USE OF THE PFO® NUT IN TREATING FRACTURES OF THE PROXIMAL THIRD OF THE HUMERUS IN PATIENTS WITH BONE FRAGILITY

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ABSTRACT

Objective: To evaluate the clinical results from application of the PFO® bone fixation nut, which was developed for use with 4.5 mm cortical screws, and to analyze any complications or bone reactions caused by this synthesis in porotic bone. Method: Between May 1999 and November 2007, the PFO® nut was used on 23 patients who underwent osteosynthesis with a PFS 80® plate in the proximal segment, to treat acute fractures, pseudarthrosis or defective consolidations. The average age of the patients was 69 years, and the average length of follow-up was 40 months. Results: Only one patient did not present consolidation. The complications observed were: two cases of medial cortical fracture; one case of loosening of the nut; three cases of bone reabsorption around the PFO®, but two of these without clinical repercussions; and one case in which the fracture failed to consolidate, with consequent loosening of the fracture. Conclusion: The authors conclude that the use of the PFO® nut is a practical and effective alternative for osteosynthesis in patients with fractures of the proximal segment or sequelae from fractures of the humerus associated with bone fragility.

Keywords - Humerus; Fractures; Osteoporosis; Aged; Fracture fixation, internal

INTRODUCTION

The most frequent locations for fractures among elderly patients are the distal metaphysis of the radius, proximal metaphysis of the humerus, proximal metaphysis of the femur and the vertebral body. Fractures of the proximal extremity of the humerus, forearm and wrist represent around one third of all fractures among the elderly(1,2); stable fixation of these fractures is a major problem for orthopedists because of bone fragility among this age group(3,4).

The proximal segment of the humerus presents thinned cortex, which implies great local bone fragility. Thus, difficulties in achieving adequate osteosynthesis may be encountered in relation to fixation of such fractures in patients with osteopenia resulting from osteoporosis that is primary or secondary to osteometabolic diseases or to disuse, such as in cases of pseudarthrosis(4,5).

Some authors have suggested that these fractures should be reduced and fixed by means of minimally invasive techniques, such as tension bands in association with screws or wires(6), intramedullary rods(7-9), fixation with plates and screws, with or without using bone cement in association with them(2,6,10,11), or, in extreme cases, primary arthroplastic replacement(12). There are also angled plates for the proximal segment of the humerus, for example the PFS 80®(13), and fixed-angle plates with locked screws.

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Over the last five to six years, the use of so-called locked plates has become more common. These plates were first developed with the aim of improving the results in cases of severe high-energy fractures close to joints. With the increasing difficulty in achieving and maintaining screw grip in synthesis performed in metaphyseal regions and/or in osteoporotic bone, these plates gained a large presence\(^{(14,15)}\).

At that time, the Shoulder and Elbow Group of the Department of Orthopedics and Traumatology, School of Medical Sciences, Santa Casa de São Paulo, “Pavilhão Fernandinho Simonsen”, was unable to make fixed-angle plates with locked screws available for all patients. Therefore, starting in 1998, the group developed a bone fixation nut (PFO\(^\circledast\); porca de fixação óssea), with a concave polyethylene surface that adapts to the opposite cortex of the bone, for use in association with 4.5 mm cortical screws. These have shown good results in mechanical tests on cadavers\(^{(16)}\).

The present study had the objective of evaluating the results from applying this nut, with follow-up throughout the bone consolidation process in cases of fractures, pseudarthrosis and corrective osteotomy due to defective consolidation of the proximal third of the humerus. These cases of patients with bone fragility were fixed using plates and cortical screws and the possible complications or bone reactions relating to the use of this nut were observed. This type of fixation could thus become a further option in the orthopedic arsenal.

**SAMPLE AND METHODS**

The inclusion criterion used in this study was the need to use the PFO\(^\circledast\) (Figure 1). Thus, all cases in which the surgeon believed that the screw had not achieved adequate grip and chose to use one or more PFO\(^\circledast\) nuts to attain adequate screw fixation were included. In this manner, between May 1999 and October 2007, 23 patients were included. These individuals presented fractures, pseudarthrosis or defective consolidation and underwent bone fixation using the PFS 80\(^\circledast\) plate and 4.5 mm screws in the proximal region of the humerus.

The lesions that gave rise to indications for this operation were pseudarthrosis of the proximal segment of the humerus in eight cases (34.7%), defective consolidation with varus following fracturing of the proximal third of the humerus in four cases (17.3%) and fracturing of the proximal extremity of the humerus in eleven cases (48%), of which ten were fractured into two parts and one into three parts. The mean duration of postoperative follow-up was 40 months, with a range from eight to 96 months (Table 1).

Ten patients were female and 13 were male. The mean age was 69 years, with a range from 30 to 85 years. The lesion affected the dominant side in 15 cases (Table 1).

In all the cases, the surgical approach was by means of the deltopectoral route, and the bone was fixed using a PFS 80\(^\circledast\) angled plate. The length of the blade ranged from 30 to 45 mm, according to the size of the humeral head and the number of holes in the plate (either four or five). In 19 cases, only one PFO\(^\circledast\) nut was used, while in three cases, two nuts were used and in a single case, three nuts were used (Table 1).

To evaluate lesion consolidation, radiographs of the shoulder were produced in three views (corrected frontal, axillary and lateral scapular views) during the monthly outpatient follow-up examinations on the patients.

Functional evaluations on these patients, according to their clinical diagnoses, did not form part of this study: these were presented in previous papers\(^{(13,17-20)}\).

**RESULTS**

We observed that 22 patients (95%) evolved with consolidation achieved in four months on average, with a range from two to ten months. Bone consolidation was not achieved in the case of one patient (case 23). In 18 cases (78%), consolidation took place without reabsorption or breakage of the cortex (Figure 2).
Table 1 – Clinical data on the patients

| Initials | Sex | Age (years) | Dominance | Etiology      | No. of nuts | Follow-up (months) | Consolidation (months) | Reabsorption | Complications |
|----------|-----|-------------|-----------|---------------|-------------|-------------------|------------------------|--------------|---------------|
| 1        | L.E.M. | M | 44 | Y | fracture 2p | 1 | 15 | 5 |             |              |
| 2        | Y.I.N. | F | 70 | Y | fracture 2p | 1 | 29 | 2 |             |              |
| 3        | J.C.S. | F | 79 | Y | fracture 2p | 1 | 12 | 3 | +           |              |
| 4        | A.M.G. | F | 83 | Y | fracture 2p | 1 | 96 | 2 |             |              |
| 5        | M.I.C. | F | 84 | Y | fracture 2p | 1 | 95 | 2 |             |              |
| 6        | A.T. | M | 67 | Y | pseudarthrosis | 1 | 30 | 10 |             |              |
| 7        | J.S.D. | M | 62 | Y | fracture 3p | 1 | 19 | 3 |             |              |
| 8        | N.A.B. | M | 45 | Y | def cons | 1 | 84 | 5 |             |              |
| 9        | J.S.S. | M | 66 | Y | def cons | 1 | 21 | 4 |             |              |
| 10       | R.O.N. | M | 75 | Y | def cons | 1 | 91 | 2 |             |              |
| 11       | W.A. | M | 74 | Y | pseudarthrosis | 1 | 33 | 3 | +           |              |
| 12       | L.C.M.S | M | 65 | Y | def cons | 1 | 12 | 4 |             |              |
| 13       | R.D.N. | M | 85 | Y | pseudarthrosis | 1 | 72 | 4 |             |              |
| 14       | R.S.  | M | 30 | Y | pseudarthrosis | 2 | 44 | 3 |             |              |
| 15       | C.H.Q. | M | 61 | Y | pseudarthrosis | 2 | 12 | 5 |             |              |
| 16       | M.R.A. | F | 80 | Y | pseudarthrosis | 3 | 50 | 3 |             |              |
| 17       | P.A.A. | M | 78 | Y | pseudarthrosis | 1 | 14 | 2 |             |              |
| 18       | A.J.D.N. | F | 85 | Y | fracture 2p | 1 | 32 | 4 |             |              |
| 19       | M.C.  | F | 82 | Y | pseudarthrosis | 2 | 62 | 5 | breakage of cortex during surgery |              |
| 20       | D.M.R.F | F | 53 | Y | fracture 2p | 1 | 45 | 7 |             |              |
| 21       | M.L.P.N | F | 64 | Y | fracture 2p | 1 | 40 | 2 |             |              |
| 22       | B.V.  | M | 83 | Y | fracture 2p | 1 | 24 | 10 | breakage of cortex during surgery |              |
| 23       | R.F.B.S | F | 78 | Y | fracture 2p | 1 | 8 | did not occur | + loosening and infection |              |

Source: Orthopedics medical files, Hospital Santa Casa de São Paulo
Legend: M = male, F = female, Y = yes, N = no, 2p = 2 parts, 3p = 3 parts, def cons = defective consolidation.

Figure 2 – Frontal radiographs of the right shoulder (a) showing consolidated two-part fracture of the surgical neck at the proximal extremity of the humerus (case 2), without reabsorption of the nut (arrow), six months after the operation with fixation using a PFO® plate and a PFO® nut; (b) detail of the humeral diaphysis, showing absence of reabsorption of the medial cortex (arrow).

Analysis on the postoperative shoulder radiographs showed reabsorption of the cortex around the PFO® in three patients (13%) (Figure 3). This reabsorption was identified during the second postoperative month in two patients (cases 3 and 11) and in the third month in one patient (case 23) (Table 1). In one of these cases (4%; case 23), reabsorption and loosening of the PFO® occurred and, after reoperation, this patient evolved with deep infection that necessitated removal of the synthesis material. In the other two (8%), there was no failure to consolidate, despite the reabsorption of the medial bone cortex.

In two cases (8%), breakage of the medial cortex occurred during the operation when the screw was tightened. In one of these cases, the nut was kept in place (case 19), while in the other, it was decided to exchange the plate for a longer one (case 22) (Figure 4).
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DISCUSSION

Because of increased longevity among the population and therefore greater numbers of risk factors for fractures in bones that present fragility, there are technical difficulties in carrying out osteosynthesis, which frequently lead to failure(3,21,22). Loosening of the diaphyseal screws, and consequently the plate, is a complication cited in some studies(2,13) and this may even occur with the use of locked plates because of technical error(22) or with non-locked plates because of bone fragility(13). These factors, added to lack of availability of locked plates for all patients for whom they would be indicated, led us to seek an alternative that would improve the fixation of cortical screws. The result was the development of the PFO® nut (Figure 1), which was an improvement of the nut developed by the AO group that had been abandoned because of the many complications that it caused(23).

The patients’ mean age was 69 years, with a range from 30 to 90 years. As expected, the great majority of the patients requiring use of the PFO® nut were elderly, i.e. over 65 years of age. Such individuals presented osteopenia more markedly(3,21).

Fixation of fractures in porotic bones will always be a challenge for orthopedists, and the emergence of locked plates was envisaged as the solution for this problem, both proximally and distally to the fracture. However, recent studies have shown complications such as breakage of locked screws distal to the fracture(22,24). This complication did not occur in our study.

It is known that in order to achieve stability of the humerus, six fixation points for cortical screws are needed. In the presence of osteoporosis, it is often necessary to increase the number of these points. The fixation on each side of the fracture needs to be equally resistant(6). The plate used in our service (the PFS 80º®) is an angled plate for which proximal fixation is accomplished by means of tying off three non-absorbable stitches using no. 5 polyester thread, including bone and the tendon of the rotator cuff muscles. Failure of this system is very rare(25).

The decision to use the PFO® nut is made by the surgeon and depends on the quality of the screw fixation during the operation. The aim is always to achieve six points of cortical fixation(6) and, for this reason, the number of nuts varies from one patient to another, according to necessities.

For four of our patients, more than one nut had to be used. These were patients with pseudarthrosis associated with severe osteopenia. In three of them (cases 14, 15 and 19), two nuts were used and in the remaining patient (case 16) three nuts were used (Table 1).

In three patients, reabsorption of the medial cortex around the PFO® nut was observed, but this evolved to loosening of the nut only in case 23. In the other two (cases 3 and 11), reabsorption did not affect the consolidation (Figure 2). Reabsorption of the medial cortex occurred in these patients because of the pressure exerted by the nut on the bone, although we believe that in the case of patient 23, it was indicative of loosening of the fixation material (Table 1).
We observed complications from using the nut in two patients (cases 19 and 22), consisting of fractures of the medial cortex of the humeral diaphysis while tightening the nut against the bone during the operation. In the case of patient 22, since great comminution of the medial cortex occurred, it was decided to change the PFS® plate during the operation, for another of greater length. Since all the screws then gripped, there was no need to use PFO® nuts. Despite this complication, both of these cases evolved to consolidation (Figure 3).

Technically, the nut was simply placed on the cortex opposite the plate, without great bone devitalization, with the aid of an appropriate clamp (Figure 1). It could be seen that lesion consolidation occurred in all cases in which nuts were used, except for the case that evolved with infection (case 23). In this case, it was decided to change the synthesis material, and several surgical cleansing procedures were performed until the infectious process had been cured.

Moonot et al.(22) had three cases (14.3%) of loosening of the synthesis material when they used a locked plate (Philos®) to treat three and four-part fractures of the proximal humerus. We had two cases (2.7%), with two-part fractures of the surgical neck of the humerus that had been fixed using PFS® plates(13). These were the cases that initially led us to seek an economically viable alternative for our service that would be easy to apply and biomechanically effective. PFO® nuts can be used with any 4.5 mm screw, without the need for previous planning, and they do not place an excessive burden on the healthcare service. We demonstrated that good fixation was achieved, with consolidation, in 22 cases (96%) that presented bone fragility.

CONCLUSION

We conclude that applying the PFO® nut may be a practical and effective solution for diaphyseal fixation of the PFS® plate in cases of bone fragility in the proximal segment of the humerus, thereby increasing the stability of the implant. Although we found a complication rate of 13%, these did not compromise the final result.

REFERENCES

1. Nguyen TV, Center JR, Sambrook PN, Eisman JA. Risk factors for proximal humerus, forearm, and wrist fractures in elderly men and women: the Dubbo Osteoporosis Epidemiology Study. Am J Epidemiol. 2001;153(6):587-95.
2. Hintermann B, Trouillier HH, Schafer D. Rigid internal fixation of fractures of proximal humerus in older patients. J Bone Joint Surg Br. 2000;82(8):1107-12.
3. Coifield RH. Comminuted fractures of the proximal humerus. Clin Orthop Relat Res. 1986(230):49-57.
4. Rose SH, Melton JL, Morrey BF, Istrup DM, Riggs LB. Epidemiologic features of humeral fractures. Clin Orthop Relat Res. 1982;168(2):24-30.
5. Gray H. Osteologia. In: Gray H, Goss CM. Anatomia. Rio de Janeiro: Guanabara; 1998. p.167-70.
6. Tile M. Fraturas do úmero proximal. In: Schatzker J, Tile M. Tratamento cirúrgico das fraturas. Técnicas recomendadas pelo grupo AO-ASIF. São Paulo: Manole; 1993. p.57-8.
7. Hoffmann R, Khodadadyan C, Raschke M, Melcher I, Maltino PD, Haas NP. Die retrograde Markdrahtund bei proximaler humerusfraktur des altes pacientes. Ergebnisse eines minimal-invasiven Versorgungskonzeptes. Zentralbl Chir. 1993;123(11):1232-8.
8. Rajasekhar C, Ray PS, Bhamra MS. Fixation of proximal humeral fractures with the Polarus nail. J Shoulder Elbow Surg. 2001;10(1):7-10.
9. Wachtl SW, Marti CB, Hoogewoud HM, Jakob RP, Gautier E. Treatment of proximal humerus fracture using multiple intramedullary flexible nails. Arch Orthop Trauma Surg. 2000;120(3):171-5.
10. Matsuda M, Kiyoshige Y, Takagi M, Hamasaki M. Intramedullary bone-cement fixation for proximal humeral fracture in elderly patients. Acta Orthop Scand. 1999;70(3):283-5.
11. Jazrawi LM, Bai B, Simon JA, Kummer FJ, Birdzell L, Koval KL. A biomechanical comparison of Schuhli nuts or cement augmented screws for plating of humeral fractures. Clin Orthop Relat Res. 2000;377:235-40.
12. Lill H, Josten C. Proximal and distal humerus fractures in advanced age. Orthopade. 2002;29(4):327-41.
13. Checchia SL, Doneux PS, Miyazaki AN, Fregoneze M, Silva LA, Lobo AC. Avaliação do tratamento cirúrgico da fratura em duas partes do colo cirúrgico do úmero com placa PFS 80® Rev Bras Ortop. 2004;39(16):555-67.
14. Smith WR, Ziran BH, Anglen JO, Stahel PF. Locking plates: tips and tricks. J Bone Joint Surg Am. 2007;89(10):2298-307.
15. Siffri PC, Peindl RD, Coley ER, Norton J, Connor PM, Kellam JF. Biomechanical analysis of blade plate versus locking plate fixation for a proximal humerus fracture: comparison using cadaveric and synthetic humeri. Orthop Trauma. 2006;20(8):547-54.
16. Checchia SL, Mercadante MT, Santos PD, Miyazaki AN, Fregoneze M, Silva LA, et al. Desenvolvimento e avaliação preliminar de uma porca para fixação óssea. Rev Bras Ortop. 2008;43(11-12):465-73.
17. Doneux PS, Miyazaki AN, Spir Az, Bringel R, Ramos CH, Checchia SL. Pseudarthrose do colo do úmero: análise dos resultados do tratamento. Rev Bras Ortop. 1998;33(9):677-84.
18. Checchia SL, Doneux SP, Miyazaki AN, Fregoneze M, Silva LA. Avaliação dos resultados do tratamento cirúrgico das fraturas metafisárias proximais do úmero com a placa PFS-80 longa. Rev Bras Ortop. 2007;42(3):71-6.
19. Checchia SL, Miyazaki AN, Fregoneze M, Doneux SP, Silva LA, Nascimento LGP. Fratura em quatro partes do ombro: tratamento não artroplástico. Rev Bras Ortop. 2007;42(5):133-8.
20. Checchia SL, Doneux PS, Miyazaki AN, Fregoneze M, Silva LA. Avaliação dos resultados do tratamento cirúrgico das fraturas metafisárias proximais do úmero: análise dos resultados do tratamento. Rev Bras Ortop. 2007;42(5):133-8.
21. Kelsey JL, Browner WS, Seeley DG, Nevitt MC, Cummings SR. Risk factors for fractures of distal forearm and proximal humerus. J Am Epidemiol. 1992;135(5):477-89.
22. Moonot P, Ashwood N, Hamlet M. Early results for treatment of three-and four-part fractures of the proximal humerus using the Philos plate system. J Bone Joint Surg Br. 2007;89(9):1206-9.
23. Kołodziej P, Lee FS, Patel A, Kassab SS, Shen KL, Yang KH, Mast JW. Biomechanical evaluation of the Schuhli nut. Clin Orthop Relat Res. 1998;347:7985.
24. Björkenheim JM, Pajarinen J, Savolainen V. Internal fixation of proximal humeral fractures with locking compression plate. Acta Orthop Scand. 2004;75(6):741-5.
25. Dal Molin, FF. Fratura do colo cirúrgico do úmero. Análise dos resultados do tratamento com osteosíntese com placas anguladas [dissertação]. São Paulo: Faculdade de Ciências Médicas da Santa Casa de São Paulo; 2000.