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Percutaneous elastic fixation of proximal humeral fractures: operative indications, techniques, results and complications

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Abstract We present a technique of osteosynthesis of proximal humeral fractures using Kirschner wires, assembled in an elastic manner. We report 29 patients (mean age, 68 years) with types II, III and V fractures, according to Neer's classification, treated with closed or open (seldom) reduction and percutaneous pinning. The pin placement was antegrade: the wires started on the epiphysis and aimed at the diaphysis, with the proximal ends fixed with an external clamp and the distal ends crossed and laying on the endosteal

surface. Patients were evaluated with the Constant-Murley scale at the end of treatment. Radiological and clinical outcome was satisfactory in all but one patient, in whom the closed reduction was insufficient. Percutaneous elastic pinning is an effective treatment of proximal humeral fractures. If necessary, it should be associated with open reduction.

Key words Proximal humeral fractures • Elastic osteosynthesis • Percutaneous pinning

Introduction

Fractures of the proximal humerus represent 4%-5% of all fractures. Although they can occur anytime after birth, their incidence increases progressively with age, particularly in women, because of postmenopausal osteoporosis, so that about 80% of affected people older than 50 years are women [1].

The most used classification of these fractures was developed by Neer [2] in 1970 (Fig. 1), starting from Codman's classification, based on the four constitutive fragments of the proximal humerus (head, tuberosities and diaphysis). Neer integrated it with notions of biomechanics, i.e. the analysis of muscular forces displacing fracture, and of physiopathology, i.e. the evaluation of possible vascular deficits of the humeral head (Fig. 2) [3] following trauma. Therefore, this classification allows one to determine the prognosis of the fracture, the risk of necrosis of

the humeral head and the expectation of functional recovery of the shoulder, and consequently to choose among conservative treatment, osteosynthesis and prosthetic replacement. More complex, and therefore less used, is the AO/ASIF classification (Fig. 3) [4].

In 85% of cases, the fractures are composed, so that they can be treated conservatively with simple immobilization [5]. In the remaining 15%, there is indication to the surgical treatment but, as it is known, there are controversies both on which classification to use (Neer versus AO/ASIF), because neither is entirely reliable [6], and on which surgical technique to choose, because neither is effective in all cases, either for technical difficulties or for insufficient functional results.

We report the short-term results of the elastic osteosynthesis with percutaneous threads, a method that differs from the traditional static assemblage because it causes compression and not only an alignment at the focus of fracture.

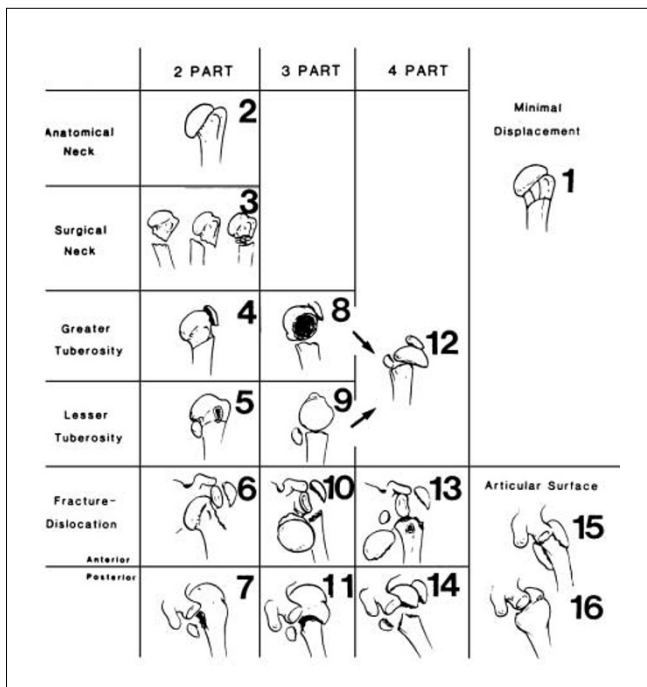


Fig. 1 Neer's four-part classification (from [2] with permission)

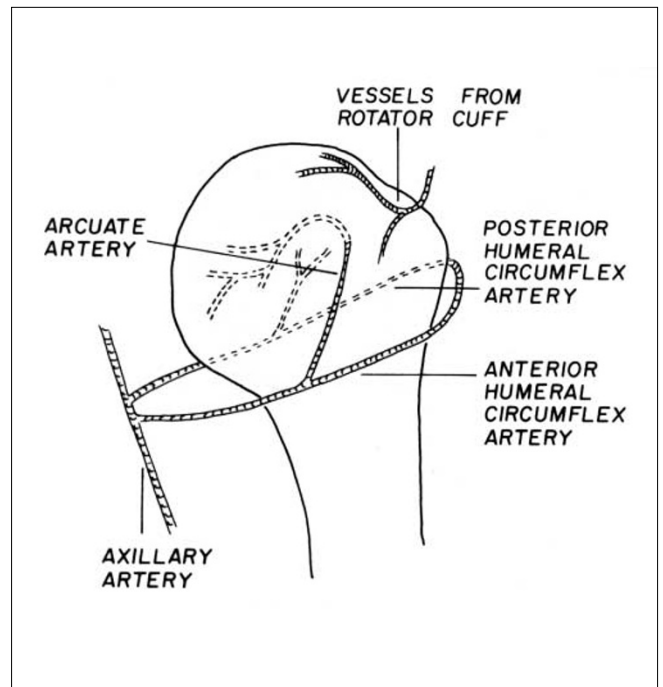


Fig. 2 Vascularization of the humeral head. All the vessels are distal to the anatomic neck (from [3] with permission)

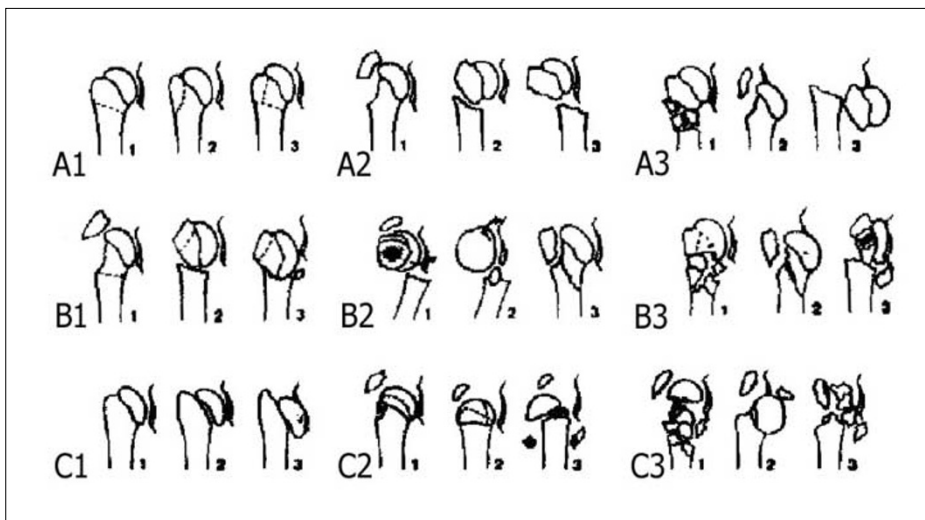


Fig. 3 AO/ASIF classification (from [4] with permission)

Materials and methods

Between January and October 2000, we treated 29 cases of fracture of the proximal humerus (24 women and 5 men), with an average age of 68 years (range, 52–83 years).

The fractures were classified according to Neer and so divided: 9 cases of type II fracture, i.e. displaced in 2 fragments, 18 cases of type III fracture, i.e. displaced in 3 fragments, and 2 cases of type V fracture, i.e. fracture-dislocation. The patients were examined at the end of treatment, both radiographically and clinically, using the scale of Constant and Murley [7]. The

Constant-Murley scale was adopted without considering that our patients were almost always women of advanced age, so that the evaluation of strength was strongly penalized.

Operating technique

The technique involves a closed reduction, followed by the stabilization with percutaneous threads inserted in the epiphyseal fragment, advanced to the diaphyseal canal and locked with a clamp external to the injured segment (Fig. 4). The reduction has

to be as anatomical as possible and must be realized before placing the threads, because eventual coarse alterations do not become correct but rather are maintained by the system.

When we do not manage to obtain a satisfactory closed reduction, we resort to open reduction: this was necessary in 3 cases of type III fracture, in 2 for the marked rotation of the head and in 1 for an associated diaphyseal fracture, treated with a cerclage.

We insert at least 2 Kirschner wires (Fig. 5, type II fractures), but often also 3 or 4 (Figs. 6 and 7, type III fractures), of 3-mm caliber and 40-cm length, by percutaneous antegrade pinning. Their

insertion is in the humeral epiphysis, around the anterior and lateral surfaces of the acromion, through points lying outside the articulation, up to the diaphyseal canal. The wires lean on the opposite cortex, without piercing it: they tend to align the fragments of the fracture, facilitating further on the reduction (Fig. 8).

Then, the external extremities of the wires are folded 2 times, so that they lay opposite each other, far from the skin. Finally, they are moved one away from the other and locked with a clamp: such external traction produces a strong internal compression of the fragments (Fig. 9).

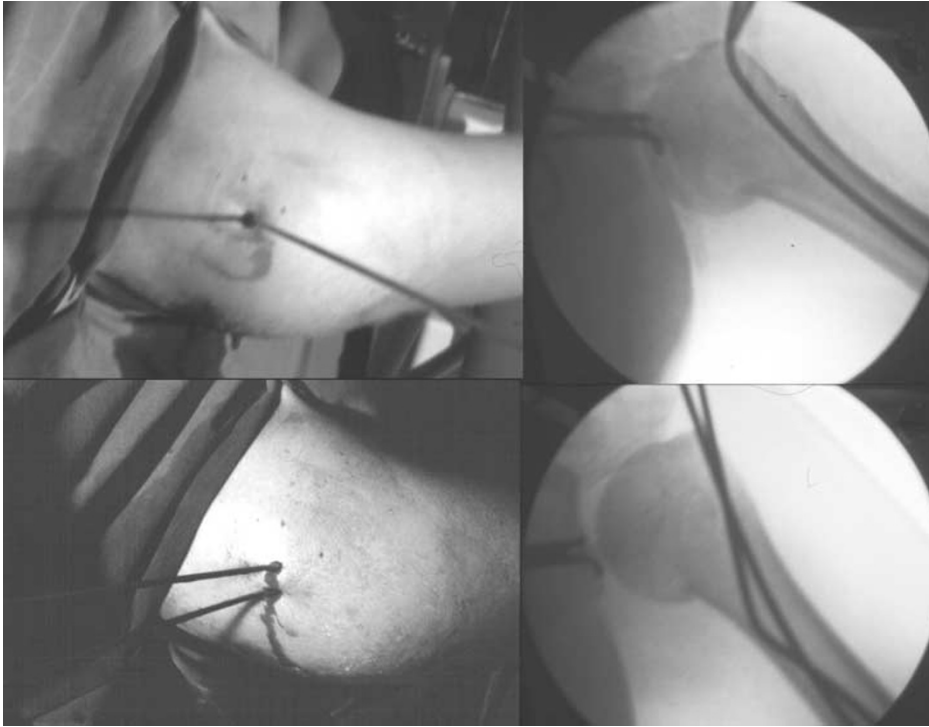


Fig. 4 Technique of insertion of the wires, from the humeral epiphysis, around the anterior and lateral surfaces of the acromion, up to the diaphyseal canal

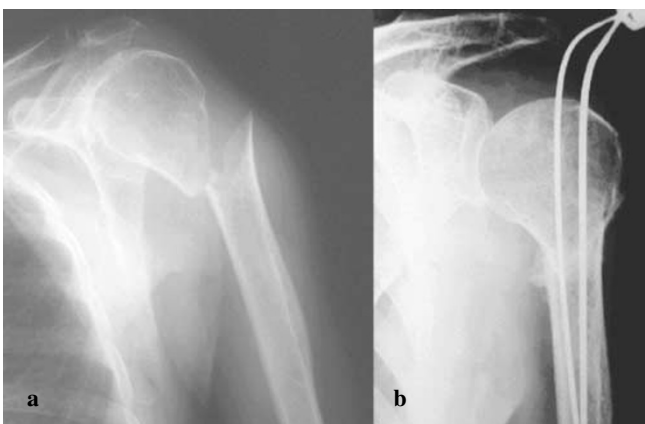


Fig. 5 Case of type II fracture (a), treated with 2 wires (b)

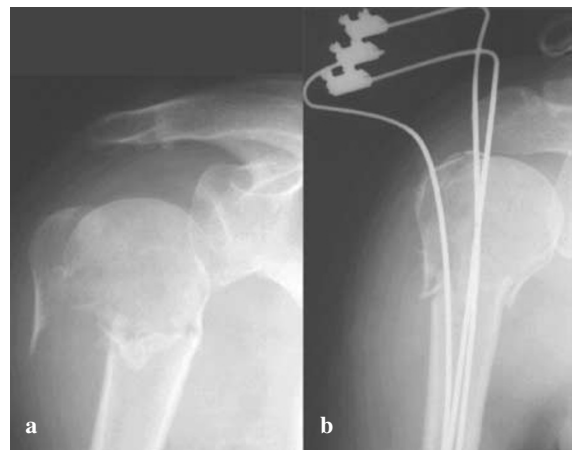


Fig. 6 Case of type III fracture (a), treated with 3 wires (b). The osteosynthesis was preceded by the open reduction, because of the marked rotation of the humeral head

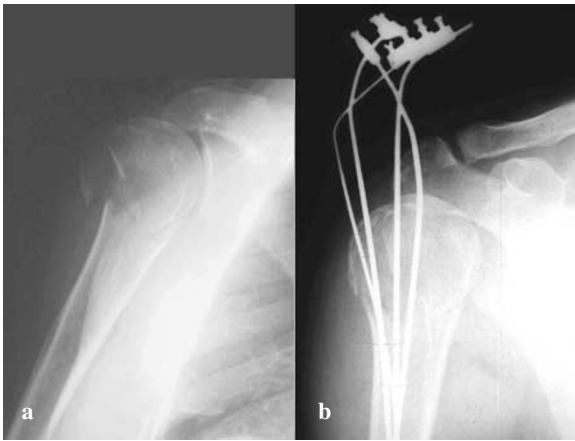


Fig. 7 Case of type III fracture (a), treated with 4 wires (b)

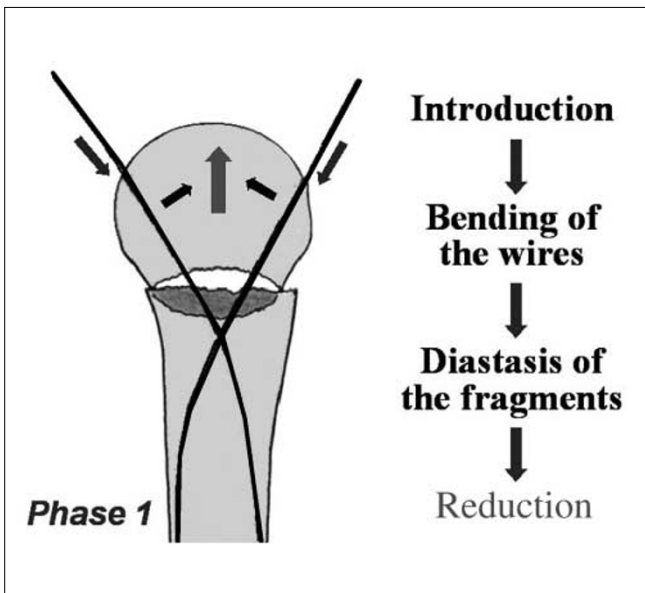


Fig. 8 In the first phase, the simple introduction of the wires tends to align the fragments of fracture

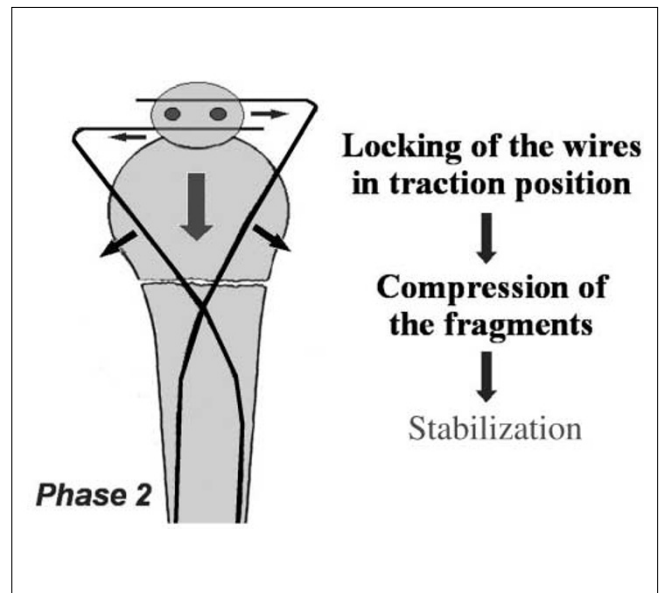


Fig. 9 In the second phase, the external extremities of the wires are tractioned and locked with a clamp, stabilizing the fracture

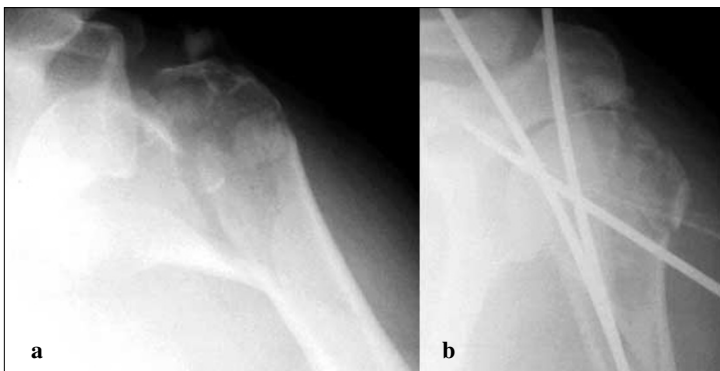


Fig. 10 Case of type V fracture (a), treated with elastic osteosynthesis integrated with a retrograde transarticular thread to realize a temporary arthrodesis (b)

In the 2 cases of type V fracture, a temporary arthrodesis, realized with 1 transarticular retrograde thread, maintained for 3 weeks, was associated with the elastic osteosynthesis, to reduce the dislocated head firmly (Fig. 10).

Rehabilitation

Generally, although the system does not require it, we apply a temporary immobilization with a removable arm-rest for 2 weeks, to decrease the painful stimulation that the early mobilization provokes. Contemporarily, we teach the patient exercises of mobilization of the shoulder of the operated limb, such as the pendular exercises of Codman, finalized to the relaxation of the capsuloliga-

mentous apparatus, and the climb with the fingers on the wall, to increase the articular excursion in elevation.

After approximately 40 days, the threads are removed and the patient performs a cycle of active kinesiotherapy, finalized to the recovery of muscular strength.

Results

Consolidation of the fracture occurred in all cases. The patients were evaluated at the end of treatment on the Constant-Murley scale and the results were satisfactory in all cases except one (Fig. 11). This was a woman of more than



Fig. 11 Clinical follow-up of a patient with a type III fracture (see also radiographs in Fig. 15)

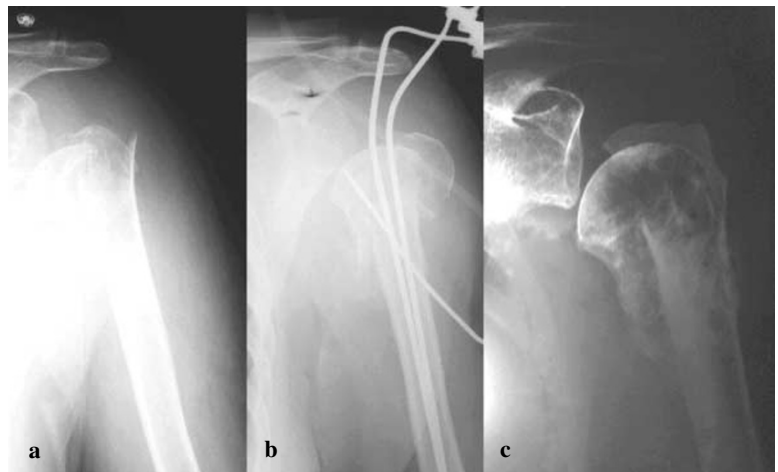


Fig. 12 Note the marked rotation of the head (a) and the considerable displacement of the great tuberosity also after percutaneous osteosynthesis (b), this is the only fair result in our series (c)

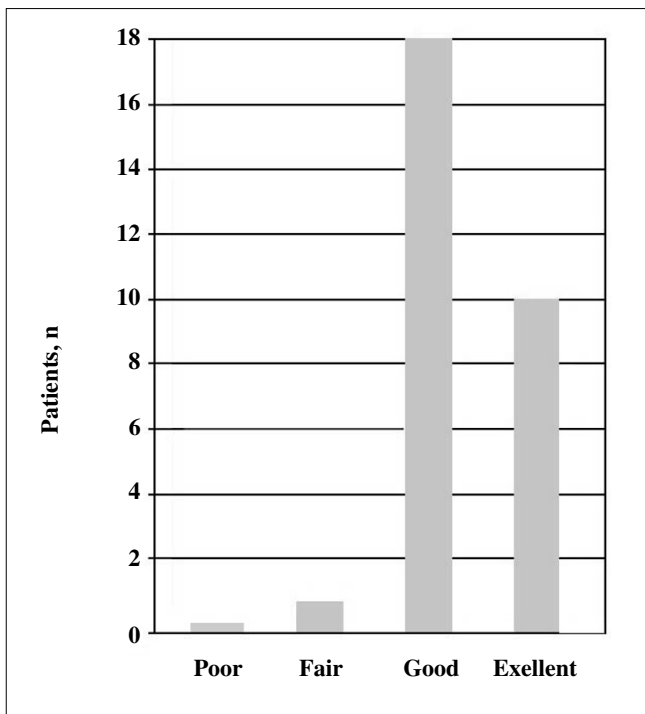


Fig. 13 Short-term results on the Constant-Murley scale. *Poor*, 0–25 points; *Fair*, 26–50 points; *Good*, 51–75 points; *Excellent*, 76–100 points

80 years with a type III fracture, in whom the closed reduction was not effective because of the marked rotation of the head and, furthermore, the greater tuberosity was not synthesized, allowing an impingement with the acromion (Fig. 12).

The Constant-Murley score varied from 33 to 84 points, with an average of 70 points (Fig. 13).

Discussion

The biomechanical basis of our technique, derived from the Epibloc system [8, 9] used for fractures of the distal metaphysis of the radius, are the following: the Kirschner wires behave as “bent beams” leaned on the fragments of fracture and on the diaphyseal canal, with a proportional thrust to the length of the tangential diaphyseal tract (Fig. 14). Therefore this system is composed of two deformable levers in balanced equilibrium, which transform the forces of cut into forces of compression, favorable to the biological recovery of the fracture.

Percutaneous pinning, no matter how effected, i.e. with a static or elastic assemblage, allows a good alignment of the fragments and a stable osteosynthesis, enough to guarantee a precocious mobilization. Additionally, this tech-

nique has a low risk of epiphyseal necrosis, which is instead strongly favored by the necessary huge dissection for implanting plates or other internal devices in an already jeopardized area by the vascular point. Nevertheless, in order to have a good functional result, it is necessary to get an anatomical reduction of the fracture as much as possible, also at the cost of performing an open reduction, realizable with a mini-invasive approach, respecting epiphyseal vascularization [10].

Such a minimal osteosynthesis is generally practiced in type III fractures, but it is also proposable in type IV fracture, especially in the subtype “four-part valgus impacted fracture” [11], avoiding to the patient, not necessarily only if young, the prosthetic replacement of the shoulder. In fact, it has been reported that 20% of type IV fractures have an excellent clinical result after osteosynthesis [12].

The treatment of type IV fractures is still extremely controversial, as shown by 2 recent studies on the use of the traditional osteosynthesis with percutaneous pinning, which reached opposite conclusions (Resch et al. [13] favorable, Herscovici et al. [14] contrary). We have not had such complex cases in our study, also because we applied Neer’s classification in a rigorous manner, considering only the significantly displaced fragments.

In this connection, it is useful to remember that a fragment is considered displaced when it is greater than 1 cm

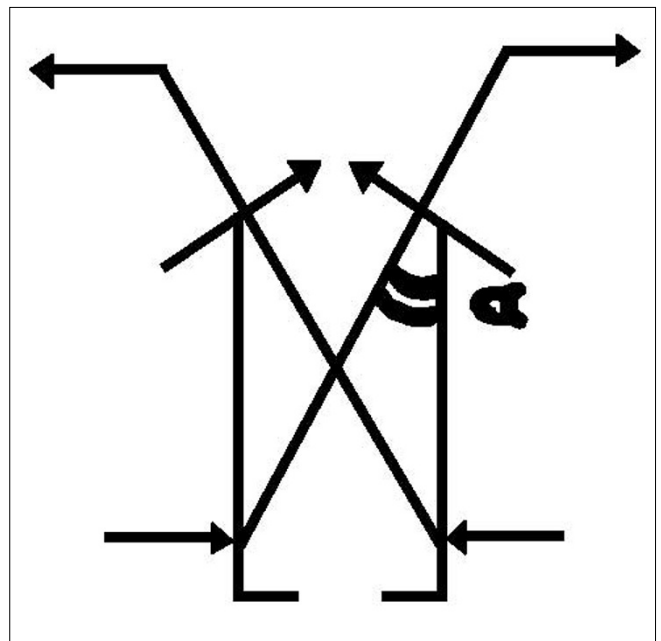


Fig. 14 Biomechanics of the elastic osteosynthesis: the Kirschner wires behave as “bent beams”. Their thrust is inversely proportional to the angle of incidence, which depends on the length of the tangential tract to the diaphyseal canal and therefore on the length of the thread itself

from the rest of the humerus, because this makes the consolidation of the fracture uncertain, or when it is angulated more than 45° , because this causes a permanent limitation of abduction and elevation. Nevertheless, with regard to the greater tuberosity, the limit must be lowered to 5 mm [15], in consideration of the probable onset of impingement syndromes for scantily superior displacements.

However, also in type IV fractures we believe that osteosynthesis with Kirschner wires, performed in a static (if comminution advises against compression) or elastic manner, is an effective method, especially in young patients, in whom one is reluctant to do hemiarthroplasty. And yet, one must strive for a perfect anatomical reduction, eventually open, not to compromise the functional results of a future prosthetic replacement. In fact, we consider a closed but insufficient intervention more harmful than an open reduction, which certainly makes the implantation of an endoprosthesis more difficult.

On the grounds of our experience, we believe that this system is suitable in different types of fracture of the proximal humeral metaphysis:

1. Fractures without significant displacement according to Neer, if the patient is affected by other lesions also requiring an intervention under general anesthesia, since the precocious mobilization allows a more rapid recovery in comparison to the simple immobilization in Desault.
2. Displaced fractures at low risk of osteonecrosis, in which an acceptable closed reduction has been obtained but that would be lost in absence of osteosynthesis.
3. Displaced fractures at high risk of osteonecrosis, as an alternative to the prosthetic replacement, associating with a perfect anatomical reduction of the fracture.

We do not use the elastic osteosynthesis in patients of pediatric age, in whom the elevated compression on the focus of fracture injures the metaphyseal cartilage, and on the other hand a static osteosynthesis often allows a bright result (Fig. 15).

The kinesiotherapy at the end of the treatment is not finalized to the recovery of the passive articular excursion, considering that the elastic osteosynthesis prevents such a complication, but to the reinforcement of the abductor and rotator muscles of the shoulder. In fact, we have found that the pins, until they remain in situ, can cause a transitory muscular deficit, seen on radiographs with the lowering of the humeral head, which nevertheless is always recovered after removing the wires (Fig. 16).

As to the clinical results, the non-achievement of a score superior to 84 points, often exceeded in other studies [13], may be correlated to the extreme severity on the Constant-Murley scale. In fact, this scale is not only founded on the mobility but also on the strength and is finalized to the evaluation of young patients, able to lift 12 kg, while our patients were 68 years old on average. The mean Constant-Murley score was 70 points, comparable to that (73 points) of a recent study of elderly people [16].

The Constant-Murley score is the only measurement that has undergone some statistic validation in the original paper. It may need to be revised, considering that it does not consider the instability [17], which, rarely, may be the outcome of a fracture-dislocation.

As to the radiographic results, it is sufficient to compare them to those of a recent retrospective study [14], in which 5 cases of type III fracture, treated with osteosynthesis with Kirschner wires, all resulted in loosening and failure of fixation: a clear proof of the frequent inadequacy of a static assemblage.

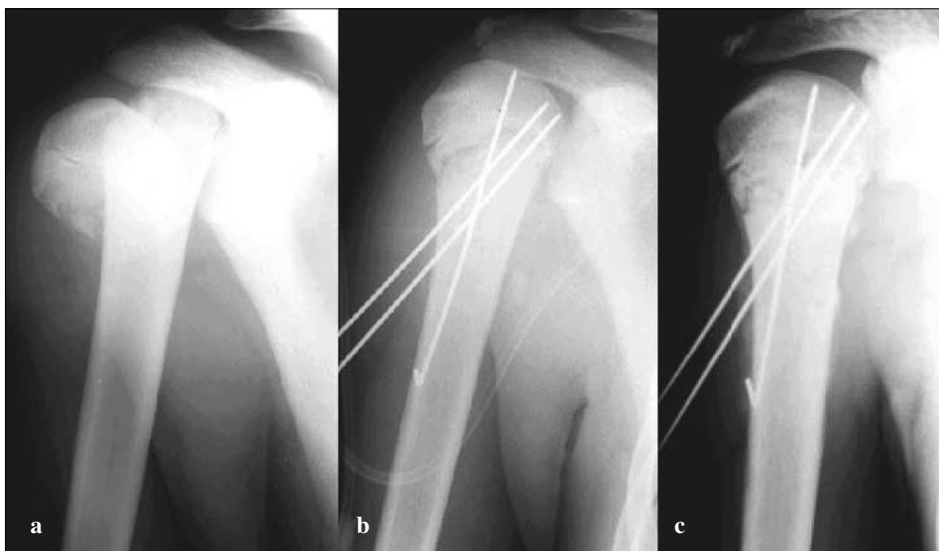


Fig. 15 Mixed epiphyseal detachment (a), treated with closed reduction and osteosynthesis (b) with percutaneous wiring in a so-called static assemblage (c)

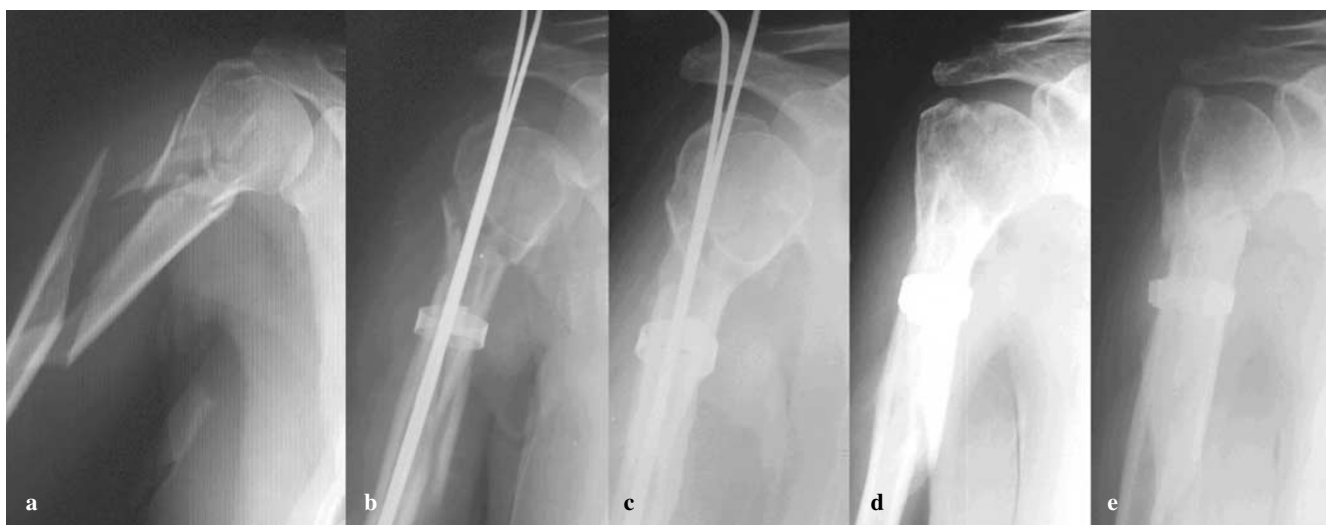


Fig. 16 This metaphyseal type III fracture (a) was accompanied by a diaphyseal fracture, which required a cerclage (b). This case is also interesting because of the lowering of the humerus in the postoperative period (c), which nevertheless was readily recovered after removing the wires (d, e)

In conclusion, the elastic osteosynthesis with percutaneous wiring is an effective method in the treatment of displaced proximal humeral fractures with 2 or 3 fragments. If

necessary, the open reduction must also be performed, to not compromise the functionality of the shoulder and consequently the result of a possible delayed prosthetic replacement.

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