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Original article

Treatment of two-part fractures of the surgical neck of the humerus using a locked metaphyseal intramedullary nail proximally with angular stability☆

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ABSTRACT

Objectives: To evaluate the functional results from patients with surgical neck fractures treated with a locked metaphyseal intramedullary nail and angular stability.
Methods: Twenty-two patients between the ages of 21 and 69 years were evaluated prospectively between January 2010 and January 2011. Their time taken for consolidation, age, sex, complications and functional results were correlated using the modified protocol of the University of California at Los Angeles (UCLA).
Results: The mean time taken for consolidation was 9.26 weeks ± confidence interval (CI) of 0.40 weeks. One case (4.5%) did not become consolidated. There were no cases of infection. There was one case (4.5%) of adhesive capsulitis with good evolution through clinical treatment. Five patients (22.7%) presented occasional mild pain and one case (4.5%) reported medium-intensity pain associated with the subacromial impact of the implant. The mean score on the modified UCLA scale was 30.4 ± CI 1.6 points, obtained at the end of 12 weeks of evaluation: 18 cases (81.8%) with "excellent" and "good" scores, three cases (13.6%) with "fair" scores and one case (4.5%) with a "poor" score.
Conclusion: In the group of patients evaluated, treatment of two-part surgical neck fractures by means of a locked metaphyseal intramedullary nail and angular stability demonstrated satisfactory functional results and a low complication rate, similar to what is seen in the literature.

☆ Work developed in the Institute of Orthopedics and Traumatology, Carmino Caricchio Municipal Hospital, São Paulo, SP, Brazil.

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Tratamento das fraturas em duas partes do colo cirúrgico do úmero com o uso de haste intramedular metafisária bloqueada proximalmente com estabilidade angular

Palavras-chave:
Fratura do úmero
Fixação intramedular de fraturas
Procedimentos cirúrgicos

RESUMO

Objetivos: Avaliar os resultados funcionais de pacientes com fraturas do colo cirúrgico tratados com haste intramedular metafisária bloqueada (HIMB) e estabilidade angular.
Métodos: Foram analisados 22 pacientes prospectivos entre 21 e 69 anos, avaliados entre janeiro de 2010 e janeiro de 2011, e correlacionados tempo de consolidação, idade, sexo, complicações e resultado funcional com o protocolo da University of California at Los Angeles (UCLA) modificado.
Resultados: O tempo de consolidação médio foi de 9,26 ± intervalo de confiança (IC) de 0,40 semana. Um caso (4,5%) não se consolidou. Não houve infecção. Houve um caso (4,5%) de capsulite adesiva com boa evolução ao tratamento clínico. Cinco pacientes (22,7%) apresentaram leve dor eventual e um caso (4,5%) referiu dor de média intensidade associada a impacto subacromial do implante. O escore médio UCLA modificado foi 30,4 ± IC 1,6 ponto obtidos no fim de 12 meses de avaliação, 18 casos (81,8%) com escore «excelente» e «bom», três casos (13,6%) com escore «razoável» e um caso (4,5%) com escore «ruim».
Conclusão: No grupo de pacientes avaliados, o tratamento das fraturas em duas partes do colo cirúrgico com HIMB e a estabilidade angular demonstraram resultados funcionais satisfatórios e baixo índice de complicações, semelhantes aos encontrados na literatura.

Introduction

Fractures of the proximal humerus represent 5% of all fractures. They are more prevalent in the elderly population and among females.[1] Surgical indications are based on the displacement presented by the fragments, according to the criteria described by Neer,[2] and on the variations in expectations from the final result, which depend on the patient's age and activity levels before the injury.[3–5]

Most fractures do not present displacement.[6] Among adolescents and young adults, high-energy mechanisms are more common. Among elderly people, low-energy mechanisms are more common, such as falling to the ground with indirect injury to one of the upper limbs.[7] Use of drugs, alcohol and tobacco, along with any clinical condition that leads to osteoporosis, increases the risk of fractures in young patients.[8–10]

Fractures of the surgical neck of the humerus represent 25% of the fractures of the proximal region. Provided that the soft tissues and blood supply are not greatly compromised, there is a low risk of osteonecrosis. Neer described three types of fracture of the surgical neck: angled, translated/separated and comminuted.[2] The diaphysis tends to be pulled anteromedially through the action of the pectoralis major muscle. The displacement expected from the proximal region through the action of the rotator cuff is for a neutral position to be adopted, or one that is progressively toward varus.[2]

There are several options for surgical treatment.[11] Open reduction and fixation using a fixed-angle plate is an option that has been widely disseminated in the literature.[12] However, indirect reduction and fixation using a locked metaphyseal intramedullary nail (LMIN) has been gradually gaining space in the therapeutic arsenal.[13]

Materials and methods

Twenty-two patients (nine females and 13 males) aged 21–69 years, with mean age 41.4 ± confidence interval (CI) of 6.2 years, were evaluated prospectively between January 2010 and January 2011. All of them presented two-part fractures of the surgical neck of the humerus that were classified as Neer type II.[2] They underwent closed reduction and internal fixation using LMIN and angular stabilization (Figs. 1 and 2).

The patients underwent regional block anesthesia, which complemented general anesthesia, and were placed in the deckchair position. A skin incision of approximate length 2 cm was made in the anterolateral region of the shoulder, at the projection of the greater tubercle. Both the deltoid muscle and the rotator cuff were pushed back longitudinally. The entry point for the nail was between 8 and 9 mm medially to the bone-cartilage transition (centralized on the humeral head in frontal and lateral views) and the initial drilling diameter was 9 mm (Fig. 3).

To facilitate localization of the entry point and introduction of the guidewire, we often used a Kirschner wire of 2.5 mm in diameter, placed eccentrically, which enabled internal rotation and adduction of the proximal fragment and generated true frontal and lateral fluoroscopy images (Fig. 4).

Correct positioning of the point of entry had the result that when the nail entered the distal fragment, it reduced the fracture.

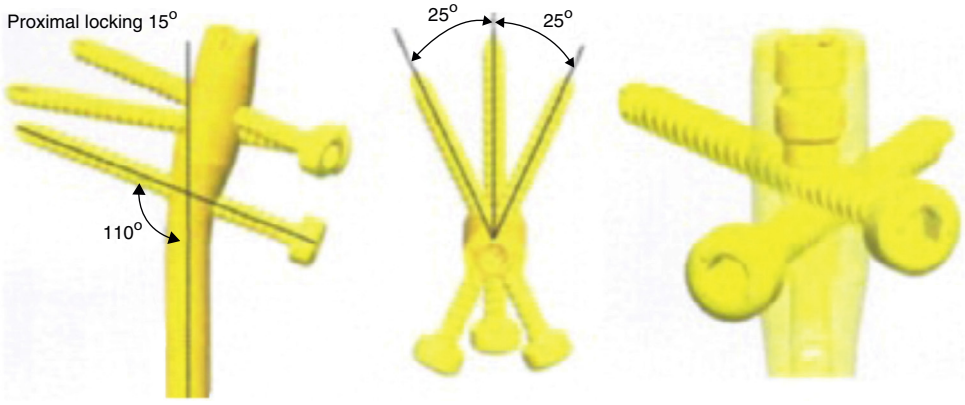

Fig. 1 – Schematic drawing of the intramedullary metaphyseal nail with proximal locking and angular stabilization.

The nail needed to be introduced such that its proximal extremity would be approximately 4 mm inside the cortical bone. We directed the guide at approximately 20–30° in the anteroposterior direction (we followed the retroversion of the humeral head), so that the proximal locking (inserted percutaneously) would remain at the center of the head. Using fluoroscopy, we checked that the cannula was in contact with the lateral cortex of the humerus, since the measurement of the proximal screw (diameter 4 mm) was done by means of the drill bit (diameter 3.2 mm), in millimeters.

The fracture was reduced under fluoroscopic control (Fig. 5). A cannula was then inserted to perform distal locking, by means of the external guide. The size of the distal screw (diameter 4 mm) was also measured by means of marking using the drill bit (diameter 3.2 mm), in millimeters.

Finally, a screw was placed to close off the nail from above (plug), which locked the two more proximal screws against each other. In this manner, angular stability was achieved. The incision in the cuff was sutured using absorbable thread.

The skin was sutured and a dressing was applied. The patient was instructed to use a Velpeau sling for

Fig. 2 – Intramedullary metaphyseal nail with proximal locking and angular stabilization.

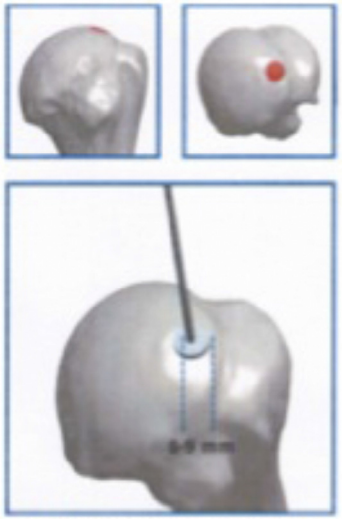

Fig. 3 – Point of entry of the nail.

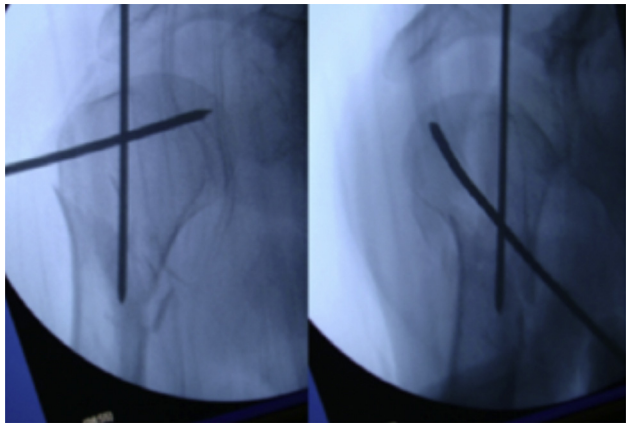

Fig. 4 – Fluoroscopic image demonstrating Kirschner wire with reduction of the fracture and positioning of the guidewire of the implant.

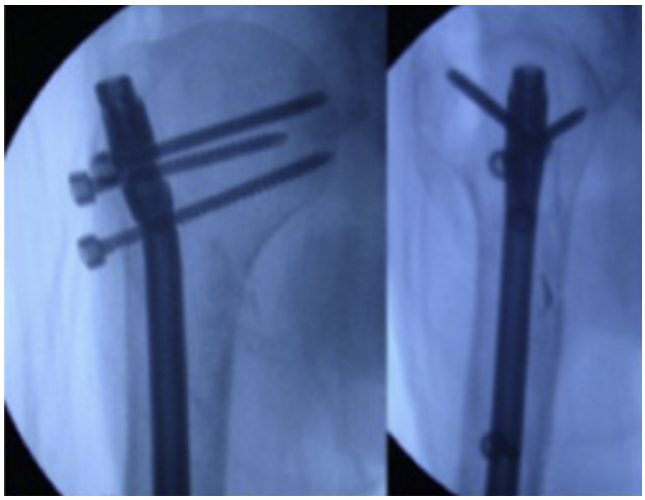

Fig. 5 – Anteroposterior and lateral-view fluoroscopic images showing reduction of the fracture, the implant and the proximal locking.

approximately four weeks. On the first day after the operation, guidance was given regarding active exercises for the elbow, wrist and hand, swinging exercises for the shoulder and isometric exercises for the upper arm. The stitches were removed 10–14 days later, according to when the conditions observed through clinical examination were deemed appropriate. Radiographs for checking on the reduction were requested every week until consolidation had been achieved.

Four weeks after the operation, the patient was referred for physiotherapy, in order to increase the range of motion and strengthen the muscles of the limb involved.

All the patients were followed up after the operation for at least 12 months (Fig. 6), with radiographic controls (Fig. 7), and they were evaluated at the end of this period using the modified UCLA score[14] (Table 1).

Nonparametric tests, tests on the equality of two proportions, correlation tests, Spearman's correlations and the Mann–Whitney test were used, with complete descriptive

Fig. 6 – Image demonstrating evaluation on the left shoulder 12 months after the treatment.

Table 1 – UCLA scoring system. Scale translated and adapted to the Portuguese language.[14]

I – *Pain*	
1) Present all the time and intolerable; medication used regularly	1
2) Present all the time but tolerable; medication used from time to time	2
3) No pain or little pain when the arm is not moving, but occurs during light work; medication used regularly	4
4) Occurs only during heavy work or specific work; medication used from time to time	6
5) Mild pain occurring from time to time	8
6) No pain	10
II – *Function*	
1) Incapable of using the arm	1
2) Only capable of performing light activities	2
3) Capable of performing light domestic work or the majority of day-to-day work	4
4) Capable of performing most domestic work, including shopping, driving, combing hair, getting dressed, getting undressed and closing a bra	6
5) Little difficulty presented; capable of making movements above shoulder level	8
6) Normal activities	10
Instructions for goniometry The patient should be in a seated position with the limb at the side of the body, in the neutral position. The examiner should instruct the patient to raise his arm as far as possible without making compensations. The goniometer will be positioned with the proximal arm on the midaxillary line of the thorax and the distal arm on the lateral midline of the humerus, and the axis was placed close to the acromion.	
III – *Active anterior flexion*	
1) 150° or more	5
2) 120–150°	4
3) 90–120°	3
4) 45–90°	2
5) 30–45°	1
6) Less than 30°	0
Instructions for the manual strength test The patient should be in a seated position with the limb beside the body and the forearm pronated. The patient should then raise this arm to 90°. The examiner should instruct him to maintain this position against the resistance that will be applied to the distal portion of the humerus (above the elbow).	
IV – *Active anterior flexion strength (manual strength test)*	
1) Grade 5 (normal)	5
2) Grade 4 (good)	4
3) Grade 3 (fair)	3
4) Grade 2 (weak)	2
5) Grade 1 (muscle contraction)	1
6) Grade 0 (absence of contraction)	0

Table 1 – (*Continued*)

V – *Patient's satisfaction*	
1) Satisfied and better	5
2) Dissatisfied and worse	0
UCLA classification	Scoring
Excellent	34–35
Good	28–33
Reasonable	21–27
Poor	0–20

analysis on the variables. Correlations between the time taken to consolidate, age, sex and functional result were evaluated using the modified UCLA protocol.[14] Short-term complications and those that appeared up to 12 months after the treatment were also evaluated.

Fig. 7 – Anteroposterior and lateral-view radiographs showing consolidation of the fracture.

Table 3 – Complete description for age, UCLA and TC.

Description	Age	UCLA	TC
Mean	41.4	30.4	9.26
Median	40.5	31.0	9.0
Standard deviation	14.9	3.9	0.94
CV	36%	13%	10%
Q1	28.3	29.0	9.0
Q3	48.8	33.0	10.0
Min	21	19	7.5
Max	69	35	11
N	22	22	21
CI	6.2	1.6	0.40

TC, time taken to consolidate in weeks; CV, coefficient of variation; Q1, first quartile (distribution up to 25% of the sample); Q3, third quartile (distribution up to 75% of the sample; N, quantity included; CI, confidence interval.

Results

The mean time taken to consolidate (TC) was 9.26 ± CI 0.94 weeks. One case (4.5%) did not consolidate and evolved with loss of reduction. Subsequently, this case was reoperated using a locked plate. There was no infection. Five patients (22.7%) presented occasional mild pain and one (4.5%) reported medium-intensity pain that was associated with subacromial impact of the implant. There was one case (4.5%) of adhesive capsulitis, which evolved well through clinical treatment. The mean modified UCLA score[14] was 30.4 ± CI 3.9 points after 12 months: five cases (22.7%) with "excellent" scores; 13 (59.1%) with "good"; three (13.6%) with "reasonable"; and one (4.5%) with "poor" (Tables 2–4).

Table 2 – All the patients with UCLA results, age, sex, time taken to consolidate in weeks (TC) and complications.

Group	UCLA	Age	Sex	TC (weeks)	Complications
Excellent	35	23	F	9	
	34	21	M	9	
	34	24	F	9	Adhesive capsulitis, locking of SE
	34	41	M	10	Possible proximal pain
	34	69	F	10	
Good	33	25	M	10	
	33	39	F	10	
	33	47	M	9	Slightly delayed consolidation
	32	40	M	10	Possible proximal pain
	31	33	M	8	
	31	49	F	8	Possible proximal pain
	31	40	F	8	Possible proximal pain
	31	60	F	8	
	31	29	M	10	
	30	62	M	10	Delayed consolidation
	29	21	M	8	
	29	48	M	10	
	28	58	F	9	Possible proximal pain
Reasonable	26	47	M	11	Slightly delayed consolidation
	25	28	M	9	High-energy fracture
Poor	25	65	F	10	
	19	41	M	No	Nail tore the head

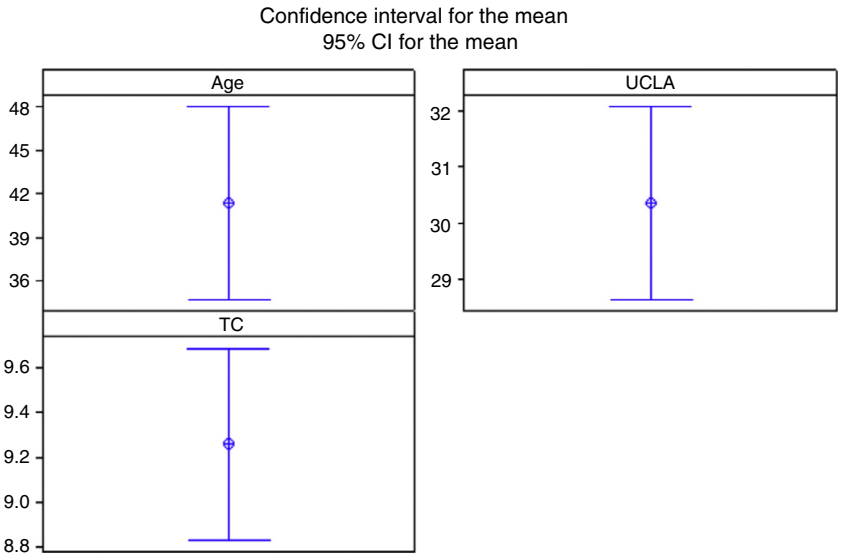

Fig. 8 – Confidence interval for the mean age, UCLA score and time taken to consolidate (TC).

Table 4 – Distribution into UCLA bands.

UCLA band	*n*	%	*p*-value
Poor	1	4.5%	<0.001
Reasonable	3	13.6%	0.002
Good	13	59.1%	Ref.
Excellent	5	22.7%	0.014

n, number in the sample; %, percentage of the group; *p*-value, value of *p*.

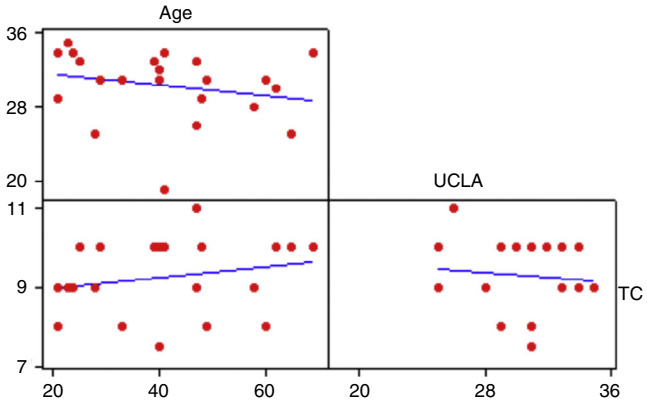

Fig. 9 – Correlation between age, UCLA score and time taken to consolidate (TC).

It was observed that there was no statistically significant difference between the sexes, in relation to age, modified UCLA score[14] or TC (Table 5, Figs. 8 and 9).

Discussion

There is a great diversity of methods and techniques for osteosynthesis of fractures of the surgical neck of the humerus. Fixation using LMIN and angular stabilization, which has the aim of facilitating the operation, can be highlighted among these techniques.

An enormous variety of studies citing the advantages and disadvantages of the different methods and implants can be

Table 5 – Comparison of sex, age, UCLA[14] and TC.

Sex	Age		UCLA		TC	
	Female	Male	Female	Male	Female	Male
Mean	47.4	37.2	31.3	29.7	8.9	9.5
Median	49.0	40.0	31.0	31.0	9.0	10.0
Standard deviation	17.0	12.3	3.2	4.3	1.0	0.9
Q1	39.0	28.0	31.0	29.0	8.0	9.0
Q3	60.0	47.0	34.0	33.0	10.0	10.0
N	9	13	9	13	9	12
CI	11.1	6.7	2.1	2.3	0.6	0.5
p-value	0.181		0.345		0.188	

TC, time taken to consolidate in weeks; Q1, first quartile (distribution up to 25% of the sample); Q3, third quartile (distribution up to 75% of the sample; *n*, number in the sample; CI, confidence interval; *p*-value, value of *p*.

found. However, few authors have dealt with the advantages of osteosynthesis using LMIN and angular stabilization.[13,15,16]

Most authors agree that non-operative treatment should be used for fractures of the proximal extremity of the humerus that do not present displacement or are stable with minimal displacement. Others have already described the natural history of fractures of the proximal humerus.[17] Non-operative treatment does not allow early mobilization.

Surgical management becomes more difficult when the fractures occur in elderly patients with osteoporotic bones, poor bone stock or a high degree of comminution and displacement. Injury to the blood supply may result in osteonecrosis. Proximity to the shoulder joint and injury of the rotator cuff may lead to severe stiffness and necessitate a program of intensive rehabilitation in order to improve the return of functions.[18]

There is insufficient evidence to determine what is the best treatment for fractures of the proximal humerus. Tension bands require extensive exposure in order to achieve reduction and fixation and may give rise to a posteromedial gap and cut-out.[16] Fixation by means of transosseous suturing also necessitates major exposure and may not provide sufficient stability. Transcutaneous pinning may cause skin irritation, infection of the pathway and loss of reduction, and requires good surgical skills.[19] Fixation with locked plates and screws is a good option when the bone is osteoporotic.[20] However, this requires extensive dissection of soft tissues and increases the risk of avascular necrosis and subacromial impact.[21]

In a biomechanical study conducted on cadavers, intramedullary fixation with proximal angular stabilization was shown to be less rotationally stable than use of fixed-angle plates. However, there was sufficient stability to allow clinical use, especially with regard to fractures of the surgical neck.[15,21–23]

Since iatrogenic injury seems to be important with regard to the pathogenesis of avascular necrosis of the humeral head and the fracture pattern, closed reduction and associated intramedullary fixation can be justified.[24] Age is an important prognostic factor in relation to nonunion and the severity of the fracture.[25]

Another problem is the development of osteoporosis, which has a large impact on the proximal third of the humerus, given that the bone mineral density of the humeral head represents only 65% of the density of the base of the femoral head.[26] Moreover, the humerus functions free from the action of loads, which may worsen the demineralization.

The possible complications from surgery include: subacromial impact of the nail, rotator cuff injury, nerve injury (axillary nerve), pseudarthrosis, skewed consolidation and superficial and deep infection.[24,26–28]

Recently with the aim of adding a resource for treating fractures of the proximal humerus, several nails with multiple locking screws have been designed, and there have been refinements to the techniques involved. In two-part fractures, satisfactory results can be obtained using locked plates or intramedullary nails.[29]

This reduction and fixation method has the following advantages: it enables early mobility; does not open the focus of the fracture; is not aggressive toward the periosteum and soft tissues; provides good stability; and causes very little bleeding. The disadvantages are its high cost and the need to use fluoroscopy (irradiation).[15]

Conclusion

In the group of patients evaluated, treatment of two-part fractures of the surgical neck using LMIN and angular stabilization showed satisfactory functional results and a low complication rate, similar to what has been shown in the literature.

Conflicts of interest

The authors declare no conflicts of interest.

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