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Locking blade nail in proximal humeral fractures

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Summary

Objective. Locking blade nail (LBN) represents a new technique that arises from better knowledge of the critical factors that stabilize a proximal humerus fracture. After 3 years of LBN practice, we examined outcomes achieved with the LBN technique compared to the previous prevailing use of plating and screw.

Methods: Over 7 years, 332 patients with 2-3-4 part fractures (Neer Classification) were surgically treated. We created 2 groups: A (n = 104) treated with intramedullary LBN nail and B (n = 104) treated with a Philos plate. VAS, SF-36 Scale and Constant Score (CS) were assessed at 1, 3 and 6 months after surgery.

Results. Active range of motion and CS showed no significant difference between the two groups for patients with less than 75 years ($p > 0.05$). In 4-part fractures and elderly patients (> 75 years), LBN showed better results in terms of active range of motion and pain. Six months after surgery, 84.6% (group A) and 73% of patients (group B) had a CS > 80 points and no patient showed persistence of pain (VAS scale).

Conclusions. In our experience, use of LBN has led to satisfactory results and a very few cases of complications, even if surgery was performed by different surgeons and on a population that differed in age, comorbidities and severity of humeral fracture.

Key words: LBN, locking blade Nail, proximal humerus fracture, constant score

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Conflict of interest
The Authors declare no conflict of interest

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Introduction

Locking blade nail (LBN) represents an osteosynthesis technique that arises from better knowledge of the critical factors that stabilize a proximal humerus fracture. Our progress, from one technique to another, has gone hand in hand with the development of biomaterials and progress of classification methods: in the past decades, we frequently chose ORIF with plate and screws. Since 2016, we gradually shifted to osteosynthesis with third generation nails, even in complex proximal humeral fractures, following the publications of P. Boileau [1-4]. Since 2017, we utilized fourth generation LBN nails for 3 and 4-part fracture fractures and very recently we have used LBN nails for 4 part fractures that are partially dislocated.

After 3 years of LBN practice, we assessed outcomes achieved on a population which differs in age, comorbidities, and severity of humeral fracture. We compared this recent technique to our previous use of plating and screw (Philos Plate). We examined function and residual pain, evaluating patients at 1, 3, 6 months after surgery.

Materials and methods

Patients

Between April 2014 and November 2019, 332 patients with 2, 3, and 4 fragments of the humeral head were surgically treated at the Hospital "ASFO-Santa Maria de-

gli Angeli" in Pordenone. All patients underwent radiographic study and preoperative CT and clinical and radiographic examination at 1, 3 and 6 months (Figs. 1-3). VAS Scale, SF-36 Scale, and Constant-Murley Score (CS) were used for clinical evaluation. Two groups were formed: Group A (104 patients), which included all patients treated with intramedullary LBN nail and Group B, created with a random selection of 104 patients from the total of 172 patients treated with Philos plate. All patients were operated by the same surgical team and had the same rehabilitation protocol. Active range of motion (AROM) was evaluated with Constant-Murley Scale as maximum 40/100 points. At six-month follow-up, we chose a score of 20/40 points as a cut-off value to compare groups A and B.

Surgery

To perform intramedullary LBN nailing of the proximal humerus, we used a trans-deltoid access with the patient in a beach-chair position. We added a minimal anterior acromial osteotomy to allow nail correct access, which is medial compared to other nail systems. It is important to carefully choose the insertion point on the articular cartilage, central to the canal and about 2 mm lateral to the highest point of humeral cartilage head on anterior-posterior X-ray view (Fig. 4) [5].

After minimal rotator cuff incision, dislocated tuberosities were found and anchored with 4 high strength wires, including in each side bone and rotator cuff. The union of tuberous bone and cuff makes the fragment more solid to allow its traction and repositioning in the correct seat. Once the head has been realigned, tuberosities are temporarily fixed by binding the wires together. The fracture is therefore transformed and simplified into a 2-part fracture. Then, a minimal opening of the supraspinatus is made and the nail is inserted after having prepared, using a guide wire, an entrance tunnel in the head. Figure 5 shows the recommended configuration, giving optimal fixation in osteoporotic bone with the use of a long blade and 4 screws in the humeral head and distal locking screw [5].

In our experience, we first insert two proximal screws to block permanently the head to the tuberosities. The second step is to evaluate the degree of retroversion of the epiphysis using a dedicated K-wire that should be in line with the forearm. Then we move on to positioning the peculiar LBN curved long blade which must be blocked with 2 screws; finally, we insert a distal screw. The curved blade generates the triangle of forces that allows support for the metaphysis of the humerus, canceling the moments of bending forces that act between the head and the diaphysis as shown in Figure 5.

Statistical analysis

We compared group A (LBN) to group B (Plate and Screw in terms of functional outcomes and residual pain, evaluating patients at 1, 3, and 6 months after surgery. Categorical variables were expressed as frequencies and percentages. To find statistical differences between the two groups, the following tests were used: Chi Square test, Student's T test, establishing significance for p values < 0.05.

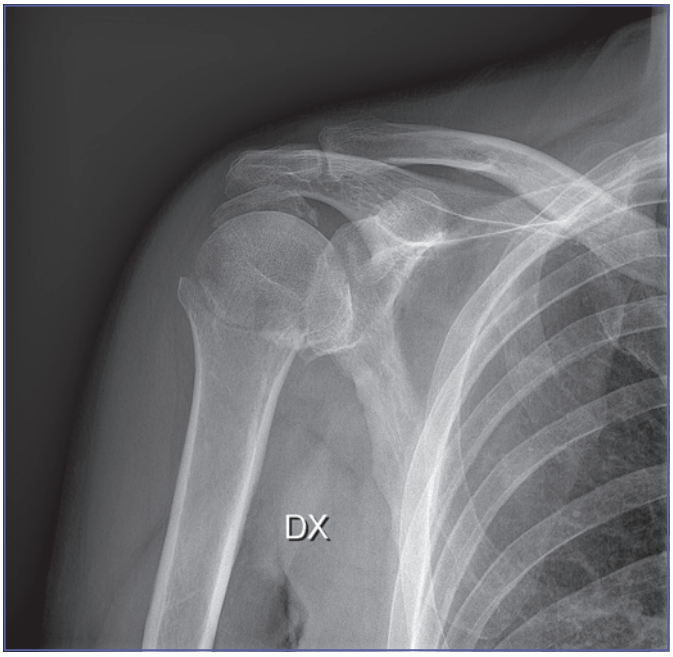

Figure 1. Male, 61 years old, preoperative X-ray.

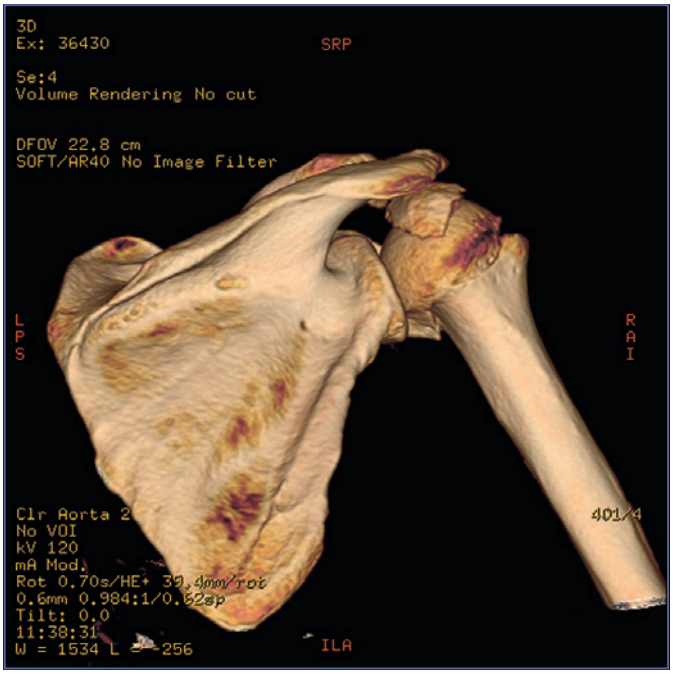

Figure 2. Same patient as Figure 1, preoperative CT study, posterior 3D reconstruction: 4 part humerus fracture.

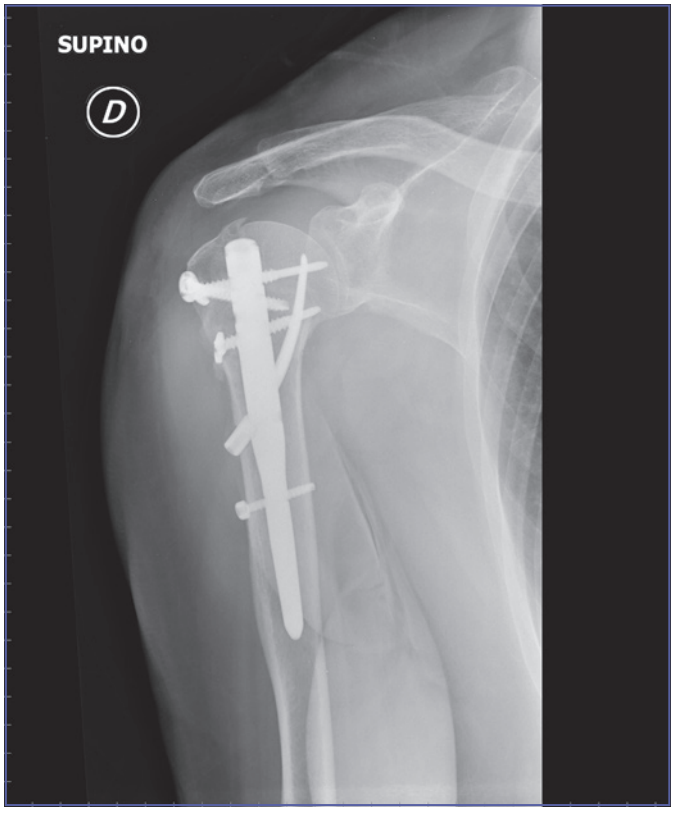

Figure 3. Same patient as Figure 1, postoperative X-ray.

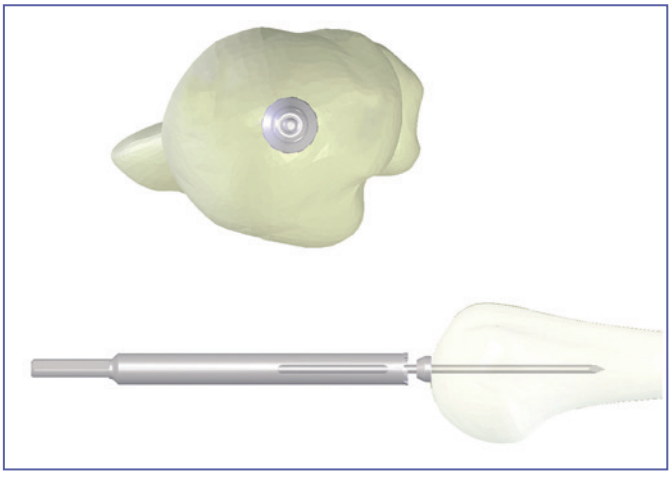

Figure 4. LBN nail insertion point (from Bell et al., 2011, mod.) [5].

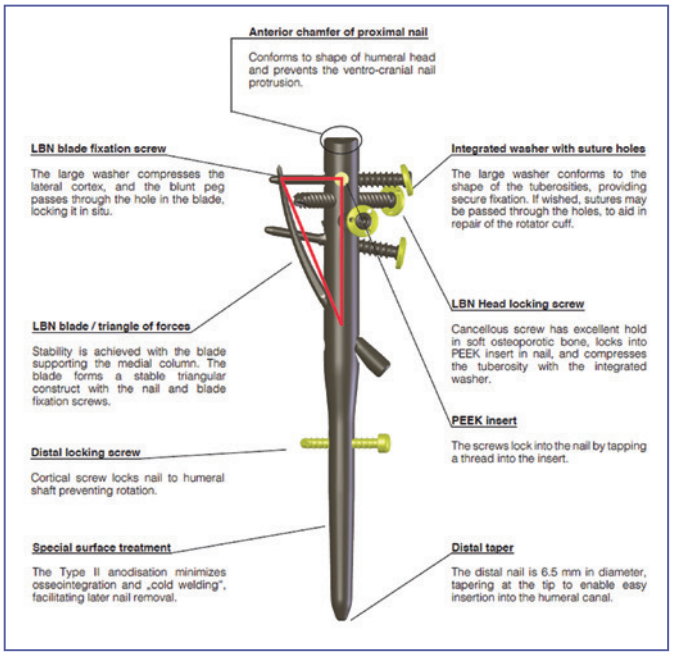

Figure 5. LBN principal features. Curved blade generates the triangle of forces that allows support for the metaphysis of the humerus (from Bell et al., 2011, mod.) [5].

Results

In group A (LBN), the following complications occurred: 2 cases of mobilization of one proximal screw, 1 one case of new fracture distal to the nail tip. In group B (Plates): 1 case of cut-out by 2 proximal screws, 1 pseudoarthrosis, and 1 superficial infection of the wound were noted.

Groups A and B had the same number of patients (n = 104), but group A included more patients over 75 years (n = 57/104), range [37-92] years than group B (44/104), range [30-91]. Three months after surgery, 48% of group A patients (n=50) and 50% of group B patients (n = 52) had residual pain < 4 in VAS scale (pain that was not disturbing sleep). Six months after surgery, no patient showed persistence of pain (VAS scale). Six months after surgical treatment, 84.6% of group A patients (n = 88) and 73% of group B patients (n = 76) had a Constant Score > 80 points ($p < 0.05$). At the end of follow up, 82.7% patients in group A (n = 86) and 75% patients in group B (n = 78) reported a SF-36 value > 50 points as shown in Figure 6 ($p < 0.05$).

AROM was evaluated in Constant-Murley Scale as a maximum of 40/100 points. At six-month follow-up, we chose a score of 20/40 points as a cut-off value to compare groups. Most patients obtained a score > 20 points with flexion and abduction between 90° and 120°, internal rotation up to L3 vertebra, and external rotation with the hand reaching behind the head and elbow forward. AROM showed no significant difference between the 2 groups for patients less than 75 years ($p > 0.05$). In 4-part fractures and elderly patients (> 75 years), LBN showed better results in terms of AROM ($p < 0.05$).

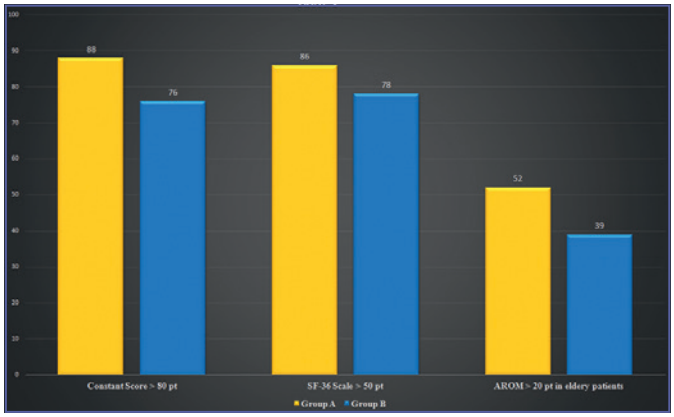

Figure 6. Data showing statistical significance (p < 0.05) between Group A and Group B: number of patients with Constant Score > 80 points; number of patients with SF-36 Scale > 50 points; number of patients older than 75 years with > 20 points of Active Range of Motion (AROM).

Discussion

In common clinical practice, the criteria to study proximal humerus fractures derives basically from: fracture classification, chances of vascularization and biological validity of the humeral head bone, patient's functional ability, and the surgeon's skills [6-8].
In fractures classified as 2 parts, according to Neer Classification, we found much experience in the literature regarding the use of intramedullary nailing systems, while in 3 or 4 part fractures the choice usually involves ORIF with plate and screws or shoulder arthroplasty [6].
A non-surgical choice has traditionally been reserved for elderly patients (generally > 80 years or with ASA Score 3-4), for whom there is a high perioperative risk and vicious consolidations of the proximal humerus did not lead to great limitations in the general patient's functional requests.
In the last decade, the literature has shown new criteria to approach proximal humerus osteosynthesis [1]. These criteria arise from the use of third generation nails, i.e., nails not yet equipped with a curved blade to support metaphysis. We can summarize these criteria in 5 points:

1. Support of the humeral head;
2. Proximal screws to allow reduction of tuberosities;
3. Screws that stabilize through fixation into the nail and not only in bone tissue;
4. Central positioning of the nail;
5. Restoration of correct retroversion of the humeral head.

It should be stresses that, when approaching a 4-part fracture, almost all expert surgeons recommend careful evaluation of bone present between the head and tuberosity, because the loss of bone substance due to impact and comminution easily leads the head to flex, medialize, and lose the correct reduction site [9-12]. Therefore, an important phase of osteosynthesis with plate and screws consists in positioning bone grafts to support humeral head reduction. This problem seems to irrelevant when using nails [13,14]. In fact, the stability of the nail is not linked to cancellous bone, but to cortical bone and the triangular metal structure that it builds with the screws [5,13,15]. Furthermore, it has been shown that the nail entry point corresponds to a region where the cancellous bone also tends to be more consistent than the other regions of the humeral head [5,16].
The last and decisive element of novelty is that the fourth-generation nails have a curved blade dedicated to neutralize residual bending forces which act peripherally on the humeral head. Thus, any stress of the junction between the head and the shaft, especially in the medial region, is countered not only by screws placed horizontally, but also by the blade that acts vertically upwards.
In our study, we found a small number of postoperative complications at follow up. In Group A (LBN), 2 cases of mobilization of one proximal screw and 1 one case of humeral shaft fracture distal to the nail tip. In Group B (Plates), 1 case of cut-out by 2 proximal screws, 1 pseudoarthrosis, and 1 superficial infection of the wound. This corresponds to data in the literature and confirms that both extra and intramedullary approaches are effective and safe solutions for proximal humerus osteosynthesis [10,11,14,17,18].
Group A included a greater proportion of patients over 75 and this may indicate a larger extension of surgical indications in eldery patients due to the reliability of this new nail, even in poor quality bone tissue.
We affirm that LBN can be a valid choice for 4-part-proximal humeral fractures, especially in younger patients, to avoid shoulder prosthesis solutions, but more data and longer follow-up are needed to reinforce this conclusion.

Conclusions

The main innovation of fourth-generation nails, such as LBN, has led to greater confidence in surgical osteosynthesis of 4-fragment fractures, especially in the active elderly population with functional requests. The less invasive approach and greater stability, conferred by the presence of the curved blade on the humeral head, has led to an increase in surgical indications. Therefore, number of patients showing functional deficits and pain following the lack of anatomical reconstruction have been limited. The number of patients in this study does not allow to draw definitive conclusions, but our almost exclusive use of this method on elderly patients, over three years, has led to satisfactory results and few cases of complications, even if surgery has been performed by surgeons with different experience and skills. Furthermore, the learning curve does not require special skills for those who are already able to perform osteosynthesis of the proximal humerus with plate and screws or other nailing systems.

We affirm that LBN can be a valid choice for 4-part proximal humeral fractures, especially in younger patients, to avoid shoulder prosthesis solutions, but more data and longer follow-up are needed to reinforce this possibility.

Acknowledgements

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