multiple injuries. The Sunnybrook experience. J Bone Joint Surg [Br] 1985;67:293-6.
16. Cheng J, Lau PY. Distal fracture with hypertrophic nonunion: a complication of Seidel humeral nail. Injury 1997; 28:223-6.
17. Paradis GR, Kelly PJ. Blood flow and mineral deposition in canine tibial fractures. J Bone Joint Surg [Am] 1975;57: 220-6.
18. Terjesen T, Svenningsen S. Function promotes fracture healing. Plate-fixed osteotomies studies in rabbits. Acta Orthop Scand 1986;57:523-5.
19. Aynaci A, Aydin H, Erkut A, Sener M. Treatment of humeral shaft fractures with the use of U-splints. [Article in Turkish] Acta Orthop Traumatol Turc 2001;35:232-5.
20. Alıcı E, Pedukcoşkun S, Erel N. Humerus cisim kırıklarının kapalı transepikondiler intrameduller osteosentezi. Acta Orthop Traumatol Turc 1989;23:204-6.
21. Kessler SB, Nast-Kolb D, Brunner U, Wischhofer E. Intramedullary nailing of the humerus as an alternative to conservative therapy and to plate osteosynthesis. [Article in German] Orthopade 1996; 25:216-22.
22. Patel VR, Menon DK, Pool RD, Simonis RB. Nonunion of the humerus after failure of surgical treatment. Management using the Ilizarov circular fixator. J Bone Joint Surg [Br] 2000;82:977-83.
23. Paul RG. Fractures of the shaft of the humerus. In: Bucholds RW, Heckman JD editors. Fractures in adult. Vol. 1, 5th ed. Philadelphia: Lippincott-Williams & Wilkins; 2001. p. 973-96.
24. Sarmiento A, Zagorski JB, Zych GA, Latta LL, Capps CA. Functional bracing for the treatment of fractures of the humeral diaphysis. J Bone Joint Surg [Am] 2000;82:478-86.