The Use of Simple Monolateral Bar External Fixation as a definitive treatment of Humeral Shaft Fractures

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الخلاصة
مقدمة : تعتبر صفيحة الضغط الديناميكي الخيار الاكثر قبولا و المتوفر لغرض التثبيت الجراحي لكسر ساق عظم العضد. لكن هذه الصفيحة ليست بدون جوانب سلبية من الناحية البايولوجية. في محاولة لأعطاء الاولوية للناحية البايولوجية تم تطوير مبدأ المثبت الداخلي و الذي يشبه من حيث المبدأ المثبت الخارجي
هدف الدراسة : دراسة استعمال المثبت الخارجي كتثبيت نهائي لهذا الكسر
الطريقة : منذ كانون الثاني ٢٠٠٥ و لغاية نيسان ٢٠٠٩ تم علاج ٣١ مريض مصاب بكسر ساق عظم العضد و المتطلب تثبيتا جراحيا بواسطة المثبت الخارجي ذو الانبوب و المستوي الواحد. تم ارجاع الكسر بالطريقة المغلقة أو المفتوحة. تم تسجيل الوقت لحين الألتحام، الوقت لحين رفع المثبت الخارجي و مدى حركة الكتف و تمت مقارنتها بالنتائج المقابلة من دراسات أخرى تستعمل صفيحة الضغط الديناميكي أو المثبت الخارجي
النتائج : كان معدل الوقت لحين اجراء التداخل الجراحي ٥.٣٢ يوم، و معدل الوقت للألتحام و ترخية و تحميل جهاز المثبت الخارجي ١١.٥٥ يوم فيما كانت الفترة لحين رفع المثبت الخارجي
الأستنتاج: اختيار المثبت الخارجي ذو الانبوب و المستوي الواحد لعلاج كسر ساق عظم العضد يمثل خيارا فعالا ، مقنعا ، قليل الخطورة مع حماية قصوى للأنسجة المحيطة و عند الاخذ بنظر الأعتبار الأهتمام المتجدد بالناحية البايولوجية فأنه يعتبر بديلا معقولا لصفيحة الضغط الديناميكي

Abstract
Background: Dynamic Compression Plating (DCP) has been the most accepted available surgical fixation method for fractures of humerus shaft in our country. DCP has biological shortcomings. By giving priority to biology, the "internal fixator" principle, has been popularized, bearing some similarity to an external fixator (EF).

Aim of the study: EF is being evaluated as an acceptable definitive fixation for this injury.
Methods: Between January 2005 and April 2009, 31 patients with acute fracture of the humeral shaft requiring surgical stabilization were treated using simple unilateral bar EF. Reduction achieved either closed or open. Time till union, time till removal of EF, and elbow & shoulder range of motion were recorded, and compared with corresponding values from studies using DCP or EF.
Results: Average time till surgery was 5.32 days. Average time for union and dynamization of EF was 11.55 weeks. And for removal of EF was 15.1 weeks.

Conclusion: Monolateral bar EF for treatment of humerus shaft fractures is reliable, effective, low risk, with maximum protection of soft tissue. Considering the renewed attention in biological approaches, it's a reasonable alternative to DCP, the only surgical alternative available in our country.
Key words: *Humerus, fracture, external, fixation, biologigal.*

Introduction

When uncomplicated diaphyseal fractures of the humerus are treated nonoperatively by reduction and subsequent immobilisation of the arm, successful healing occurs in over 90-95% of cases (3,7,24,32,34), with good functional results (20,33,36). Surgical intervention, however, is preferred for open, segmental and pathological fractures. Surgical stabilization is also considered to be the best treatment for bilateral fractures of the humerus and floating elbow (ipsilateral fractures of the humerus and forearm), as well as in cases of polytrauma, progressive neurological deficit, vascular injury, obesity, and failed conservative treatment (4,7,24,28,34). Studies are still carried out about the most appropriate surgical treatment method of humeral shaft fractures. Most recent studies concentrate on comparing the use intramedullary nailing with plate fixation (10,22,29), listing their advantages and disadvantages, and giving priority to one over another (12,16,22,34).

Plating techniques varies from conventional total contact DCP and limited contact LC-DCP, to the locked compression plate (LCP); using open reduction technique or minimally invasive one (MIPO). These are also the subject of further studies (8,10,14,19,26), while others still discuss the role of external fixation (EF) (9,17,18,21,31, 23)

Humeral shaft fractures represent a good proportion of the overall fracture cases treated in hospitals, in one study 5% of all fractures(25). In Iraq, young people are mostly affected because of the special situation that we have. Medico legal aspects in our society plus the young, active, and working population affected; added to the known indications for surgical management of fracture shaft humerus; this made us, increasingly adopt surgical solutions. Our theaters lack locked I.M nails and the most recent plating instruments (LCP); this has limited the surgeon's therapeutic possibilities for humeral midshaft fractures to; nonoperative, conventional plating DCP (there is no LC-DCP, or LCP), EF (most available is the unilateral bar), and a combination of external and limited internal fixation(lag screws, circlage wire…).

Material and Method

31 patients requiring surgical stabilization, were enrolled in our study, Starting from January 2005 in Baaquba General Hospital & ending in April 2010. Patients consulted either the out-patient department or the emergency room. All patients had acute humeral shaft fractures. The fractures were located from 5 cm distal to the surgical neck to 5 cm proximal to the olecranon fossa. We excluded non displaced and minimally displaced fractures that were suitable for conservative methods, and patients that refused surgical interference, and neck & supracondylar humeral fractures. All surgeries were done by the same surgeon.

Reduction was achieved either closed, open through the fracture wound, or through a limited classic approach for some closed fractures. X-ray control was used whenever available in the theater.

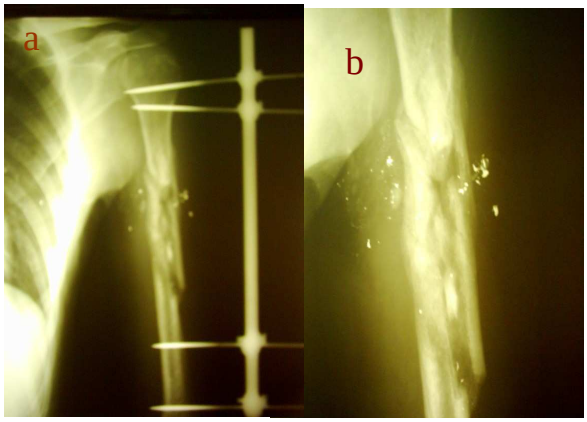

Fig. 1: left humerus of 21 y old male, Gostillo type II caused by bullt injury closed reduction and external fixation (a) done 7 days from his injury , (b) callus bridging bony fragments at 8 weeks, dynamization done on 10th week and removal on 14th week post injury

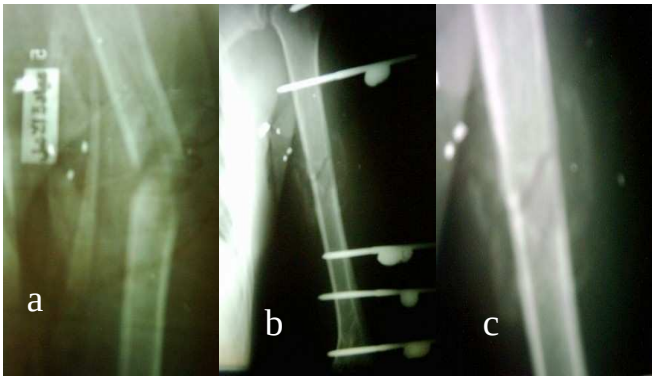

Fig. 2: (a) 25 y old male, Left humerus gostillo II due to shell injury. Associated radial and ulnar nerves dysfunction.(b) Open reduction with exploration of injured nerves plus external fixation done. (c) very good healing at 10 weeks from injury, dynamization on 10 weeks and removal on 14 weeks

All were fixed by simple unilateral bar external fixation, 5 patients had an additional (lag screws) when there was the need for open reduction and suitable fracture configuration. In most patients 4 pins were used 2 above and 2 below fracture site, since the aim was relative stability rather than absolute. In comminuted cases free fragments were not reduced exactly. A relatively safe positioning technique of the distal screws of the fixator was used, taking into consideration, careful study of fracture morphology, inserting the distal screws in a perfect lateral plane with pin entry at the lateral supracondylar ridge, and clinical localization of radial nerve as it crosses the lateral intermuscular septum. Similar precautions were followed regarding the axillary nerve relation to surgical neck (5,6).

Patients were followed in the out-patient clinic every two weeks, whereby instructions and care are provided to the patients. Check X-rays done post-operatively, at 2 weeks, and then every 4 weeks. They were allowed full activity to the limit of tolerance, encouraging both elbow and shoulder movments from the start. As soon as adequate callus of union was seen, dynamization of external fixator was carried out; and that was followed by removal of fixator after 3-4 weeks (**Fig. 1, Fig. 2**).

Results

Age of patients ranged from 19 y to 51 y (average 29.74 y). 28 (0.903%) patients were males and only 3 females (0.096%). Lt humerus was involved in 18 (58.0%) patients, while the Rt humerus in the other 13 (41.9%). All 31 patients had acute fractures. Acute closed fractures were 17 (54.8%) cases, open 14 (45.2%) (Gostillo I two cases, II four cases, IIIA three, IIIB three, and IIIC two). 19 (0.612%) patients had fracture comminution. In 12 (38.7%) patients, there was a simple fracture configuration (4 transverse, 6 oblique, and 2 spiral). Most associated injuries were nerve injuries (radial 5, ulnar 2, and median 2), the same patient may have more than one injured nerve, other associated injuries were fractures (clavicle 2, mandible 1, and contralateral radius 1), brachial artery 2, penetrating abdominal 2, penetrating chest 2. Injuries were due to Firearms 10 (bullets and shells), RTA 12, and falls 9. The average time till surgery was 5.8 days (range from same day of injury to 3 weeks delay).

17 (54.8%) fractures were reduced closed, and 14 (45.2%) reduced open (through the fracture wound, or through a deliberately made limited approach). External fixation (single unilateral bar) was used in all cases. In 5 cases, open reduction was accompanied by additional minimal internal fixation (2 lag screws). Average time for union and dynamization of fixator was 11.5 weeks (range 8-17 weeks.), lowest in those with lag screws, and higher in the high energy comminuted fractures. Average time for removal of fixator was 15 weeks (range 11-20 weeks.), lowest in those with lag screws, and higher in the high energy fractures. Waiting till sound healing of fractures for removal of external fixator affected these figures

There was one postoperative partial radial nerve palsy that recovered after manipulating the construct. One fracture had to be re-manipulated under GA because of undesirable angulation that persisted from emergency surgery. One fracture ended with a painful posterior upper arm bony prominence that was trimmed after healing and consolidation. There was no failure of union or fixation. There were no malunion in the postoperative X-rays. All patients referred to physiotherapy department upon removal of external fixation. 22 patients were contacted 1 month after removal of fixator. Range of motion at short term follow-up:- elbow range of motion was 120 degrees, shoulder abduction 135 degrees, external rotation 50 degrees and internal rotation 75 degrees. These results are expected to improve with progress of physiotherapy. 20 reported they were satisfied with their result, 17 had no functional limits, and 16 reported no pain at all.

Discussion

Several studies in recent years has tried to identify the best method for humeral shaft fixation. Many compared plate fixation with intramedullary fixation and has reached different conclusions (10,22,25,29). The rate of complications associated with intramedullary rodding was higher than that associated with plate fixation. These were related to the rates of union and increase functional symptoms such as shoulder pain and weakness. Complications such as infection, radial nerve palsy, delayed union, and failure of fixation seem to occur at an equivalent rate with both types of fixation (12,25,34).

To overcome biological shortcomings that are associated with conventional plating, the trends in plating techniques are characterized by a shift towards biological approaches. Trauma and surgery result in damage of bone blood supply, plus additional impairment of vascularity due to compression of plate against the bone (11). The contact of the implant without undercuts (DCP) results in a prismatic sequestrum, that increases the risk of an infection (**fig.3**), and when comparing the amount of staphylo-coccus aureus required for the onset of a local infection, it was 450 times more bacteria were required to start an infection with the internal fixator point contact PC-Fix, than that for DCP (1,2,11)

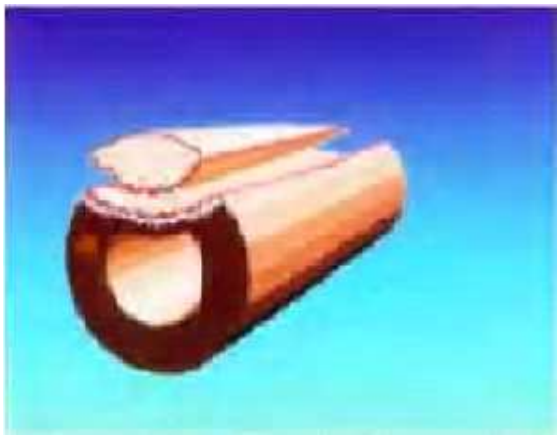

Fig. 3: impairment of vascularity due to compression of plate against the bone results in a prismatic sequestrum, that increases the risk of an infection (2)

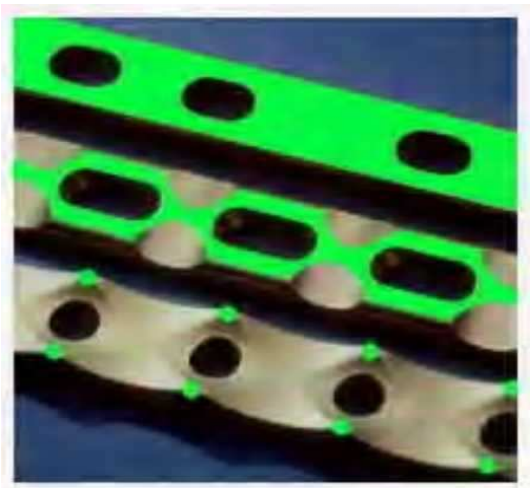

Fig. 4: from above downwards, DCP, LC-DCP,and PC-Fix, decreasing area of contact with bone surface (2)

The latest development, the internal fixator principle and "peri-osseal" internal fixation, does not depend on pressing the plate body to the bone, because the screws heads that are firmly locked in the plate (Pc-fix, LCP) (**fig.4**) provide angular stability comparable to the clamps of external fixator that links the Schanz screws to the longitudinal rod. In the internal fixator, the latter is replaced by a plate which is applied slightly elevated from the bone surface submuscularly or subcutaneously, thus, preventing squeezing of the periosteal blood supply (1,11,13,26,27,30). To further respect the biology of bone and soft tissue, minimally invasive approaches are suggested with percutaneous plate insertion, with a parallel shift from obsolute stability towards relative, or elastic one(1,19,27,30).

With regard to this biological priorities, without forgetting the requirements of ideal fixation system (1), and instead of using conventional plating with DCP (the only available plate here); we chose to use external fixation as a primary and definitive method to treat most patients attending our clinic with humeral midshaft fractures. In most cases, as long as the fracture fragments were in line, they were not reduced exactly. Early function and undisturbed fracture healing with homogeneous restitution of the bone, justified giving biology priority over perfect reduction and absolute stability.

The average patients' age 29.4 years reflects the population mostly affected in our society as result of war and civilian violence. This fact was also reflected by the dominance of males 28 of 31 (90.3%). 19 (61.3%) patients had fracture comminution, and 14 (45.2%) were open at presentation. Reviewing these figures for comminuted and compound fractures can provide a rough indication about severity of injuries in our series, for comparison with other studies.

Chiu et al 1997 treated a group of humeral shaft fractures with DCP without BG in which union time was 12.5 weeks. In another study, Chen et al 1998 in his series for closed humeral shaft fractures using DCP without BG, the fracture union time was 13.5 weeks.

The periods given for union, without using bone graft, in their studies are comparable to our union (dynamization) time. Our time for union was 11.5 weeks,

which is acceptable for this type of injury, especially if we put in mind that in non-operative treatment, brace usually removed in 10 to 13 weeks (34). This time represents the time for undisturbed natural healing.

Chantelot et al 2002 treated 23 humeral fractures using the Orthofix external fixator. The average duration of external fixation was 21 weeks. Most fractures were comminuted and the external fixator was removed after complete union: this explains the long delay of union in his series. Despite this long time, they stated that external fixation was their favourite for this type of injury. Our time for fixator removal was 15 weeks only which is significantly better than that given by Chantelot et al.

There was one postoperative partial radial nerve palsy that recovered after manipulating the construct. One fracture had to be re-manipulated under GA and changing two pin insertion sites because of undesirable angulation that persisted from emergency surgery. One fracture resulted in a painful posterior upper arm bony prominence that was trimmed after healing and consolidation. All these second touch interventions were minor, safe, and effective with predictable outcome. There was no failure of union or fixation. There were no malunion in the postoperative X-rays. All patients referred to physiotherapy department upon removal of external fixation. 22 patients were contacted 1 month after removal of fixator. Range of motion at short term follow-up elbow range of motion was 120 degrees, shoulder abduction 135 degrees, external rotation 50 degrees and internal rotation 75 degrees. These figures were less than those obtained by Chantelot et al, but this was partially due to difference in follow-up period. Our results are expected to improve with progress of physiotherapy. 20 patients reported that they were satisfied with their result, 17 had no functional limits, and 16 reported no pain

The figures obtained with our patients for union, fixator removal, and limited postoperative follow-up; supports our choice for this method, and when we consider the absence of (LC-DCP, LCP, and IM nails); the availability and ease of use of external fixation for midshaft humerus fractures, and the recent trends for biological internal fixation, one can see that the surgeon can achieve many points that meet the requirements of ideal fixation system such as restoring anatomical relationships, providing the required stability, respecting biology, and allowing early and safe mobilization. Certain limitations exist, mostly due to presence of pin track infection, but can be minimized with good pin care and adjacent joints exercises. The risk of injuring the radial & axillary nerves can be minimized by proper preoperative & intra-operative planning & the possible use of mini-incision.

conclusion

From the above review and results one can conclude that the use of simple monolateral bar external fixation in the treatment of humerus shaft fractures is reliable, effective and low risk provided that the patient is cooperative; furthermore, with carefull pin insertion, the monolateral external fixator is tolerated well and allows movement of the shoulder and elbow throughout the period of treatment. It is a valuable option because of its ability to provide rigidity or elasticity and the possibility of secondary dynamization. There is maximum protection of the soft tissue with this method of treatment. External fixation combines the advantages of conservative and operative treatment by influencing callus formation by dynamization, distraction or compression.

References

1. AO international, AO teaching series, locking compression plate, interactive CD-ROM, 2002 by AO publishing- Switzerland, AOI-E1 002.1/version 1.
2. Arens S, Kraftc, Schiegel U, etal. Susceptibility to local infection in biological internal fixation. Experimental study of open vs minimally invasive plate osteosynthesis in rabbits. Arch Orthop TraumaSurg1999;119:82-85.
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-A:11-3.
4. Bell MJ, Beauchamp CG, Kellam JK, McMurty RY. The results of plating humeral shaft fractures in patients with multiple injuries: the Sunnybrook experience. J Bone Joint Surg [Br*]* 1985;67-B:293-6.
5. Bhandari M, Devereaux PJ, McKee MD, Schemitsch EH. Compression plating versus intramedullary nailing of humeral shaft fractures—a meta-analysis. Acta Orthop, 2006:(77):279-84.
6. Bono, Christopher M, Grossman, Mark G, Hochwald, Neal, Tornetta, Paul III**.** Radial and Axillary Nerves: Anatomic Considerations for Humeral Fixation. Clinical Orthopaedics & Related Research. 2000 Apr;373:259-264.
7. Brumback RJ, Bosse MJ, Poka A, Burgess AR. Intramedullary stabilisation of hummers shaft fractures in patients with multiple trauma. J Bone Joint Surg [Am] 1986;68-A:960-70.
8. Chen CM, Chiu FY, Lo WH, Huang YL, Chen TH, Huang CK. Acute closed humeral shaft fractures treated with dynamic compression plate. Zhonghua Yi Xue Za Zhi 1998 Oct;61(10):584-8.
9. Chantelot C, Robert G, Aihonnou T, Gueguen G, Migaud H, Fontaine C. Role of external fixators for treatment of humeral fractures: report of 23 cases using Orthofix fixators. Chir Main. 2002 Mar; 21(2):134-9.
10. Chiu FY, Chen CM, Lin CF, Lo WH, Huang YL, Chen TH. Closed humeral shaft fractures: a prospective evaluation of surgical treatment. J Trauma. 1997 Dec;43(6):947-51.
11. Farouk 0, Krettek C, Miclau T, et al. Effects of percutaneous and conventional plating techniques on the blood supply to the femur. Arch Orthop Trauma Surg 1998;117:438-441.
12. Farragos, Anthony F, Schemitsch, Emil H. McKee, Michael D. Complications of Intramedullary Nailing for Fractures of the Humeral Shaft: A Review. Journal of Orthopaedic Trauma. 1999 May;13(4):258-267.
13. Flinkkila, Tapio MD; Ristiniemi, Jukka MD, and; Hamalainen, Martti MD. Nonunion after Intramedullary Nailing of Humeral Shaft Fractures. Journal of Trauma-Injury Infection & Critical Care. 2001 Mar;50(3):540-544.
14. Frigg R Locking Compression Plate (LCP). An osteosynthesis plate based on the Dynamic Compression Plate and the Point Contact Fixator (PC-Fix). Injury. 2001 Sep:32 Suppl 2:63-6.
15. Gongol T, Mracek D. Functional therapy of diaphyseal fractures of the humeral bone Acta Chir Orthop Traumatol Cech. 2002;69(4):248-53.
16. Hems TE, Bhullar TP. Interlocking nailing of humeral shaft fractures: the Oxford experience 1991 to 1994. Injury. 1997 Oct;28(8):571-2.
17. Johnson EC, Strauss E. Recent advances in the treatment of gunshot fractures of the humeral shaft. Clin Orthop Relat Res. 2003 Mar;(408):126-32.
18. Joshi A, Labbe M, Lindsey RW. Humeral fracture secondary to civilian gunshot injury. Injury. 1998;29 Suppl 1:SA13-7.

19. Krettek C Foreword: concepts of minimally invasive plate osteosynthesis. Injury 1997 ;28:A1-2.
20. Kulenkampff HA, Rustemeier M. Clinical experiences in the treatment of humeral shaft fractures with the Sarmiento brace Unfallchirurgie. 1988 Aug;14(4):191-8.
21. Lavini F, Renzi Brivio L, Pizzoli A, Giotakis N, Bartolozzi P. Treatment of non-union of the humerus using the Orthofix external fixator. Injury. 2001 Dec;32 Suppl 4:SD35-40.
22. Lin, Jinn MD, Treatment of Humeral Shaft Fractures with Humeral Locked Nail and Comparison with Plate Fixation. Journal of Trauma-Injury Infection & Critical Care. 1998 May;44(5):859-864.
23. Li ZZ, SX, Wu KJ, Zhang WJ, Li WF, Shang WL, Wu WW. Unilateral external fixation in the treatment of lower third humeral shaft fracture. Chin J Traumatol, 2005: (8):230-5.
24. Mast JW, Spiegel PG, Harvey JP, Harrison C. Fractures of the humeral shaft. Clin Orthop 1975;12:254-62.
25. McCormack RG, Brien D, Buckley RE, McKee MD, Powell J, Schemitsch EH. Fixation of fractures of the shaft of the humerus by dynamic compression plate or intramedullary nail, a prospective randomized trial. JBJS. 2000 Apr;82-B, No.3, 336-339.
26. Miclau T, Remiger A, Tepic 5, et al. A mechanical comparison of the dynamic compression plate, limited contact-dynamic compression plate, and point contact fixator. J Orthop Trauma1995 ;9:17-22.
27. Perren SM. Evolution of the internal fixation of long bone fractures. The scientific basis of biological internal fixation: choosing a new balance between stability and biology. J Bone Joint Surg(Br)2002;84:1093-110.
28. Robinson CM, Bell KM, Court-Brown CM, McQueen MM. Locked nailing of humeral shaft fractures. J Bone Joint Surg [Am] 1992;74-A:558-62.
29. Rodriguez M, Carlos E, Gomez C, Fernando. Internal Fixation of nonunions**.** Clinical Orthopaedics & Related Research. 2004 Feb;419:13-20.
30. Ruedi TP, Murphy WM. AO Principles of Fracture Management. Thieme, Stuttgart-Newyork, 2000.
31. Ruland WO. Is there a place for external fixation in humeral shaft fractures? Injury. 2000;31 Suppl 1:27-34.
32. Sarmiento A, Kinman P, Galvin E. Functional bracing of fractures of the shaft of the humerus. J Bone Joint Surg [Am] 1977;59-A:596-601.
33. Sarmiento A, Zagorski JB, Zych GA, Latta LL, and Capps CA. Functional Bracing for the Treatment of Fractures of the Humeral Diaphysis The Journal of Bone and Joint Surgery 2000;82:478.
34. VaccaroAR. Orthopedic knowledge update 8, home study syllabus, Rosemont. American Academy of Orthopedic Surgeons, 2005:275-277.
35. Wisniewski TF, Radziejowski MJ. Gunshot fractures of the humeral shaft treated with external fixation. J Orthop Trauma. 1996;10(4):273-8.
36. Zagorski JB, Latta LL, Zych GA and Finnieston AR. Diaphyseal fracture**s** of the humerus. Treatment with prefa bricated braces The Journal of Bone and Joint Surgery, Vol 70, Issue 4 607-610.