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ORIGINAL PAPER

Comparison of the use of the humerus intramedullary nail and dynamic compression plate for the management of diaphyseal fractures of the humerus. A randomised controlled study

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Abstract The aim of this study was to compare the results of the humerus intramedullary nail (IMN) and dynamic compression plate (DCP) for the management of diaphyseal fractures of the humerus. Forty-seven patients with diaphyseal fracture of the shaft of the humerus were randomised prospectively and treated by open reduction and internal fixation with IMN or DCP. The criteria for inclusion were grade 1 or 2a compound fractures, polytrauma, early failure of conservative treatment and unstable fractures. The patients with pathological fractures, grade 3 open fractures, refractures and old neglected fractures of the humerus were excluded from the study. Twenty-three patients underwent internal fixation by IMN and 24 by DCP. Reamed antegrade nailing was done in all cases. DCP was done through an anterolateral or posterior approach. The outcome was assessed in terms of the union time, union rate, functional outcome and the incidence of complications. Functional outcome was assessed using the American Shoulder and Elbow Surgeons' Score (ASES). On comparing the results by independent samples *t* test, there was no significant difference in ASES scores between the two groups ($P>0.05$). The average union time was found to be significantly lower for IMN as compared to DCP ($P<0.05$). The union rate was found to be similar in both groups. Complications such as infection were found to be higher with DCP as compared to IMN, while shortening of the arm (1.5–4 cm) and restriction of shoulder movements due to impingement by the nail were found to be higher with IMN as compared to DCP. However, this improved in all patients following the removal of the nail once the fracture had healed. This study proves that IMN can be considered a better surgical option for the management of diaphyseal fractures of the humerus as it offers a short union time and lower incidence of serious complicatins like infection. However, there appears to be no difference between the two groups in terms of the rate of union and functional outcome.

Résumé Le but de cette étude est de comparer les résultats de l'enclouage centro médullaire de l'humérus à ceux d'une plaque en compression dans le traitement des fractures diaphysaires. Quarante-sept patients avec une fracture diaphysaire de l'humérus ont été traités prospectivement, de façon randomisée par réduction à foyer ouvert et une fixation soit par clou centro médullaire (IMN) ou par plaque à compression (DCP). Les critères d'inclusion des patients ont été des fractures de grade 1 à 2a dans le cadre d'un polytraumatisme, après échec d'un traitement conservateur ou une fracture instable. Les patients avec une fracture pathologique, les fractures ouvertes de grade 3, les fractures itératives ou les fractures négligées ont été exclues de cette étude. Vingt-trois patients ont bénéficié d'un clou centro médullaire, 24 d'une plaque de compression. Problème du clou: les clous ont été mis en place après alésage, dans tous les cas, les plaques après un abord antéro latéral ou postérieur. Ont été étudiés en termes de consolidation, de résultats fonctionnels et de complications. Les résultats ont été appréciés selon le score de l'Association américaine de Chirurgie du coude et de

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l'épaule (ASES). La comparaison des résultats montre qu'il n'y a pas de différence significative entre les deux groupes (P>0,05). Le temps de consolidation a été significativement réduit pour l'enclouage centro médullaire comparé à l'ostéosynthèse par plaque (P<0,05). Il y a beaucoup plus de complications infectieuses avec l'ostéosynthèse par plaque comparée au clou. Par contre, la diaphyse humérale a été raccourcie de 1.5 à 4 cm avec l'enclouage et cet enclouage a entraîné une limitation des mouvements de l'épaule de façon plus importante, celle-ci s'améliorera après ablation du clou. Cette étude prouve que le clou centro médullaire dans le traitement des fractures de la diaphyse humérale peut être considérée comme la meilleure option chirurgicale, néanmoins il n'y a pas de différence entre les deux groupes en terme de consolidation et de devenir fonctionnel.

Introduction

Most uncomplicated humeral shaft fractures can be managed non-operatively, with an expected union rate of more than 90%. The methods include the hanging cast, functional brace, Velpau dressing and shoulder spica cast [1, 10, 15].

The indications for operative treatment are open fractures, segmental fractures, pathological fractures, those with associated vascular injuries, bilateral humerus fractures, humerus fractures in polytrauma patients, radial nerve palsy after fracure manipulation, neurological loss after penetrating injuries, fractures with unacceptable alignment and failed conservative treatment [2, 3, 13]. The usual operative modalities used are the dynamic compression plate (DCP) and intramedullary nail (IMN). The use of the dynamic compression plate requires an extensive operation with stripping of soft tissues from the bone, complications due to the proximity of the radial nerve in the usual field of dissection and less secure fixation especially in osteoporotic bones. The recent technical advances and aggressive marketing have popularised the use of the IMN nail [4]. Rockwood and Green recommend fixation of diaphyseal fractures of the humerus by the IMN, which can be inserted antegrade from the shoulder or retrograde from the elbow [14]. Theoretically speaking, fixation with the IMN requires less invasive surgery, has a biomechanical advantage, acts as a load-sharing device, has less stress shielding, has less chance of refracture after implant removal and reaming can yield autograft.

Materials and methods

The proposed study was undertaken in the Department of Orthopaedic Surgery at King George Medical University College, Lucknow, India, between 1998–2001. During this period, 47 consecutive patients with fracture of the shaft of the humerus requiring surgical stabilisation were randomised using a sealed envelope to undergo fixation with either DCP or IMN.

The operating surgeons were experienced with both procedures. The fractures were located between 2 cm distal to surgical neck or 3 cm proximal to the olecranon fossa.

The criteria used for selection were:

(1) Patients with grades 1 and 2a open fractures
(2) Polytrauma
(3) Early failure of conservative treatment
(4) Unstable fractures

All patients were skeletally mature adults.

The following patients were excluded:

(1) Patients with grade 3 compound fractures
(2) Patients with pathological fractures
(3) Patients with neglected fractures of the humerus
(4) Those with refractures of the humerus
(5) Patients who were uncooperative because of head injuries

After being randomised, the patients were treated surgically by DCP or IMN.

DCP was implanted through an anterolateral or posterior approach. The plates used were AO 4.5 mm 8 DCP plates, with the length depending upon the type of fracture.

Fixation of eight to ten cortices proximal and distal to the fracture was obtained in every patient.

The Russell Taylor IMN was used, and only antegrade nailing was done because of greater familiarity with the method among the surgeons. Proximal and distal locking, and reaming was done in all cases. The surgery was carried out under general anaesthesia in all patients.

Follow-up

All patients had a loading dose of antibiotics at induction and of prophylactic antibiotics for 48 hours.

All patients were discharged after 48 hours.

Stitch removal was done at 10 days in all patients.

From the first day, isometric exercises of the muscles of the upper and lower arm were carried out.

All patients were followed up in outpatient clinics at 6 weeks and at 3, 6 and 12 months.

Clinical and radiological assessment was done at each visit. Six months was chosen as a minimum as by that time healing of the fracture would normally have taken place, and functional improvement would be starting to level off.

The implants were removed after the consolidation of the fracture, usually after 12 months.

The outcomes were assessed in terms of functional outcome, ability to return to previous jobs after 6 months,

union time, union rate and the incidence of complications. Functional outcome was assessed using the American Shoulder and Elbow Surgeons' Score [9].

Autogenous iliac bone grafting was done in 12 cases of group A (IMN) and 7 cases of group B (DCP).

Results were analysed using the independent samples *t* test.

Results

Out of 47 patients, 23 patients underwent internal fixation by IMN and 24 by DCP. Two patients from the IMN group were lost to follow-up. Thus, the final assessment was done for 21 patients in the IMN group and 24 patients in the DCP group.

Age The mean age of patients with IMN fixation was 39 years (SD -12) and 35 years (SD -11.5) for those who underwent DCP fixation ($P>0.05$).

Sex In group A (IMN), 20 were males (86.9%) and 3 females (13%), while in group B (DCP), 19 were males (79.2%) and 5 females (20.8%) (see Table 1).

Mode of injury Most of the patients sustained injuries in road traffic accidents [17 in group A (73%) and 16 in group B (66.6%)]. The second most common cause of injury was falling on the ground (four in group A and seven in group B) (see Table 2).

Duration of injury Most of the cases of both groups were more than 7 days old because initially conservative methods had been tried, but all were less than 3 months old.

The mean duration of injury for group A (IMN) was 45 (SD -29) days, while for group B (DCP) it was 38 (SD -19; $P>0.05$).

Two patients from the IMN group were lost to follow-up. Thus, the final assessment was done for 21 patients in the IMN group and 24 patients in the DCP group.

Table 1 Baseline characteristics of two groups

Variable	Group A (IMN)	Group B (DCP)
Age	39 years (SD -12)	35 years (SD -11.5)
Sex: male	20 (86.9%)	19 (79.2%)
Female	03 (13%)	05 (20.8%)
Mean duration of injury (days)	45 (SD -29)	38 (SD -19)

Table 2 Type of fracture

Type of fracture	IMN	DCP
A	12	14
B	7	6
C	4	4

Follow-up The mean period of follow-up was 14.3 months (6–33 months) in both groups.

Functional outcome

All patients of both groups were able to return to their previous jobs within 6 months, except for three patients of group A and three patients of group B who developed non union. Thus, the functional result was good in 85.7% of the cases in group A (IMN) and 87.5% of the cases in group B (DCP).

No statistically significant difference was found in the mean ASES score between the two groups [0.44 in group A (IMN) and 45 in group B (DCP); $P>0.05$)].

Fracture union

Out of 21 patients available for follow-up in group A (IMN) and 24 patients in group B (DCP), 18 (85.7%) united in group A and 21 (87.5%) in group B ($P>0.05$).

The average union time for group A was 6.3 weeks compared to 8.9 weeks for group B ($P<0.001$).

There was no significant difference between the union rate and the incidence of non union between the two groups.

The union time was found to be significantly lower in patients with IMN as compared to DCP.

Complications

Five patients of group B managed by DCP (20.8%) developed infection. Two of them were superficial infections that responded well to antibiotics and later healed uneventfully. Three patients in this group developed deep-seated infection and discharging sinuses. These were treated with long-term antibiotics, and once fracture union was achieved, the plate was removed and the sinus tract excised. Eventually, the sinus tract healed, but left an unsightly scar over the arm.

Only one patient (4.7%) of group A developed deep-seated infection and subsequent non union. This was managed by removal of the nail followed by reinsertion of the nail and bone grafting once the infection had subsided.

Seven (33.3%) patients of group A (IMN) developed shortening of an arm from 1.5–4 cm compared to 1 (4.1%) in group B (DCP).

Non union occurred in three (14.3%) of the IMN compared to three (12%) of the DCP group.

Implant failure occurred in one case (4.7%) of IMN due to breakage of a nail at the site of the distal locking screw.

One patient (4.7%) with IMN developed axillary nerve injury, which was due to the fact that the proximal incision extended 6–7 cm beyond the acromian process. One patient (4.1%) in the DCP group had a radial nerve injury.

Four patients with IMN had restriction of full abduction of the shoulder because of impingement of the nail. They were managed by removal of the nail once the fracture was united.

There were six patients in group A (IMN) and four in group B (DCP) with open fractures (Gustilo 1 or 2a). All had an initial debridement and early internal fixation. Two patients in group B developed superficial infection, which responded well to antibiotics. All of them united well (the average union time for group A was 7 weeks compared to 8.8 weeks for group B) with no complications (see Table 3).

Discussion

The previous studies suggest that in cases of DCP fixation the rate of non union is about 5%, infection about 2–4% and radial nerve palsy about 2–5%. In our study, nonunion occurred in 2 case out of 24 (8.3%), infection in 5 cases (20.8%) and radial nerve injury in 1 case (4%). All the patients regained nearly a full range of shoulder and elbow movements as evaluated by the ASES Score.

In our study of the IMN, non-union was seen in two cases (9.5%), which were managed by freshening of the bone ends and with bone grafting. The incidence of non-union reported in the literature is between 0–8%, and the reports of shoulder and elbow function vary widely [5, 7–9]. Hems and Bhullar suggested that antegrade nailing affects fracture healing by distracting the fracture and soft tissues [5]. The shortening of the affected arm by 1.5–4 cm was noted in seven (33%) cases with IMN fixation.

Table 3 Results

Variable	Group A (IMN)	Group B (DCP)
ASES score	44	45
Ability to return to previous jobs	85.7%	87.5%
Union rate	85.7%	87.5%
Union time	6.3 weeks	8.9 weeks
Infection	1 (4.5%)	5 (20.8%)
Nerve injury	1 (axillary)	1 (radial)
Implant failure	1 (4.5%)	0
Restriction of shoulder abduction	4 (19%)	0

Restriction of shoulder abduction due to impingement of the nail was noted in four cases, which were later managed by removal of the nail; implant failure was noted in one case due to breakage of the nail at the site of the distal locking screw; this was managed by DCP and bone grafting.

It has been reported that antegrade nailing can cause damage to the rotator cuff, leading to problems with shoulder function and the range of movements [14]. Our study resulted in four cases of shoulder impingement in the IMN group.

Heim et al. reported a 5% incidence of radial nerve injury with DCP fixation [6]. Out of 24 patients in our study treated by this method, only 1 case was found to have iatrogenic radial nerve palsy. None of the patients in the IMN group had this complication.

Though theoretically DCP can lead to stress risers at the end of the plate, our experience is consistent with the findings of McCormack et al. [15], finding that such problems may be greater at the site of distal locking screws and at the tip of the IMN.

Conclusion

The limitations of our study include the lack of a large group of patients, but despite that, the study has shown that in our hands IMN is a better surgical option than DCP for the management of diaphyseal fractures of the humerus. This is because it offers a short union time and lower incidence of serious complicatins such as infection.

However, there appears to be no significant difference between intramedullary nailing and dynamic compression plating in terms of the functional outcome and the rate of union of the fracture.

References

1. Balfour GW, Mooney V, Ashby ME (1982) Diaphyseal fractures of the humerus treated with a ready made brace. JBJS (AM) 64-A:11–13
2. Bell MJ, Beauchamp CG, Kellam JK, McMurty RY (1985) The results of plating humeral shaft fractures in patients with multiple injuries; the Sunnybrook experience. J Bone Joint Surg 67B:293–296
3. Brumback RJ, Bosse MJ, Poka A, Burgess AR (1986) Intramedullary stabilisation of humerus shaft fractures in patients with multiple trauma. JBJS (AM) 68-A:960–970
4. Habernek H, Orthner E (1991) A locking nail for fractures of the humerus. JBJS (Br) 73-B:651–653
5. Hems TE, Bhullar TP (1996) Interlocking nailing of humeral shaft fractures. The Oxford experience. 1991–1994. Injury 27:485–489

6. Heim D, Herkert F, Hess P, Regazzoni P (1993) Surgical treatment of humeral shaft fractures; the Basel experience. J Trauma 35:226–232
7. Ikpeme JO (1994) Inramedullary interlocked nailing for humeral fractures: experience with Russel-Taylor humeral nail. Injury 25:447–455
8. Ingman AM, Waters DA (1994) Locked intramedullary nailing of humeral shaft fractures. JBJS (Br) 76-B:23–24
9. Lin J, Shen PW, Hou SM (2003) Complications of locked nailing in humeral shaft fractures. J Trauma 54(5):943–949, May
10. Mast JW, Spiegel PG, Harvey JP, Harrison C (1975) Fractures of the humeral shaft. Clin Orthop 12:254–262
11. McCormack RG, Brien D, Buckley RE et al (2000) Fixation of fractures of the humerus by dynamic compression plate or intramedullary nail. JBJS (Br) 82-B:336–339
12. Petsatodes G, Karataglis D, Papadopoulos P et al (2004) Antegrade interlocking of humeral shaft fractures. J Orthop Sci 9(3):247–252
13. Robinson CM, Bell KM, Court-Brown CM, McQueen MM (1992) Locked nailing of humeral shaft fractures. JBJS (Am) 74-A:558–562
14. Rockwood C, Matsen F (1990) The shoulder. WB Saunders, Philadelphia, p 161
15. Sarmiento A, Kinman P, Galvin E (1977) Functional bracing of fractures of shaft of humerus. JBJS (Am) 59-A:596–601