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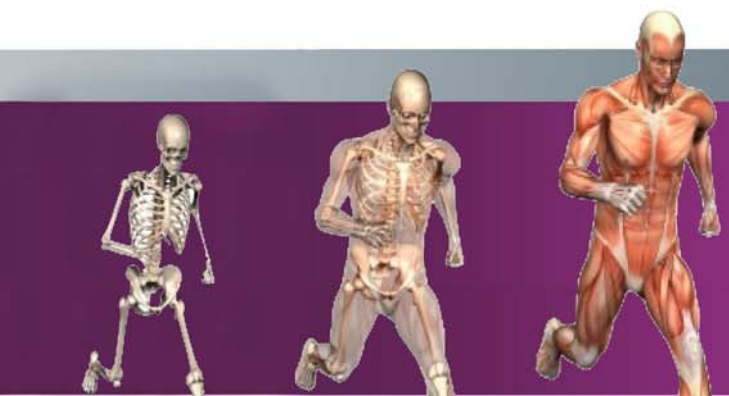
Studi Clinici



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Sistema MIROS
Quando le indicazioni operatorie suggeriscono un suo utilizzo.

Vantaggi legati all'utilizzo del Sistema Miros®:

Vantaggi preoperatori

- Intervento da inquadrare come **chirurgia minore-media**, nessuna apertura cutanea è prevista
- Minori perdite ematiche intraoperatorie , nessun bisogno di prevedere la presenza di sacche di sangue per una eventuale trasfusione
- Quindi una minore preparazione pianificata rispetto ad un intervento di chirurgia aperta.

Significativi Vantaggi Intra-operatori

- Miros® è un Sistema non invasivo .
- Economiche e di Risorse Umane : un Chirurgo e un Infermiere in meno
- Campo operatorio ridotto, non avendo necessità di utilizzare gran parte degli strumentari necessari per un intevento di chirurgia aperta
- gli accessori e gli strumenti chirugici tradizionali non sono necessari
- risparmio del consumabile, garze, bisturi elettrico, aspiratore chirurgico, fili di sutura, suturatrice meccanica.
- Riduzione dei tempi operatori necessari a qualsiasi altro sistema

Significativi Vantaggi Post-operatori

- Ridotto soggiorno in Ospedale , possibile dimissione del paziente anche nella stessa giornata se operato nella mattinata
- Mobilizzazione precoce
- Non necessità di alcun gesso
- Una medicazione di controllo ogni 10 giorni
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- Normalmente, potete procedere con una sola radiografia di controllo ad un mese dall'installazione del Sistema Miros , anche se questo resta a discrezione del Chirurgo.

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Early Minimally Invasive Percutaneous Fixation of Displaced Intra-Articular Calcaneal Fractures With a Percutaneous Angle Stable Device

Alberto Battaglia, MD [1], Pompeo Catania, MD [1], Stefano Gumina, MD [2], Stefano Carbone, MD [2]

[1] Department of Orthopaedic and Traumatology, San Giovanni-Addolorata Hospital, Rome, Italy
[2] Department of Orthopaedic and Traumatology, University of Rome at Sapienza, Rome, Italy

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ABSTRACT

The Minimally Invasive Reduction and Osteosynthesis System® (MIROS) is a percutaneous angle stable device for the treatment of fractures. The aim of the present study was to evaluate the clinical and radiographic results of an early minimally invasive osteosynthesis with the MIROS device. A total of 40 consecutive patients were treated for an intra-articular fracture of the calcaneus. We evaluated the clinical and radiographic outcomes after treatment of intra-articular calcaneal fractures with the MIROS hardware. Soft tissue damage was noted. The patients completed the American Orthopaedic Foot and Ankle Society survey at 12 and 24 months and underwent radiologic evaluations. A statistically significant association between the American Orthopaedic Foot and Ankle Society score and type of soft tissue lesion. A Sanders type II, III, and IV fracture was found in 15, 20, and 15 of 50 fractures, respectively. Postoperatively, restoration of the posterior facet was reached in 13 of 15, 18 of 20, and 11 of 15 with a type II, III, and IV fracture, respectively. The American Orthopaedic Foot and Ankle Society scale mean score was 85 at the final follow-up visit. No significant association was found between the score and the preoperative variables ($p > .09$), although patients with bilateral fractures had a significantly lower score. The MIROS device for early treatment of intra-articular calcaneus fractures resulted in excellent clinic and radiologic results. The standardized technique we have reported, with the elastic wires acting as a girder for the fractured and displace subtalar joint and the collapsed lateral calcaneal wall, has permitted early weightbearing with positive stimuli for the bone healing. The drainage effect of the percutaneous wires likely prevented compartment syndrome when applied within the first hours after the trauma.

The calcaneus is the most commonly fractured tarsal bone, accounting for 75% of displaced intra-articular fractures (1). The treatment of complex intra-articular calcaneal fractures is still controversial (2). Evidence from previous studies has shown that anatomic restoration of the calcaneal shape and joint congruity is associated with higher functional scores (3–6), a lower incidence of post-traumatic subtalar arthritis, and a lower rate of secondary subtalar fusion (7) when treating these fractures. When performing open reduction and internal fixation, a frequent complication has been soft tissue trauma with disturbance of wound healing and necrosis, in particular over the lateral calcaneal wall exposed during surgery (8). The rate of skin necrosis has varied from 2% to 11%, with the soft tissue infection rate ranging from 1.3% to 7% after an extended lateral approach, with reported wound complications in 25% of patients (3,6,8–10).

To overcome the soft tissue problems in the treatment of complex calcaneus fractures, some investigators have proposed minimally invasive reduction and fixation (5,11,12). Compared with open procedures, minimally invasive techniques can guarantee good reduction with fewer complications. The Minimally Invasive Reduction and Osteosynthesis System® (MIROS; Technovare Europa Trading, Anagni, Frosinone, Italy) is a recently introduced angle stable device for the treatment of fractures. It has shown good results in osteosynthesis of complex proximal humerus fractures in the elderly with severe osteoporosis (14). To achieve the best results, timing is an important factor, with surgery ideally performed within 3 to 5 days, especially in percutaneous or minimally invasive procedures (13). It allows for correction of angular displacement and fixation of fracture fragments using elastic Kirschner wires locked in a metallic clip placed externally to the skin.

In our department, in the previous 4 years, we have used the MIROS device to treat displaced intra-articular calcaneus fractures in

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Address correspondence to: Stefano Carbone, MD, Department of Orthopaedic and Traumatology, University of Rome at Sapienza, P.le Aldo Moro, 5, Rome 00185 Italy.
E-mail address: stefcarbone@yahoo.it (S. Carbone).

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43 consecutive patients, 10 of whom had bilateral fractures, for a total of 53 fractures. The aim of the present prospective cohort study was to evaluate the clinical and radiographic results of early minimally invasive osteosynthesis of the calcaneum using the MIROS device.

Patients and Methods

From January 1, 2008 to December 31, 2011, all patients admitted with a diagnosis of unilateral or bilateral displaced intra-articular fractures of the calcaneus were considered for inclusion in the present study. The included Current Procedural Terminology diagnostic codes were 825.0 and 825.1 (2012 "International Classification of Diseases, 9th Revision, Clinical Modification" diagnosis code). The inclusion criteria were the diagnosis of a closed or open displaced intra-articular fracture of the calcaneus (posterior articular facet step-off of >2 mm, significant shortening, loss of height, and widening of the calcaneus [i.e., decreased Böhler's and Gissane's angles], valgus deviation >10°, varus deviation >5°) of Sanders type II, III, or IV; recovery of the patient within 12 hours from the time of trauma; and patient age 18 years or older.

The exclusion criteria included a history of previous fractures or surgeries in the affected lower limb, a previous diagnosis of neurologic or vascular diseases affecting the lower extremities, and/or local vascular or neural complications associated with the injury.

All patients admitted to the hospital with a diagnosis of a calcaneal fracture were examined by 1 of 2 of us (A.B., S.C.), who first classified the soft tissue damage in accordance with the classification system of Tscherne and Oestern (15). In the emergency department, all patients underwent standard radiographic assessment, including the calcaneus lateral, axial, and Brodén views at 20° and 40°, and bilateral computed tomography for fracture classification and preoperative planning (16). The fractures were classified using the Sanders (4) scale, with the letters A, B, and C denoting the location of the fracture lines within the posterior facet. Type A represents a lateral fracture line, type B a fracture line through the middle of the facet, and type C a medial fracture line adjacent to the sustentaculum tali. The 2 of us (A.B., S.C.) involved in classifying the soft tissue damage and the fracture pattern were trained by repeating the evaluation 3 times per fracture.

After hospitalization, the study participants gave their informed consent for inclusion in the present study and for the operation, which was performed 6 to 12 hours (after the recovery) in 36 patients (83.72%) and in 7 patients within 4 days, always by the same 2 surgeons (A.B., P.C.). The fitness for surgery was assessed using the American Society of Anesthesiologists grade (17). Of the 43 patients, 26 (60.47%) were American Society of Anesthesiologists grade I, 10 (23.25%) grade II, and 4 (9.30%) were grade III. The duration of surgery and the fluoroscopic time were recorded.

The study participants underwent clinical evaluation with standard radiographs at 3, 6, and 12 weeks postoperatively. At 12 and 24 months postoperatively, the patients were assessed by the same 2 examiners (A.B., S.C.), and the American Orthopaedic Foot and Ankle Society (AOFAS) ankle hindfoot scale (18,19) was administered to quantify the functional outcomes. The scale measures the intensity of pain, function (including restraint of activities and the need for support with an orthosis), maximum walking distance, abnormality of gait, sagittal mobility (flexion and extension), hindfoot mobility (inversion and eversion), the anteroposterior and varus–valgus stability of the ankle and hindfoot, and alignment of the foot and ankle. The scores for each item were summed, providing a total from 0 to 100. Total scores of 90 to 100 were classified as excellent, from 80 to 89 as good, and from 70 to 79 as fair; a total score less than 70 was considered a poor result.

At the final follow-up evaluation, a clinical assessment was performed (A.B. or S.C.) and a full radiographic assessment completed, including standard views, hindfoot alignment view (20), lateral and dorsoplantar weightbearing radiographs (21), and a 20° Brodén view (16). The 2 examiners (A.B., S.C.) judged (3 times each for each measurement) the reduction of the calcaneal shape considering the Böhler tuberosity joint angle (in angular degrees), the crucial Gissane angle (in angular degrees), and the height and width of the calcaneus (in millimeters) (20).

Standard Operative Technique

After a carbocaine lower limb block, the patient was placed in a lateral decubitus position. No tourniquet was used. For antibiotic prophylaxis, 2 g of cefazolin was administered intravenously 30 minutes preoperatively and at 3 and 12 hours postoperatively. Before inserting the Kirschner wires, attempts were made to reduce the fracture by manipulation. A lateral incision of 2 cm was made as an access entry point for insertion of a periosteal elevator (Fig. 1). The elevator was moved to the lower posterior articular surface, and the articular fragment was elevated into anatomic configuration. Next, 1 wire was inserted from the same direction of the major axis of the calcaneus, parallel to the reduced posterior facet, and pulled until the cuboid, because the purchase in the calcaneus alone might be not sufficient. The same procedure is used with a second wire, parallel to the first. If necessary, additional elevation of the articular posterior facet can be done using the 2 wires as elevators, with the cuboid as a fulcrum. In this configuration, the 2 wires act as an inferior girder for the depressed articular fragment, and correction of Böhler's angle is obtained (Fig. 2). Reduction of the posterior facet should be checked on the Brodén radiographic views, and reduction of the calcaneus can be verified from the lateral radiographic views. The first 2 wires can then be locked in the pin and clip fixator. Next, the heel was compressed to impact the lateral wall, reduce the calcaneal width, and prevent lateral impingement of the peronei tendons. Acting on the lateral wall, 2 wires were introduced and pulled until reaching the sustentaculum tali, which will usually not have been dislocated in most calcaneal fractures because of its attached ligaments. The other 2 wires will act as 2 lateral girders to sustain the collapsed wall. The second 2 wires can now be locked in the metallic clip (Fig. 3). Additional fragments can be fixed with other wires, which should be positioned conically into the talus and cuboid and bent to lock them in 1 of the 2 metallic clips or in an additional metallic clip. As an alternative, bone fragments that could cause lateral or medial impingement can be percutaneously removed by osteotomy. Finally, 2 or more metallic clips were fastened with connecting wires to improve the stability of the whole system (Fig. 3).

Postoperative Care

Postoperatively, a simple dressing was applied without a cast. Physical therapy with passive and active range of motion at the ankle, subtalar, and midtarsal joints was initiated the day after surgery under the supervision of a physiotherapist. The patients were encouraged to perform their exercises at least 30 minutes twice a day, in addition to isotonic and isometric exercises of the leg. The patients were allowed to walk with 2 crutches 2 days after surgery but were instructed to remain non-weightbearing. Partial weightbearing was begun in the fourth postoperative week and increased to full weightbearing at the eighth postoperative week. The pins were removed once the fracture was considered healed, usually 70 days after surgery, without any anesthesia in an outpatient procedure. The fracture was considered healed when the lines of the fracture were not visible on standard radiographs. In addition, fracture stability and healing were consistently evaluated by testing the inversion, eversion, flexion, and extension of the ankle under fluoroscopy. This was performed by the 2 surgeons involved in evaluating the clinical and radiologic assessments.

Statistical Analysis

The statistical analysis was performed using Statistical Package for Social Sciences software, version 16.0 (SPSS, Chicago, IL). The intra- and interobserver agreement was determined using the κ statistic, with the level of significance set a priori at $p < .01$. Interpretation of the κ statistic was performed as described by Landis and Koch (22). Agreement was considered excellent if the κ statistic was from 0.81 to 1.0, high if it was 0.61 to 0.80, moderate if 0.41 to 0.60, fair if 0.21 to 0.40, and poor if 0.20 or less (22). Fisher's exact test was used to compare the proportions and Student's *t* test for average values. Student's *t* test, paired, was used for average values.

We defined statistical significance at the 5% ($p \leq .05$) level. Multiple regression analysis was performed to identify potential associations between dependent variables

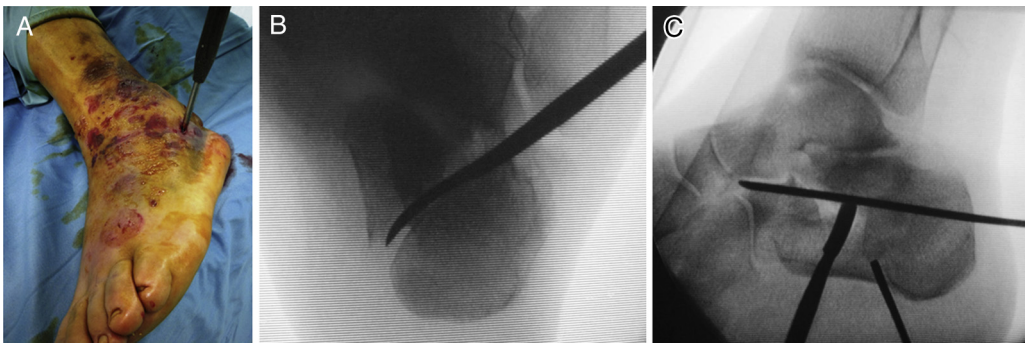

Fig. 1. (*A* and *B*) The periosteal elevator was inserted through a 2-cm incision in the lateral aspect of the calcaneus to reduce the posterior facet. (*C*) The first elastic wire was inserted to stabilize the articular fragment.

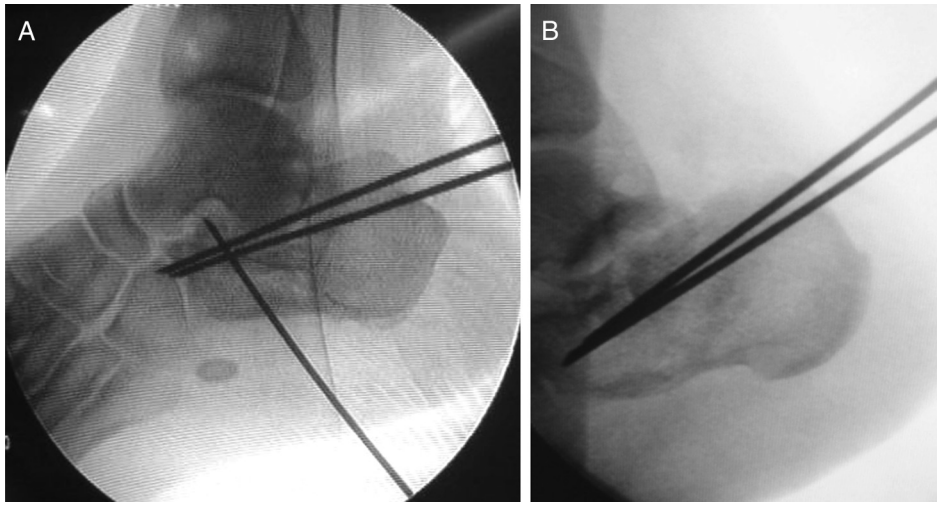

Fig. 2. (*A* and *B*) Additional elevation of the articular posterior facet can be accomplished using the 2 wires as elevators, with the cuboid as a fulcrum. The 2 wires act as an inferior girder for the depressed articular fragment.

(AOFAS score, Böhler's angle, Gissane's angle, calcaneal height, and calcaneal width) and independent variables (classification of soft tissue injury, type of fracture).

Results

A total of 43 consecutive patients met the inclusion criteria and agreed to participate in the study. Of the 43 patients, 3 (6.97%) did not attend the final assessment visit; thus, 40 patients (50 fractures) were included in the analysis. Of the 40 patients, 35 (87.5%) were male and 5 (12.5%) were female; the overall mean age was 46 ± 17 (range 28 to 70) years. A concomitant fracture or additional fracture was present in 16 patients (40%). The cause of the fracture was a fall from varying heights in 35 patients (87.5%) and a motor vehicle accident in 5 patients (12.5%). These and other demographic data are listed in Table 1.

In 42 fractures (84%), the soft tissue lesion was classified as 1° or 2°; in 8 fractures (16%), it was classified as 3° (Fig. 4*A*). No significant association was found between the AOFAS score and the type of soft tissue lesion at both 12 ($p = .72$) and 24 ($p = .79$) months.

No delay occurred in surgical treatment for patients with severe soft tissue lesions. The mean operative time was 47.3 ± 20 (range 35 to 100) minutes. The mean fluoroscopy time was 96 ± 53 (range 32 to 225) seconds. To achieve satisfactory fixation of the fragments, 4 to 6 wires were used with 2 or 3 external metallic clips.

Sanders type II fractures were diagnosed in 15 cases (40.0%), type III fractures in 20 (30.0%), and type IV fractures in 15 (30.0%; Table 2). Postoperatively, restoration of the posterior facet was reached in 13 type II fractures (86.6%), 18 type III fractures (90%), and 11 type IV fractures (73.3%). The radiographic parameters (Böhler's tuberosity joint angle, crucial Gissane's angle, height and width of the calcaneus) were comparable to the contralateral side on the weightbearing radiographs in all but 1 case. In patients with bilateral fractures, the calcaneus with the better postoperative radiographic result was considered as the basis for comparison. These and other data are listed in Table 3. The patient with an unsatisfactory radiographic outcome underwent subtalar fusion.

Böhler's angle showed a mean improvement of 17° ± 6° (range 5° to 22°; $p = .017$). At the final follow-up visit, the mean improvement was 24° ± 14° (range 10° to 38°), with respect to the mean of 26° on the contralateral side ($p = .72$).

No complications related to surgery were observed.

In the evaluation of the soft tissue lesions, the interobserver κ value ranged from 0.85 to 0.89. The intraobserver κ value ranged from 0.85 to 0.9 (excellent intra- and interobserver value). In the evaluation of the fracture pattern, the interobserver κ value ranged from 0.78 to 0.84. The intraobserver κ value ranged from 0.8 to 0.87 (excellent intra- and interobserver value). The patients were discharged after a mean of 3 ± 3 (range 1 to 10) days after surgery.

At 1 year of follow-up, the AOFAS mean scale was 88 ± 9 (range 72 to 100). At the final follow-up visit, the AOFAS mean scale was 85 ± 11 (range 70 to 100; $p = .33$; Table 4). No significant association was found between the AOFAS score, Böhler's angle, Gissane's angle, calcaneal height, and calcaneal width with the preoperative variables ($p \geq .09$ to $\leq .059$). Patients with bilateral fractures had a significantly lower AOFAS score at 12 months postoperatively (mean 78 ± 4, range 72 to 80, $p = .036$) and 24 months postoperatively (mean 73 ± 5, range 68 to 80, $p = .032$). All but 1 patient had a stable plantigrade foot,

Fig. 3. (*A* to *C*) Two elastic wires were introduced and pulled to the sustentaculum tali through the lateral wall. These other 2 wires acted as 2 lateral girders to sustain the collapsed wall. The final construct of the Minimally Invasive Reduction and Osteosynthesis System® (MIROS) was then obtained, with 4 wires and 2 metallic clips. (*D*) Photograph taken after implantation of the MIROS, showing the external part of the system.

Table 1
Demographic profile of study group (N = 40)

Characteristic	Frequency Count (%) or Mean ± SD
Sex	
Male	35 (87.5)
Female	5 (12.5)
Side	
Right	24 (60)
Left	16 (40)
Mean age (y)	46 (2.5)
Body mass index (kg/m^2)	
<20	28 to 70, SD = 19
20 to 25	15 (37.5)
25 to 30	17 (42.5)
>30	7 (17.5)

Abbreviation: SD, standard deviation.

without chronic swelling. One patient developed very restricted motion in the subtalar joint with chronic pain. The eversion and inversion of the foot was a mean of 39° ± 15° (range 15° to 60°), with ankle motion comparable to the contralateral side.

Independently of the preoperative variables, 18 of the 50 ankles (36%) developed arthritic changes in the lower ankle, with 3 with sinus tarsi syndrome, which were treated with steroid injections. The patients returned to work activities within 10 weeks after surgery in all cases, except for the patient who underwent subtalar fusion, who received Worker's Compensation and did not return to work.

The power calculation detected a significant difference in the total AOFAS scale score of 76 ± 8.3 at the first evaluation and 86.8 ± 8 at the final follow-up visit. From these differences, and assuming a 2-tailed α value of 0.05 (sensitivity 95%) and β value of 0.95 (study power 95%), we determined that at least 35 patients would be required at the follow-up evaluation (G3 power analysis program; Softpedia, Bucharest, Romania).

Discussion

In the present case series, joint depression and tongue-type fractures of all grades of severity (Sanders type II, III and IV fracture found in 15, 20, and 15 of 50 fractures) were treated using the same protocol and the MIROS device. Both extra- and intra-articular anatomy were restored in most cases, with an excellent AOFAS mean score and satisfactory radiologic evaluations at 1 and 2 years of follow-up. The protocol we have adopted uses the principles of minimally invasive reduction and percutaneous fixation that have emerged in published studies (11–13,23), with carefully performed semiopen reduction and percutaneous fixation as an effective method for complex displaced intra-articular fractures of the calcaneus, and we have used a new fixation device of percutaneous wires with particular elasticity that permits a modular construct locked in a metallic clip. Previously, this method has shown clear advantages with respect to classic percutaneous pinning in the upper limb (14). In complex fractures of the calcaneus, this system has been able to ensure a stable intracalcaneal girder in the major axis of the calcaneus to support the achieved reduction of the posterior facet, with precocious weightbearing owing to the elasticity and the angular stability of the wires. This concept of an intrafracture girder is totally different from that of plates, in which the stability of the fragments is achieved laterally owing to compression of the plate in the lateral wall of the calcaneus and to the support of the lateral to medial screws.

An important characteristic of the study design was the precocious treatment, performed within 6 to 12 hours in 36 of the 40 patients (90%) and in the remaining 4 patients within 4 days. It is well known that percutaneous techniques should be used as soon as possible after injury. In contrast, for open reduction and, in particular, using the lateral extensile approach, an interval of 5 to 9 days between the trauma and surgery has been advised to prevent complications with wound healing (4,24,25). In our series, even those cases with a grade 3 soft tissue lesion according to the Tscherne and Oestern (15) classification were treated as an emergency, with no related complications. The lateral extensile approach, which has been the most widely used (4,24), has also been associated with serious complications, with the most common being wound dehiscence. Abidi and Gruen (24) reported a 32% rate of wound healing problems. Sanders (4) reported 5 free flaps and 3 amputations in 120 patients. Schuler et al (25) noted that the better the radiological result after surgery, the greater the soft tissue tension, with a greater risk of wound dehiscence. We believe that a clear advantage of percutaneous pinning is that it works as a drainage point for the fracture site (Fig. 4), resulting in a lower local compartmental pressure, with approximately 10% of patients with calcaneal fractures developing compartment syndromes of the foot (26,27).

Several studies have shown that early postoperative weightbearing can result in better outcomes (28–30). Prolonged nonweightbearing can cause osteoporosis and joint stiffness (28), and it can shorten the time to the occurrence of subtalar arthritis (30). The subtalar joint has a key role in inversion and eversion of the hindfoot. The range of motion of this joint has been well established (31), and most of the patients with calcaneal fractures are young or middle-age males. The early weightbearing leads to early molding on the subtalar surface, which helps the congruity of the subtalar joint, with the probable outcome of less development of post-traumatic subtalar arthritis (32). The standard amount of non-weightbearing after open reduction and internal fixation with locking plates is 9 weeks (30), and for closed reduction and percutaneous pinning, the period increases to 11 weeks (23). With the MIROS device, partial weightbearing began at the fourth postoperative weeks and was increased to full weightbearing at the eighth postoperative week. This system allows precocious weightbearing owing to the stable configuration of the assembly, with up to four 2.5-mm elastic wires locked together in 2 metallic stainless steel clips. In addition, the wires provide a stable

Fig. 4. A case with severe soft tissue damage (Tscherne and Oestern grade 3). Photographs showing (*A*) the preoperative aspect, (*B*) the view 3 days after surgery, and (*C*) the view 12 days after surgery.

Table 2
Fracture distribution using the Sanders classification system (N = 50 fractures in 40 patients)

Sanders Classification	No. of Fractures (%)
Type IIA	5 (10)
Type IIB	8 (16)
Type IIC	2 (4)
Type IIIAC	3 (6)
Type IIIAB	15 (30)
Type IIIBC	2 (4)
Type IV	15 (30)

fulcrum in the uninjured cuboid bone, permitting a much faster recovery with respect to what has been reported in published studies. The assessment of functional outcome in our study showed good to excellent AOFAS scores, comparable to those obtained with open reduction and internal fixation (21,24,29,30). We believe that this excellent functional result, despite an articular reconstruction that cannot be as anatomical compared with that achieved with open reduction, is the consequence of less postoperative swelling, less periarticular scarring, and an improved range of motion.

The present study had several limitations that need to be assessed. First, the study cohort was relatively small, but a power calculation analysis was performed with a minimum of 35 patients. In addition, we lacked a comparison group, although in the discussion section, our results were compared with those of other studies. A related limitation was that the radiographic parameters were compared with the contralateral side, which was also injured in 10 patients. In those cases, the calcaneus with the better postoperative radiographic result was considered as the basis for comparison. Second, we adopted this treatment method from 2008, and we only had a mean follow-up of 2 years. Regardless, from a recent systematic review of the published data (33), a minimum of 2 years follow-up is required to assess the outcome of calcaneal fractures. However, a longer follow-up period is needed, especially to assess arthritic changes in the subtalar joint, which is one of the most common complications, with subtalar fusion often needed independently of the operative treatment (34). Third, the clinical and radiographic evaluations were performed by the authors involved in the study, with the surgeons measuring their own results, and thus a related potential bias. Finally, the identification of cases using the "International Classification of Diseases," 9th or 10th revision, or Current Procedural Terminology codes relies on the accuracy of the input data, which varies from surgeon to surgeon and could have been miscoded. Nonetheless, our entire reimbursement process, insurance company, and government identification of the disease burden hinges on these codes. We realize some bias could be inherent in using such codes.

Table 3
Preoperative and postoperative radiologic assessment of study group and comparison with contralateral side at the final follow-up visit

Parameter	Study Group (N = 50 fractures in 40 consecutive patients)			
	Anderson Fracture Type II	Anderson Fracture Type III	Anderson Fracture Type IV	Contralateral (*p* value)
Böhler's angle (°)				
Postoperative	29 ± 5.4	26 ± 5.1	25 ± 3.2	
2-y Follow-up visit	28 ± 4.8	24.9 ± 2.7	24.5 ± 3.6	29.1 ± 9 (.06)
Gissane's angle (°)				
Postoperative	125.7 ± 8	124.6 ± 5.2	126 ± 9	
2-y Follow-up visit	117.5 ± 3.4	119.6 ± 7.5	124 ± 8.1	122 ± 9 (.18)
Calcaneal height				
Postoperative	44.1 ± 5.1	43.8 ± 3.2	43.3 ± 6.2	
2-y Follow-up visit	43.6 ± 4.3	43 ± 4.5	42.9 ± 5.7	44 ± 7 (.059)
Calcaneal width				
Postoperative	48.1 ± 7.6	48.9 ± 8.3	49.1 ± 7.4	
2-y Follow-up visit	47.9 ± 7.4	48.5 ± 5.2	48.9 ± 9.3	46.8 ± 6 (.66)

Data presented as mean ± standard deviation.

Table 4
AOFAS clinical assessment of the study group at 12 and 24 months of follow-up (N = ??)

Follow-up Duration (mo)	AOFAS Scale Score for Study Group (N = 50 fractures in 40 consecutive patients)		
	Anderson Fracture Type II	Anderson Fracture Type III	Anderson Fracture Type IV
12	85 ± 9	90 ± 8	87 ± 9
24	82 ± 7	86 ± 10	85 ± 10

Abbreviation: AOFAS, American Orthopaedic Foot and Ankle Society.
Data presented as mean ± standard deviation.

In conclusion, the MIROS device for the early treatment of intra-articular calcaneus fractures has been shown to give excellent clinic and radiologic results in a cohort of 40 patients, 10 of whom had bilateral fractures. The standardized technique we have reported, with the elastic wires acting as a girder for the fractured and displace subtalar joint and the collapsed lateral calcaneal wall, permitted early weightbearing with positive stimuli for the bone healing. The drainage effect of the percutaneous wires likely prevented compartmental syndrome when applied in the first hours after the trauma.

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Modern Minimally Invasive Treatment of Proximal Humeral Fractures

Philipp Moroder, MD, Mark Tauber, MD,*† Stefano Carbone, MD,‡ Alexander Auffarth, MD,* and Herbert Resch, MD**

Summary: Proximal humerus fractures are often difficult to treat, especially in the case of displaced and comminuted fractures in combination with poor bone quality owing to osteoporosis. Because of constantly improving implants and evolving surgical techniques, the reduction and fixation of even the most complex proximal humeral fractures might be technically achievable nowadays. However, certain biological limitations need to be considered as they will dictate the fracture healing, vascularity of the fragments, and especially the clinical outcome. Therefore, it is of utmost importance to treat patients with a soft tissue and blood-supply–sparing technique that at the same time provides sufficient stability for retention of the previously achieved fracture reduction. The Humerusblock is a semi-rigid implant, which in combination with a percutaneous screw fixation system allows for minimally invasive treatment even of complex proximal humeral fractures. The greatest technical challenges are encountered in the percutaneous reduction of fragments with disrupted periostal bridges. In terms of clinical outcome, the results of the Humerusblock seem strongly related to the age and bone quality of the treated patient and the fracture type encountered. The fact that the minimally invasive and soft tissue–sparing Humerusblock technique enables a dynamic fixation of the head fragment that allows for controlled sintering and fracture consolidation without major cutout complications when adhering to the postoperative treatment protocol makes this technique especially attractive in the treatment of proximal humeral fractures in elderly patients with poor bone quality.

Key Words: proximal humeral fractures—proximal humerus—Humerusblock—percutaneous screwfixation—minimally invasive treatment.

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Closed reduction and percutaneous stabilization of the displaced proximal humeral fractures was introduced as early as 1962 by Böhler.[1] With the use of percutaneously placed K-wires, even slightly displaced 3-part and 4-part fractures were treated quite successfully.[2] Some authors described modifications as, for example, terminally threaded pins to achieve better stability; however, comminuted and displaced fractures remained a concern.[3] Stableforth and Svend-Hansen reported unsatisfactory results of patients with displaced 3-part and 4-part proximal humeral fractures treated with percutaneous pinning.[4,5] As Zyto[6] already pointed out in the late 90s, conservative management even of comminuted fractures in the elderly might be a viable treatment option, especially considering the rather poor results with early fixation techniques for complex proximal humeral fractures. Over the decades, the focus shifted from percutaneous pinning toward plate and screw fixation. Especially after the introduction of angle-stable implants, the plate fixation became the predominant technique for stabilization of proximal humeral fractures. With this change in technique also a shift from percutaneous or minimally invasive toward open reduction and internal fixation took place. According to a recent survey on 348 hospitals in central Europe, 63.4% preferred angle-stable implants for fixation, 30.9% intramedullary nailing, and 10.1% treatment with a fracture prosthesis.[7] It can be noted that percutaneous pinning has entirely lost its dominant status of the early ages of surgical treatment of proximal humeral fractures. Some might argue that the intramedullary nailing is a type of minimally invasive treatment; however, it still requires partial exposure of the fracture side and involves dissection of the rotator cuff for nail insertion. In general, the development of new surgical techniques in fracture treatment tends toward minimally invasive and soft tissue–sparing approaches not only to improve the cosmetic outcome but to prevent soft tissue dissection to preserve blood supply and periosteal bridges between the fracture fragments. As reported by Hertel et al,[8] the humeral head blood supply can be compromised by as little as 2 mm medialization of the shaft and 8 mm reduction of the dorsomedial metaphyseal extension. With an open surgical approach, the highly sensitive and fracture type–dependent, possibly already compromised, blood supply of the humeral head might be further deteriorated along with an inevitable damage to the deltoid muscle. This is why in a few shoulder centers the minimally invasive treatment of proximal humeral fractures has reemerged with some major improvements to make the fixation technique sufficiently stable to allow for reduction and retention even of complex fractures.

THE HUMERUSBLOCK

One of the modern minimally invasive techniques to treat proximal humeral fractures is the Humerusblock (DePuySynthes, Leeds, UK) introduced by Resch et al in 1997.[9] The goal of the Humerusblock is to combine the benefits of minimally invasive K-wire fixation with the stability achieved by rigid implants. Proximal humerus fractures are often difficult to treat, especially in the case of displaced and comminuted fractures in combination with poor bone quality owing to osteoporosis. Therefore, in our opinion, it is of utmost importance to treat elderly patients with a soft tissue and blood-supply–sparing technique that at the same time provides sufficient stability for the retention of the previously achieved

From the *Department of Traumatology and Sports Injuries, Paracelsus Medical University, Salzburg, Austria; †Department of Shoulder and Elbow Surgery, Atos Clinic, Munich, Germany; and ‡Department of Orthopaedics and Traumatology, University of Rome Sapienza, Rome, Italy.

The authors declare that they have nothing to disclose.

Address correspondence and reprint requests to Philipp Moroder, MD, Department of Traumatology and Sports Injuries, Paracelsus Medical University, Muellner Hauptstrasse 48, Salzburg 5020, Austria.
Email: philipp.moroder@pmu.ac.at.

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fracture reduction. The Humerusblock is a semi-rigid implant consisting of a metallic cylinder (the "block"), a block screw, and 2 K-wires (Fig. 1). The block is secured to the lateral aspect of the proximal part of the humeral shaft with a cannulated screw and 2 K-wires are passed through 2 converging holes within the block in an angulation of 35 degrees toward the humeral head fragment (Fig. 2). By blocking the K-wires within the block by means of set screws, a 3-point stabilization can be achieved: within the block itself, in the lateral cortex of the proximal humeral shaft, and in the subchondral bone of the head fragment. In addition, the converging K-wires cross distally to the subcapital fracture side that further increases rotational stability. In the case of dislocation of 1 or both tubercula, a percutaneous screw fixation system (Arthrex, Naples, FL) consisting of a blunt trocar, a cannulated drill, a guide wire, and cannulated self-tapping screws is used to secure the tuberosities after achieved reduction.

Surgical Technique—Humerusblock Placement

The surgery is performed in the beach-chair position. First, the anatomic landmarks are identified and a 4 cm vertical incision is made on the proximal lateral aspect of the arm at the level of the deltoid insertion after checking the correct craniocaudal position using fluoroscopy. The soft tissue layers are split until reaching the lateral cortex of the humeral shaft. A drill guide with mounted Humerusblock (Fig. 3) is inserted and placed centrally on the lateral cortex with the arm in neutral rotation. Then a guide wire is inserted through the block and placed slightly ascending toward the medial cortex. A cannulated 2.7-mm drill is used to perforate the lateral cortex and slightly spud the medial cortex, which leads to a stable fixation of the subsequently inserted block screw. The 4.0-mm cannulated screw is inserted over the guide-wire to fixate the Humerusblock to the lateral cortex without tightening the screw to allow for residual movement of the block. This flexibility in the frontal plane and the slightly ascending placement of the block screw allows for more vertical angulation of the K-wires, which is beneficial in the case of postoperative fracture-sintering and K-wire perforation through the subchondral bone, as the eventually perforating K-wires will not come easily into contact with the glenoid articular surface. The K-wires should be directed toward the area between the superior glenoid pole and the humeral apex. To insert the

FIGURE 2. In situ image of a Humerusblock and percutaneous cannulated screws used to treat a 3-part fracture of the proximal humerus.

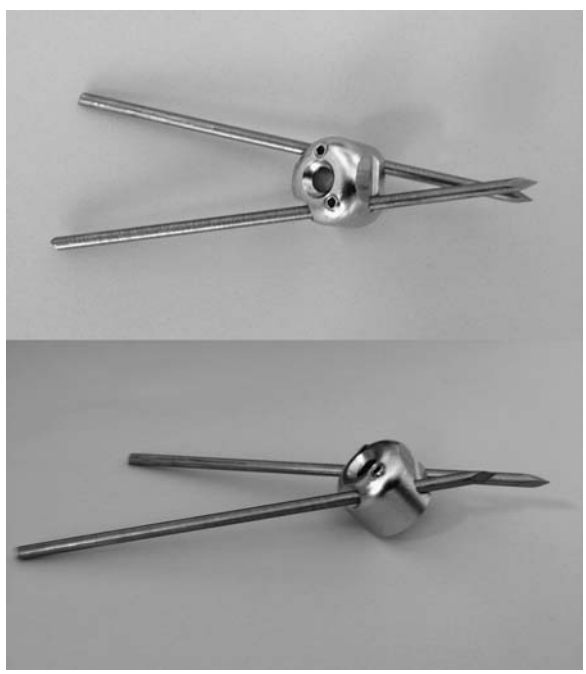

FIGURE 1. The Humerusblock consists of a metallic cylinder, a block screw, and 2 K-wires.

FIGURE 3. Image of the drill guide with mounted Humerusblock, drill-sleeves, and inserted K-wires.

K-wires, 2 drill sleeves are attached to the drill guide and inserted percutaneously through 2 auxiliary 5 mm incisions. In doing so, it is important to align the long axis of the drill guide with the lateral humeral epicondyle to ensure correct rotation of the Humerusblock in the sagittal plane. A 2.5 mm K-wire is inserted through the sleeves and block and drilled through the lateral humeral cortex till slightly distal to the subcapital fracture site under fluoroscopy vision. We call this the "waiting position." If the lateral humeral cortex is too difficult to breach a drill can be used before inserting the K-wire. After these steps, correct Humerusblock and K-wire placement are confirmed by antero-posterior and axial fluoroscopy.

Reduction and Fixation of Different Fracture Types

In the following, the reduction and fixation of 2 typical fracture types using the Humerusblock are described.

The Valgus-type Fracture

Valgus-type fractures are typically associated with lateral or postero-lateral impaction of the humeral head fragment into the metaphysis. Generally, the impaction of the head fragment does not destroy the medial periostal hinge, which is important for blood supply and aids in the reduction of the fragment. Often this impaction goes along with a fracture and dislocation of the greater tuberosity cranio-posteriorly and sometimes with a fracture of the lesser tuberosity as well. To reduce a valgus-type 4-part fracture, an incision is made lateral to the humeral head and a periostal elevator is inserted in the subdeltoid space. The elevator is moved to the back of the head superficial to the infraspinatus and dragged toward lateral until falling into the intertubercular fracture site. The articular fragment is elevated into anatomic configuration and the K-wires are advanced till reaching subchondral bone to stabilize the reduced head fragment. Then a hook is inserted through the incision into the subacromial space and pulls the cranially dislocated greater tuberosity into its position against the resistance of the supraspinate muscle. Usually, the greater tuberosity is also dislocated posteriorly because of the pull of the infraspinate. Therefore, a second incision is made a little posterior to the first one. A periostal elevator is used to hold the greater tuberosity in its caudal semireduced position while the hook is switched to the posterior aspect of the tuberosity and pulls it toward anterior against the resistance of the infraspinate muscle. Then a percutaneous cannulated drill system is used to fixate the cranial aspect of the greater tuberosity. A second drill system is used to fixate the caudal part of the greater tuberosity with the drill being angulated toward the calcar, which typically offers the best bony support. Then a guide wire is gently advanced through the drill systems using a hammer. The drill systems are then removed one by one and 3.0 mm screws are inserted over the guide-wires. During these steps, it might be necessary to retain reduction by the use of a periostal elevator inserted through one of the incisions. To reduce the lesser tuberosity, an incision is made on the anterior aspect of the humeral head and the lesser tuberosity is reduced under axial fluoroscopy view against the pull of the subscapularis. One or 2 percutaneous screws are inserted using the same technique as mentioned above (Fig. 4).

The Varus-type Fracture

Varus-type fractures are the most challenging fractures to reduce, fixate, and retain, especially if a complete disruption of the periostal bridges between the head fragment and the shaft has occurred. The shaft is dislocated antero-medially because of the pull of the pectoralis major muscle. The head fragment is tilted into the varus position by the pull of the supraspinate muscle. Varus-type 2-part fractures can be reduced by manually directing the shaft latero-posteriorly under constant traction until achieving a satisfactory approximation of the 2 fragments. Then a hook is inserted through an incision lateral to the greater tuberosity and directed toward the supraspinate footprint. By engaging the hook at the side of the footprint, the head fragment can be reduced from the varus position. As soon as satisfactory reduction is achieved, the K-wires of the Humerusblock are advanced to fixate the head fragment. For varus-type fractures, we recommend advancing the K-wires as close as possible to the subchondral bone without perforating the articular cartilage, because varus-type fractures are difficult to retain postoperatively, especially when the K-wires do not find sufficient stability in the often osteoporotic head fragment. In the case of additional fracture and displacement of the greater tuberosity, the head fragment is typically internally rotated because of the pull of the subscapularis muscle. In this case, the shaft is similarly pushed postero-laterally and traction is applied. Through an antero-lateral incision, a hook is directed toward the lesser tuberosity and the head fragment is derotated against the pull of the subscapularis with the arm in slight internal rotation. Once the correct rotation is achieved, the arm is slightly abducted to correct the varus malpositioning of the head fragment. Then the K-wires of the Humerusblock are advanced as mentioned above. Finally, the greater tuberosity is reduced with hook traction in the antero-caudal direction and fixated using 2 percutaneous screws with 1 preferably being angulated toward the calcar where a good bony support can typically be found, even in the osteoporotic bone. Typically, the varus-type fractures with concomitant dislocation of the tuberosities represents the greatest challenge for percutaneous reduction (Fig. 5).

Surgical Technique—How to Finish Up

Before finishing up, the correct fracture reduction and implant positioning are assured using fluoroscopy. It is especially important to check for the perforating screws that might harm the glenoid cartilage. Then the K-wire set screws and the block screw are tightened to create stability of the Humerusblock. The drill sleeves and the drill guide are removed. Finally the K-wires are cut 1 cm distally to the block to allow for future easy removal.

Postoperative Management

Postoperatively the shoulder is immobilized in a sling for 4 weeks with subsequent physiotherapy to reachieve mobility and strength. Implant perforation of the humeral articular surface because of sintering of the head fragment is a common complication with all types of surgical treatment for proximal humerus fractures and should be identified early by the use of routine postoperative radiographic follow-up of the patients. With the Humerusblock device, management of the K-wire perforation is recommended as follows: In the case of K-wire perforation at least 6 weeks after surgery and sufficient fracture union, the entire Humerusblock can easily be removed. Early K-wire perforation before achieved fracture consolidation represents no danger during the immobilization period of 4 weeks after surgery as long as the K-wires were placed with correct angulation. After the immobilization period, there are 2 possible solutions: (1) Restrict the patients' shoulder abduction to a certain level for another 2 to 3 weeks and then remove the Humerusblock after sufficient fracture union is achieved; and (2) Retract the K-wires to a subchondral level in a

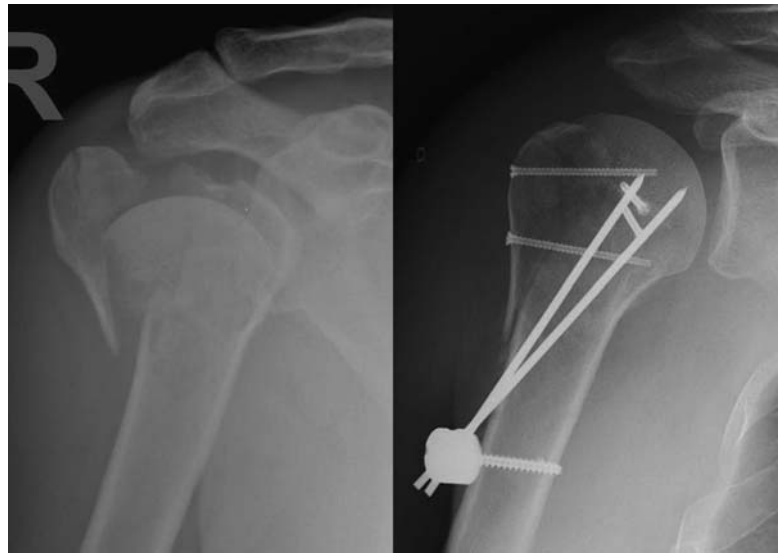

FIGURE 4. Postoperative radiograph of a valgus-type fracture treated with the Humerusblock and percutaneous cannulated screws.

mini-procedure to allow for early complete range of motion with Humerusblock removal later on. In any case, an individual strategy needs to be adopted to prevent glenoid erosion by the K-wires.

Indications and Outcomes

The indication for minimally invasive treatment of proximal humeral fractures using the Humerusblock largely depends on the fracture pattern and soft tissue considerations such as intact periostal bridges. Of course, patient-specific factors including age and bone quality are also of importance as in every osteosynthetic treatment. Excellent indications for minimally invasive reduction and osteosynthesis are 2-part, 3-part, and 4-part fractures with moderate displacement and partially intact periostal bridges, especially valgus-type fractures. However, also varus-type fractures with a higher rate of periostal disruption can be successfully treated with the Humerusblock, even if the percutaneous reduction is technically more challenging. Contraindications for Humerusblock osteosynthesis include the following: (1) Subcapital fractures extending distally that compromise the stability of the cortex of the proximal humeral shaft, thus preventing a stable fixation of the Humerusblock. In these cases, intramedullary nailing or plate osteosynthesis offer clear advantages. (2) Head-split fractures should not be treated using the Humerusblock and primary fracture arthroplasty should be considered depending on the patients age. (3) Fracture dislocations that require either open reduction or even primary fracture arthroplasty. (4) Complex proximal humeral fractures in older patients with poor bone quality, and a high degree of fragment dislocation and comminution represent a relative contraindication and should be evaluated individually for the eventual benefit of a reversed shoulder arthroplasty, including early reuptake of functionality of the shoulder.

The treatment of proximal humeral fractures with the Humerusblock showed a good clinical outcome in our own

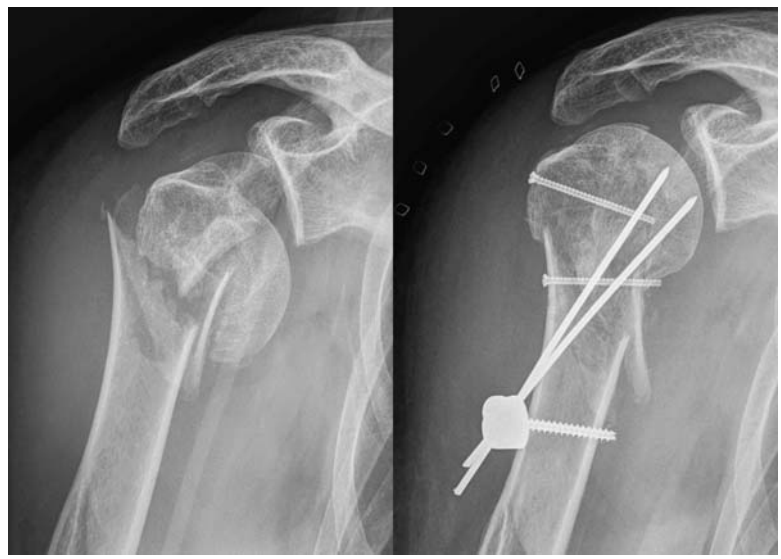

FIGURE 5. Postoperative radiograph of a varus-type fracture treated with the Humerusblock and percutaneous cannulated screws.

FIGURE 6. Postoperative radiograph and photograph of the MIROS, an alternative technique for minimally invasive treatment of proximal humeral fractures.

hands reaching a Constant score of 85 for 3-part fractures and 82 for 4-part fractures.[9] In a population of elderly patients with an average age of approximately 80 years (range, 70 to 96 y) examined at our institution after a mean of 2.8 years, a constant score of 61.2 for 3-part fractures and 49.5 for 4-part fractures was observed with 7.8% of all cases showing an avascular necrosis of the head fragment.[10] A recent outcome publication of patients treated with the Humerusblock at another institution showed an average constant score of 73.6 and a rate of avascular necrosi of 3.4% in a patient population with an average age of approximately 70 years (range, 32 to 95 y). Of all the cases, 8.6% required secondary plate osteosynthesis owing to loss of reduction.[11]

ALTERNATIVE MINIMALLY INVASIVE TECHNIQUES

The MIROS (Minimally Invasive Reduction and Osteosynthesis System, Technovare Europa Trading s.r.l., Anagni, Italy) is a recently introduced device for the treatment of proximal humeral fractures. It allows for percutaneous reduction and fixation of fracture fragments by means of elastic K-wires locked in a metallic clip placed externally to the skin. The MIROS was found to provide greater fixation stability and less complications compared with traditional percutaneous pinning.[12] The MIROS consists of four 2.5 mm thick and 50 cm long stainless steel or titanium wires whose end is inserted in a metallic clip. The clip has a diameter of 20 mm and contains a set screw that is tightened to lock the wires. The first K-wire is introduced percutaneously from the top into the greater tuberosity and then advanced down toward the lateral humeral epicondyle. The second K-wire is also inserted from the top in the humeral head fragment and directed toward the medial epicondyle. When inserting these K-wires, attention has to be paid to avoid subacromial impingement by slightly bending the wires after they are introduced perpendicularly to the skin. The remaining 2 K-wires are inserted at the height of the proximal humeral metaphysis and directed toward apical until they reach the subcondral bone of the articular surface of the humeral head. Subsequently, the 4 K-wires are bent to fit them into the external clip, which is placed at least 2 cm superficial to the skin above the deltoid muscle. Varus or valgus malposition of the head fragment can be corrected by manipulating the K-wires. After achieved reduction, the set screw inside the clip is tightened and the K-wires are cut. The MIROS is usually removed 5 or 6 weeks after operation (Fig. 6). In 2010, Blonna et al[13] introduced the similar hybrid technique, which consists of fully threaded pins in combination with an external fixator. The goal of this technique is to provide a stable fracture fixation by moving the device-fixation site from the soft and insufficient cancellous bone to the stronger bone of the lateral cortex, similar to the Humerusblock.

A modification of the Humerusblock technique was recently presented by Roberts et al.[14] The technique uses a sequential percutaneous interfragmentary fixation utilizing 1.6 mm K-wires with later replacement by 4 mm cannulated screws. The reported constant score for 3-part fractures was 79 and for 4-part fractures 72, after an average of 3.8 years in a patient population with a mean age of 56 years (range, 28 to 83 y).

DISCUSSION

In general percutaneous reduction, the Humerusblock osteosynthesis of proximal humeral fractures has a certain learning curve as every technique does; however, once mastered, it allows for quick and minimally invasive surgical treatment of even complex proximal humeral fractures. With the above-mentioned limitations in mind, almost all proximal humeral fractures are treated with the minimally invasive Humerusblock system at our institution. The greatest technical challenges are encountered in the percutaneous reduction of fragments with disrupted periostal bridges; however, open reduction in these complex cases might not always be easy as well. In terms of clinical outcome, the results of the Humerusblock seem strongly related to the age and bone quality of the treated patient as well as the fracture type encountered. These factors along with the individual patient characteristics need to be considered when choosing the appropriate treatment method.[15] Owing to constantly improving implants and possibly increasing surgical skills, the reduction and fixation of even the most complex proximal humeral fractures might be technically achievable nowadays; however, certain biological limitations need to be considered as they will dictate the fracture healing, vascularity of the fragments, and especially the clinical outcome. The fact that the minimally invasive and soft tissue–sparing Humerusblock technique enables a dynamic fixation of the head fragment, which allows for

controlled sintering and fracture consolidation without major cutout complications when closely following the postoperative treatment protocol, makes this technique especially attractive in the treatment of proximal humeral fractures in elderly patients with poor bone quality. Further improvement of the device is currently tested, with special focus on the development of a device capable to guide the expected sintering of the head fragment without perforating the articular cartilage and without increasing the risk of secondary loss of reduction.[16]

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ORIGINAL PAPER

Percutaneous pinning of three- or four-part fractures of the proximal humerus in elderly patients in poor general condition: MIROS® versus traditional pinning

Stefano Carbone · Mario Tangari · Stefano Gumina · Roberto Postacchini · Andrea Campi · Franco Postacchini

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Abstract
Purpose Elderly subjects often have fractures of the proximal humerus, which may be difficult to manage in patients in poor general condition. The MIROS is a new percutaneous pinning device allowing correction of angular displacement and stable fixation of fracture fragments. We evaluated the results of percutaneous fixation of three- or four-part fractures of the proximal humerus of patients in the American Society of Anesthesiologists physical status three or four treated either with MIROS or traditional percutaneous pinning (TPP).
Methods A total of 31 patients treated with MIROS and 27 undergoing TPP were enrolled in the study. Pre-operatively anteroposterior and transthoracic or axillary radiographs were obtained in all cases and computed tomography scans in patients with the most complex fractures. Follow-up evaluations were carried out at three, six, 12 and 16 weeks, and six months, one year and two years postoperatively, using the Constant Score (CS) and subjective shoulder value (SSV) methods.
Results Of the 58 patients, 52 could be evaluated at all follow-ups. In both three- or four-part fractures there were significantly higher CS and SSV scores in the MIROS compared to the TPP group at all the late follow-ups. Lower rates of deep infection, pin tract infection and pin mobilisation were found in the MIROS group ($p<0.001$). In both groups there was a significant association between the final result (CS) and either the type of fracture or complications ($p<0.001$).
Conclusions The MIROS resulted in better clinical results and less complications than TPP in elderly patients. This method, however, may not be indicated for younger patients in good general condition.

S. Carbone (✉) · S. Gumina · F. Postacchini
Department of Orthopaedics and Traumatology,
University of Rome Sapienza,
Rome, Italy
e-mail: stefcarbone@yahoo.it

M. Tangari · A. Campi
Department of Orthopaedics and Traumatology,
San Giovanni-Addolorata Hospital,
Rome, Italy

R. Postacchini
Department of Orthopaedics and Traumatology,
Israelitico Hospital,
Rome, Italy

Introduction

Treatment of three- or four-part fractures of the proximal humerus in elderly patients is still controversial. While a few studies reported that non-operative management is associated with poor results [1, 2], a recent prospective, but not controlled, trial found it difficult to demonstrate a significant advantage of surgical over non-operative management [3]. Consistent with the findings of the latter study is the observation that the results of various surgical treatments, such as closed reduction and percutaneous pinning [4, 5], plate fixation [6, 7] and hemiarthroplasty [8], may be unpredictable. However, the fracture pattern, amount of displacement of the fragments, bone stock of the upper humerus, pre-existing rotator cuff disease or arthrosis and the patient's age and general condition are important factors in the choice of treatment.

For many years, worries over possible avascular necrosis of the humeral head have led hemiarthroplasty to be the

treatment of choice for displaced three-part and especially four-part fractures. In the last two decades, better knowledge of the vascular supply to the humeral head has shifted the surgical choice towards procedures of reduction and internal or external fixation for most three-part and even four-part fractures [5, 6, 9–12].

Percutaneous techniques may allow displaced fractures of the proximal humerus to be reduced and stabilised by Kirschner wires (K-wires) alone or wires clamped into a locking device. The advantages of these techniques are not only the possible preservation of vascular supply to bone fragments, but also no blood loss and the possibility of surgery under brachial plexus block. The latter prerogatives may be of considerable importance when treating patients in poor general condition, such as those in American Society of Anesthesiologists (ASA) physical status (PS) three or four [13].

The MIROS (Minimally Invasive Reduction and Osteosynthesis System®) is a recently introduced device for treatment of fractures of the upper limb, particularly those of the proximal humerus. It allows correction of angular displacement and fixation of fracture fragments by means of elastic K-wires locked in a metallic clip placed externally on the skin. We assumed that the MIROS might provide greater fracture stability and less complications with respect to traditional percutaneous pinning (TPP). A prospective study was thus carried out to compare the MIROS to TPP for the treatment of three- or four-part fractures of the upper end of the humerus of elderly patients in ASA PS 3 or 4.

Materials and methods

Between 2007 and 2009, ASA PS three or four was assigned to 58 consecutive patients admitted at two hospitals of a single town for fracture of the proximal humerus. In one hospital the patients were treated with the MIROS, while in the other TPP was performed. There were 37 women and 21 men with a mean age of 76 years (68–93), the patients of the two groups being matched for mean age, sex, mean ASA PS score and type of fracture (Table 1). A concomitant fracture was present in five and three patients in each group, respectively.

Patients underwent true anteroposterior and transthoracic radiographs, and an axillary view when the arm could be abducted. Radiographs were evaluated by two of the authors with a special interest in shoulder trauma and classified according to the Neer system[14]. In the presence of complex fractures, computed tomography (CT) scan with 3-D reconstructions was performed. In no patients were there local vascular or neural complications. Excluded from the study were patients with a fracture extending to the humeral diaphysis or the articular surface of the humeral head and those with no active motion of the arm due to previous cerebrovascular diseases. Patients under study gave their informed consent to the operation.

Table 1 Patients' details

	TPP	*p* values	MIROS
Enrolled	27	–	31
Mean age±SD (range)	78.3±11.3 (68–89)	0.8	80.7±7 (76–85)
Three-part fracture	15 (55.5%)	0.5	18 (58.1%)
Four-part fracture	12 (44.5%)	0.9	13 (41.9%)
ASA PS	3/15 pts; 4/12 pts		3/15 pts; 4/16 pts
Complete follow-up	26	–	28
Three-part fracture	15	0.2	17
Four-part fracture	11	1	11
Concomitant fractures	3 (11.5%)	0.1	5 (17.8%)

The patients of both hospitals underwent clinical evaluation and shoulder radiographs at three, six, 12 and 16 weeks. In each hospital they were assessed by an orthopaedic surgeon not involved in the patient's management. At six, 12 and 24 months the patients of both groups were assessed by the examiner who had carried out the earlier evaluations of the patients in the TPP group. Of the original patients, six were lost to the latest follow-up (two had died and four did not attend for assessment), thus leaving 28 patients in the MIROS group and 26 in the TPP group. The number of three-part, or four-part, fractures was similar in the two groups (Table 2). The shoulder function was evaluated using the Constant Score (CS) method [15]. The patients were also asked to rate the result of surgery with the subjective shoulder value (SSV) method [16]. Measurement of the range of motion was performed in the standing position using a goniometer and that of the abduction strength by the Micro-FET dynamometer (Hoggan Health Industries, West Jordan, UT, USA). Radiographic evaluation included true anteroposterior and axillary views of the shoulder.

Operative techniques

The MIROS (Technovare, Europa Trading s.r.l., Anagni, Italy) consists of four 2.5 mm thick and 50 cm long stainless steel or titanium wires the end of which is introduced into a metallic clip (Fig. 1). The latter has a diameter of 20 mm and contains a screw that is tightened to lock the wires.

The patient, after supraclavicular brachial plexus block, was placed supine with the head of the operating table raised to 30°. Before inserting the K-wires, attempts were made to reduce the fracture by manipulation. The first K-wire was introduced into the greater tuberosity and then pushed down

Table 2 CS and SSV scores at all follow-up evaluations in our cohorts of patients

		TPP Average±SD	*p* values	MIROS Average±SD
6 months CS	Three-part	45±7 (30–58)	0.02	57±12 (45–68)
	Four-part	38±11 (28–59)	0.01	50±11 (35–64)
	Mean	41.5	0.016	53.5
6 months SSV	Three-part	60±10 (30–70)	0.023	70 ±15 (40–80)
	Four-part	55±5 (35–60)	0.038	65±5 (50–70)
	Mean	57.5	0.032	67.5
12 months CS	Three-part	55±11 (42–64)	0.04	63±8 (47–70)
	Four-part	47±9 (28–59)	0.037	55±12 (38–68)
	Mean	51	0.039	59
12 months SSV	Three-part	75±10 (60–80)	0.023	90±15 (70–100)
	Four-part	70±10 (60–90)	0.018	85±5 (65–95)
	Mean	72.5	0.2	87.5
24 months CS	Three-part	53±9 (45–65)	0.01	62±11 (48–70)
	Four-part	50±10 (40–60)	0.03	58±13 (39–66)
	Mean	51.5	0.02	60
24 months SSV	Three-part	75±10 (60–85)	0.023	90±15 (70–100)
	Four-part	70±10 (60–90)	0.01	90±5 (75–95)
	Mean	72.5	0.015	90

to the lateral epicondyle. The second cranial K-wire was inserted into the largest part of the humeral head and directed to the medial epicondyle. When inserting these K-wires attention was paid to avoid subacromial impingement by slightly bending the wires after they were introduced perpendicularly to the skin. The remaining two K-wires were inserted from the proximal humeral metaphysis with a cranial direction until they reached the subchondral bone of the humeral head (Fig. 1). Then, further bending of the four K-wires was carried out to lock them into the external clip, which was placed at least 2 cm from the skin of the deltoid area. Once the clip was blocked, it was possible to slightly correct the varus or valgus position of the humeral head by compressing or distracting the K-wires into the metallic clip. They were then cut and the screw inside the clip was tightened (Fig. 2). Post-operatively a sling was applied. The MIROS was removed five or six weeks after the operation (Fig. 3)

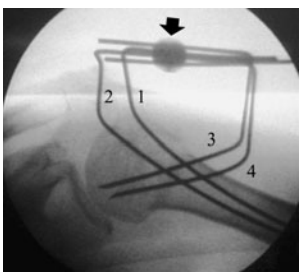

Fig. 1 Fluoroscopic view after insertion of the four K-wires of MIROS. The *numbers* indicate the sequence with which the wires are inserted. The *arrow* points to the externally placed metallic clip

TPP was performed according to the technique first described by Jaberg et al. [17] using five terminally threaded 2.5-mm Schanz pins. The edges of the pins were bent manually and left outside the skin. Post-operatively, patients wore a sling for three or four weeks. The pins were removed five or six weeks after the operation.

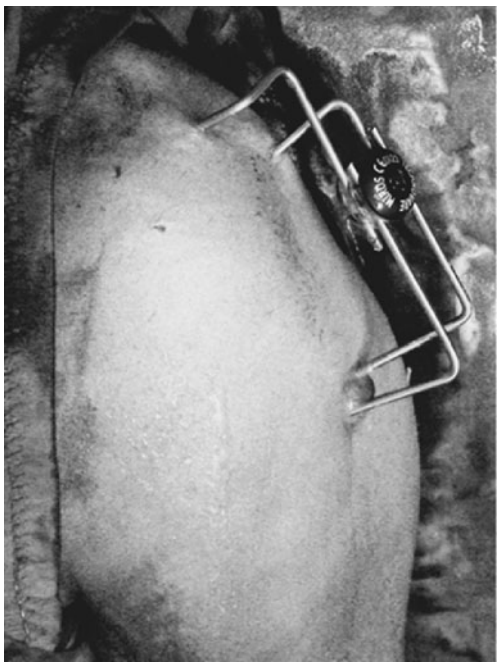

Fig. 2 Photograph taken after implantation of the MIROS, showing the external part of the system

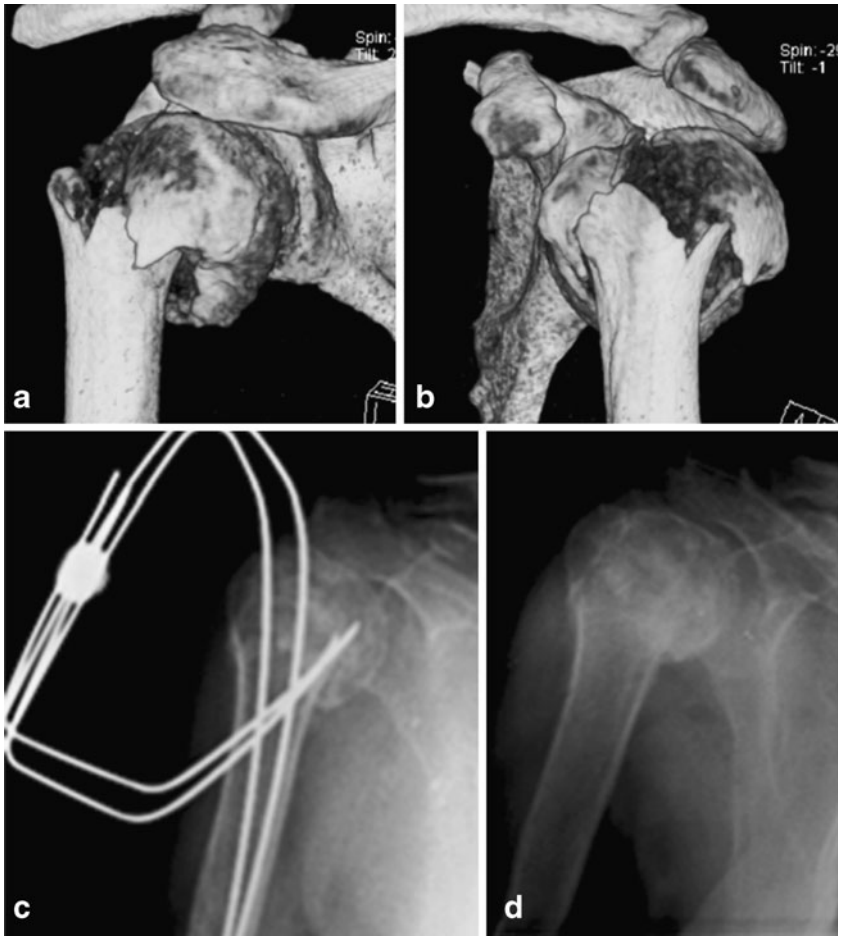

Fig. 3 A 74-year-old woman with a four-part fracture of the upper humerus and ASA PS four treated with MIROS. **a**, **b** Preoperative 3-D CT scans. **c** Post-operative anteroposterior radiograph. **d** Anteroposterior radiograph obtained at the six-month follow-up

Post-operative treatment

In the MIROS group pendulum exercises were begun a mean of four days after surgery and passive assisted exercises two weeks post-operatively. Passive motion was progressively increased depending on the patient's tolerance. In the TPP group, passive shoulder motion was started three or four weeks depending on the type of fracture and active motion five or six weeks after surgery.

Statistical analysis

Fisher's exact test was used to compare the proportions and Student's t test for average values; p values <0.05 were deemed to be statistically significant. Multiple regression analysis was performed to identify potential associations between dependent variables (CS and SSV) and independent variables (type of fracture, complications).

Results

The mean operative time was 37.3 min (range 19–44) in the MIROS group and 40.1 min (range 32–125) in the TPP group. The mean fluoroscopy time was 76 s (range 32–125) and 50 s (range 40–68), respectively ($p<0.001$).

The mean CS and SSV scores were significantly higher in the MIROS group compared to the TPP group at all late follow-ups (Table 2). The mean range of motion was consistently greater in the MIROS patients with either a three-part or four-part fracture (Table 3); the differences were found to be consistently significant except for the three-part fracture pattern at the 24-month follow-up. The mean abduction strength was greater in the MIROS group at the six, 12- and 24-month follow-ups (Table 3).

The overall complication rate was 10.7% in the MIROS group and 26.9% in the TPP group (Table 4). The intra-operative complications were a perforation of the humeral head in one patient undergoing TPP and of the humeral head and the glenoid fossa in one of the MIROS group. Other complications were pin mobilisation or displacement, local deep infection and avascular necrosis of the humeral head. One or two pins displaced, that is partially came out from the humerus, in five patients in the TPP group; they were removed with no loss of reduction of the fracture. In one patient in the MIROS group there was a moderate displacement of pins within the upper humerus with resultant moderate loss of fracture reduction. The case in the TPP group

Table 3 Range of motion (ROM) (/40) and muscle strength (/25) in the two groups of patients

		TPP Mean±SD (range)	*p* values	MIROS Mean±SD (range)
6 months ROM	Three-part	14±3 (9–22)	0.001	30±7 (23–33)
	Four-part	12±4 (8–15)	0.001	26±5 (20–29)
6 months strength	Three-part	3±2 (1–6)	0.03	8±5 (5–15)
	Four-part	3±3 (1–7)	0.05	6±6 (3–12)
12 months ROM	Three-part	21±7 (16–29)	0.002	31±5 (23–34)
	Four-part	18±4 (14–23)	0.01	26±6 (21–28)
12 months strength	Three-part	7±3 (2–10)	0.047	10±5 (6–16)
	Four-part	4±2 (3–7)	0.05	7±2 (4–9)
24 months ROM	Three-part	30±8 (20–35)	0.056	33±6 (26–35)
	Four-part	27±12 (20–38)	0.048	32±4 (26–31)
24 months strength	Three-part	8±5 (5–12)	0.044	11±7 (6–18)
	Four-part	7±5 (3–10)	0.047	10±4 (4–14)

The figures in parentheses indicate the maximum CS for each parameter

with a deep infection was treated with antibiotics with no sequelae. Of the four patients who had avascular necrosis, three did not ask for revision surgery because their clinical condition was acceptable. In the patient in whom the severity of pain would need repeat surgery, hemiarthroplasty could not be performed because general anaesthesia was contraindicated. However, at the latest evaluations, these patients were those with the lowest CS and SSV scores in each group. A statistically significant difference between the two groups was found for overall complications, pin mobilisation and pin tract infection ($p<0.05$) (Table 4).

In both groups, the multiple regression analysis showed that the variables that influenced the CS at the latest follow-up were the type of fracture [three- vs four-part fractures ($p=0.03$)] and complications ($p<0.001$).

Discussion

The prerogatives of the percutaneous pinning techniques are of paramount importance when treating elderly patients with cardiovascular or pulmonary diseases, particularly those in ASA PS three or four, in whom general anaesthesia is very risky or clearly contraindicated. Their limitation, compared to open reduction internal fixation (ORIF), is that they may allow a less anatomical reduction of bone fragments. However, several studies [4, 17–19] have shown that this is not a major drawback in most fractures of the proximal part of the humerus, because the clinical results can be satisfactory even in the presence of a non-anatomical reduction of the fracture.

Table 4 Complications in the two groups of patients

	TPP (27)	*p* values	MIROS (31)
Overall complications	7 (26.92%)	0.008	3 (10.7%)
Pin tract infection	4 (15.38%)	>0.001	0
Pin mobilisation	7 (26.9%)	>0.001	0
Pin displacement	0	0.8	1 (3.57%)
Deep infection	1 (3.84%)	0.6	0
Avascular necrosis	2 (7.69%)	0.8	2 (7.1%)

TPP, which is the simplest technique of external fixation, has several drawbacks. In our series, the mean CS showed a limited increment from the six-month to the 24-month follow-up, the scores being 41 and 51 points, respectively. Furthermore, complications occurred in 26.9% of cases. They included pin displacement, pin tract and/or deep infection and avascular necrosis of the humeral head, i.e. the same complications that were found, in similar percentages, in previous studies on this method of treatment [17, 20]. These observations indicate that TPP should be avoided not only in patients in poor general condition, but also in those in fair or good condition who can stand general anaesthesia.

So far, two methods of percutaneous pinning with the use of a device locking the end of the pins have been described [4, 21, 22]. In one of them the locking device, called "humerus block", is placed deep to the lateral portion of the deltoid muscle, adherent to the cortical bone of the uppermost humeral diaphysis, through a 4-cm skin incision. The device, which can lock two pins, is left on site and removed, together with the pins, after fracture healing if the patient complains of local discomfort; when needed, one or more screws inserted percutaneously can be utilized with the pins to fix single fragments [4]. The second method, called the "hybrid technique", implies open reduction of the fracture fragments that are then fixed with pins connected to an external fixator [21]. With the MIROS four pins are used, the ends of which are blocked in a clip placed externally on the skin. The rationale of these techniques is to stabilise the fracture fragments by shifting the site of fixation from the cancellous bone of the proximal humerus to the stronger

bone of the lateral cortex of the humeral diaphysis. They also allow passive shoulder motion to be started a few days after surgery. However, only the humerus block and MIROS are minimally invasive techniques that can be carried out under brachial plexus block. Compared to the humerus block, the MIROS has the advantage that four pins, instead of two, can be anchored to the locking device. The four pins can provide better fracture fixation, with no need for percutaneous screws to fix tuberosities not stabilised by the pins. Furthermore, the external placement of the locking device allows the instrumentation to be removed when the fracture has healed with no need of a further operation, which can be problematical in older patients in very poor general condition (ASA PS four).

In patients treated with the MIROS the mean fluoroscopy time was significantly longer than in those of the TPP group. However, the longer X-ray exposure was justified by the clinical results, which were significantly better in the former group at the latest follow-up. The mean CS ranged from 53.5 points at the six-month follow-up to 60 points at the latest evaluation, i.e. significantly higher figures than those obtained in the TPP group. One explanation for the differences between our two groups may be the more stable fixation of the fracture fragments in the MIROS patients, which allowed the rehabilitation programme to be started earlier. Another reason may be related to the complications, which were similar to those in the TPP group, but occurred at a significantly lower rate, except for avascular necrosis.

In both groups the clinical results were better in patients with three-part factures compared to those with four-part injuries, which is understandable considering the greater difficulty in obtaining a satisfactory reduction in four-part lesions. Based on this finding, we believe that methods of percutaneous pinning should be avoided in young or middle-aged patients in the absence of comorbidities that contraindicate ORIF. In older patients in poor general condition, the percutaneous procedure with MIROS can even be performed with the only aim of pain relief. However, the main goal of the procedure is not to jeopardise the already critical health status of individuals even with a long life expectancy, in whom a satisfactory functional outcome is of primary importance for performing the activities of daily living. Furthermore, it can also be indicated for elderly patients in satisfactory general health in whom there is less need of anatomical fracture reduction and excellent functional result than in younger patients.

The reported incidence of avascular necrosis of the humeral head after traditional pinning ranges from 4% [17] to 14% [20]. In our cohorts, it was 7.7% in patients undergoing TPP and 7.1% in those treated with the MIROS. This indicates that the occurrence of avascular necrosis is related to the type of fracture and the extent of compromise of the arterial supply to the humeral head rather than the stability of fixation of the fracture fragments. The four patients with avascular necrosis in our cohorts had the lowest CS and SSV scores at the latest evaluations. However, only in one was there a clear-cut indication for hemiarthroplasty, which could not be performed due to the poor general condition.

In conclusion, our study shows that, although TPP can be a valid treatment for three- or four-part fractures, the MIROS gives better results. However, both types of treatment imply closed reduction of the fracture, which can be a very demanding procedure that may fail to provide a satisfactory reduction, particularly in four-part injuries. Therefore, not only in the young, but also in the middle-aged patient with no general comorbidities, ORIF should generally be preferred to percutaneous pinning.

Conflict of interest The authors declare that they have no conflict of interest.

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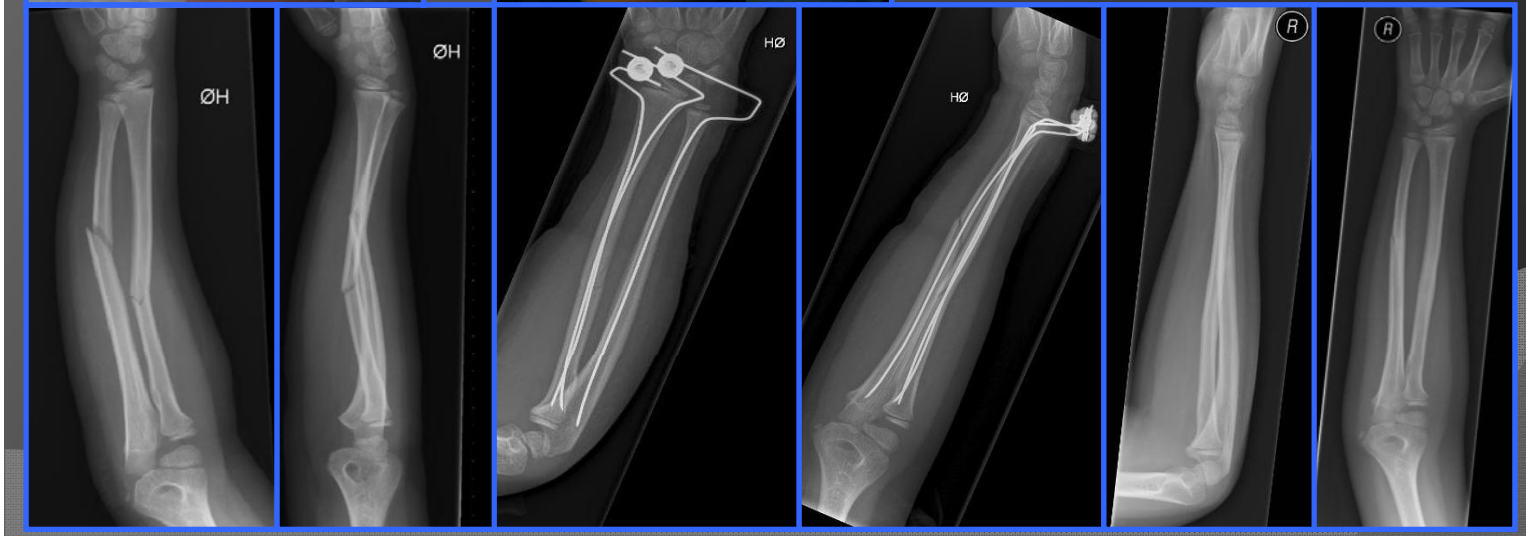

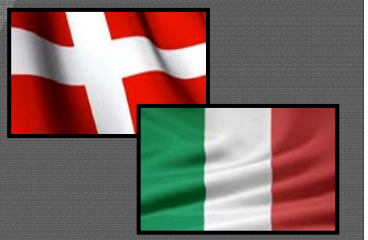

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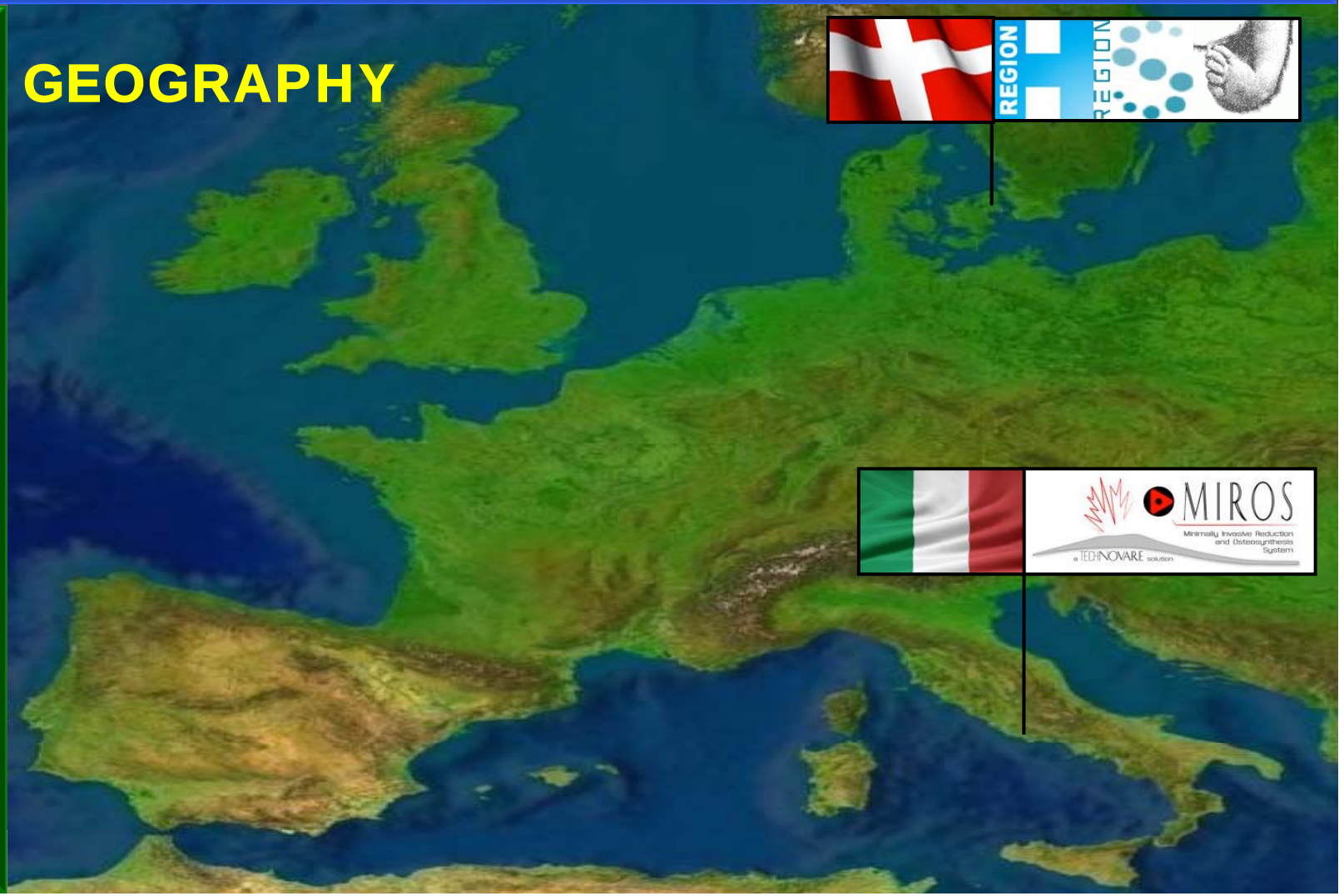
GEOGRAPHY



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AUTHORS

T. Karbo[1.2], S. Sonne-Holm[1], C. Wong[1]

[1]:*Pediatric Orthopaedic Section*
Hvidovre University Hospital
Denmark

[2]:*Department of Orthopaedic Surgery & Trauma*
Copenhagen University Hospital Nykøbing
Denmark

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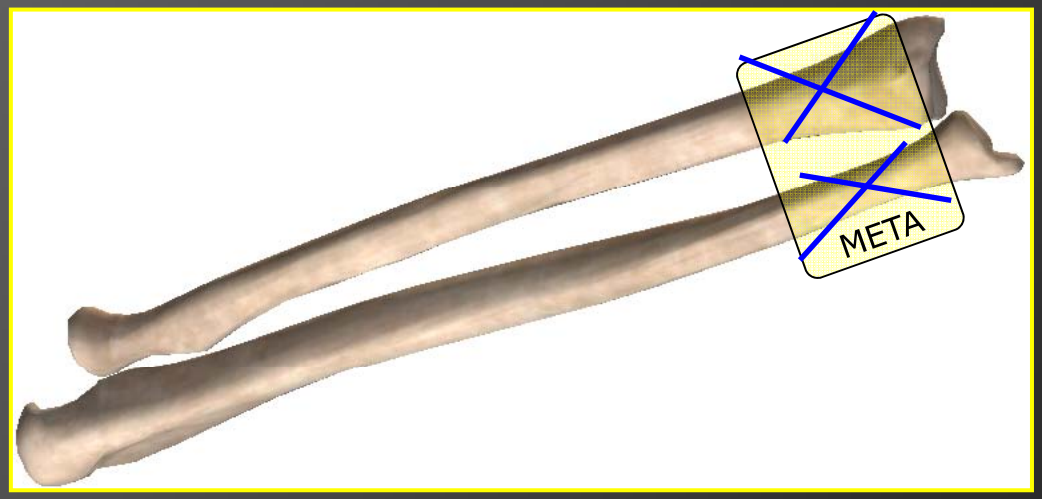

For the displaced distal **meta**physeal fracture are the surgical option: Crossed **K**irschner **W**ires, KW.

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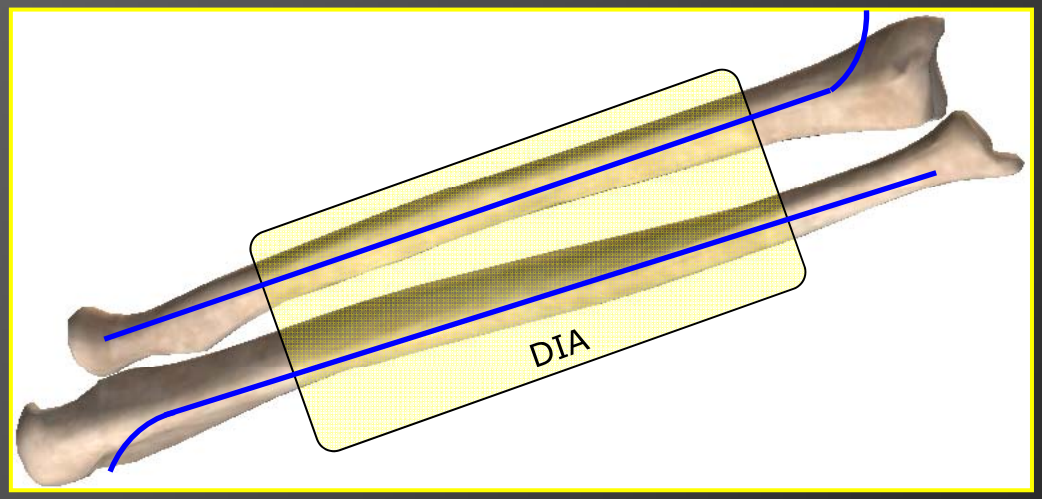


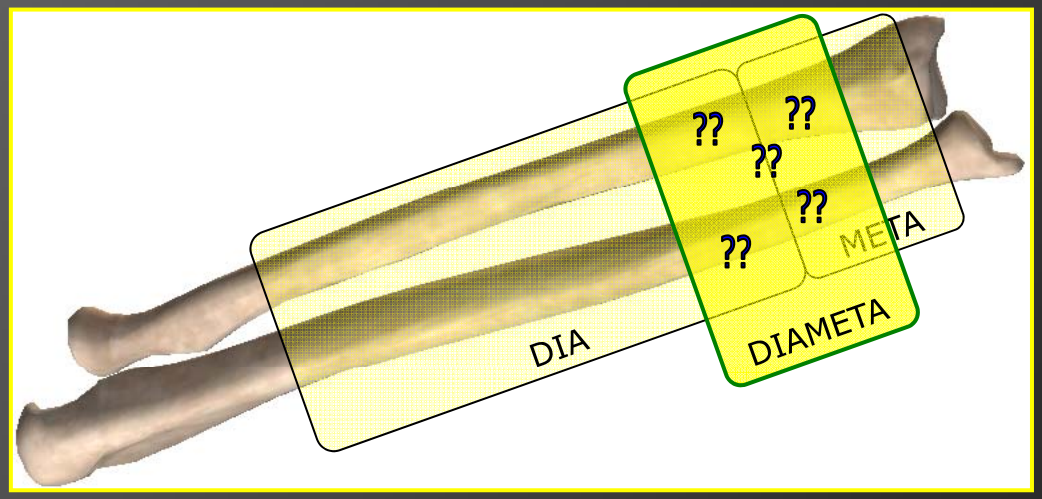
For the displaced **dia**physeal fracture are the surgical option: intermedullary **T**itanium **E**lastic **N**ails, TEN

Testing A New Type Of Osteosynthesis And After Care In Treatment Of Antebrachium Fractures In Children Preliminary Results Of A Prospectiv Pilot Case-Control Study

Societa Italiana di Ortopedia e Traumatologia Pediatrica, ROMA '13

T.Karbo, S.Sonne-Holm, C.Wong; Hvidovre University Hospital

BACKGROUND



For the displaced distal **dia-metaphyseal** fracture are there **no** apparent adequate surgical option

A **new** type of combined internal elastic nail and external fixation (MIROS®) was applied in 10 patients and compared with 10, age and fracture type matched, children.

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PURPOSE / AIM OF STUDY

To compare MIROS® to the conventional osteosynthesis methods in treatment of children with diaphyseal, distal **diametaphyseal** and distal metaphyseal fractures of the antebrachium.

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MATERIALS & METHODS

A prospective pilot case-control study

20 children, age 4-15
- 10 operated on with standard – T.E.N. or K.W.
- 10 operated on with M.I.R.O.S

Follow-up at 3 month after removal, including
- x-rays of both antebrachii
- systematic testing of bilateral range of motion
- visual analogue pain scale
- bilateral strength measurements

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FINDINGS / RESULTS

Trends: statistically no significant power with n=20

- Minor differences in clinical and radiological outcome
- Minor differences in operating time for insertion and removal was faster with MIROS compaired to KW
- Faster operating time for insertion and removal with MIROS compaired to TEN
- Surgical incision was smaler with MIROS
- All MIROS had a plaster-cast-free aftercare and therefore early mobilzation of wrist and elbow
- Almost no differences in bilateral strength or range of motion in the MIROS-children compaired to KW and TEN

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FINDINGS / RESULTS

PRIM. OPERATION TIME, measured in Min.:
REMOVAL TIME (amotio atella), mesured in Min.:

	Time	Mean DIA	Mean META
TEN, Prim.	37-111 min.	71,2 min	
TEN, Remov.	14-44 min.	30,2 min.	
KW, Prim.	24-57 min.		37,4 min.
KW, Remov.	2-13 min.		7,2 min.
MIROS, Prim.	30-55 min.	44,3 min.	31,5 min.
MIROS, Remove	2-10 min.	5,7 min.	5,8 min.

DIA: Diaphyseal fractures META: Metaphyseal fractures

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FINDINGS / RESULTS

GRIP STRENGHT, measured in Newton, at 3 month past removal:

	Nm	Diff	%
TEN, Frx	18-110 /// 55,7	4,4 Nm	7 %
TEN, Cont	27-129 /// 60,1		
KW, Frx	18-60 /// 41,7	3,1 Nm	7%
KW, Cont	15-69 /// 44,8		
MIROS, Frx	37-121 /// 67,3	2,3 Nm	3%
MIROS, Cont	36-126 /// 69,6		

Frx: fracture

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FINDINGS / RESULTS

SPORTS, at 3 month past removal:

TEN: Starting up regular training

KW: Increased training intensity
+ No restrictions at the playground / skatepark

MIROS: same as KW - incl. matches / sports games
+ Mountaineering
+ Horse riding
+ Elite Swimming (>5 km / week)
+ Football / Handball / Basketball
+ Athletics
+ Gymnastics / Trampoline

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CONCLUSIONS

MIROS® is as good as conventional osteosynthesis methods at 3 month follow-up

MIROS® have advantages
- faster operating time
- less surgical scaring
- faster removal
- no plaster cast
- early movement of elbow and wrist

Further prospective multicenter **R**andomized **C**linical **T**rials should be performed and this is already in progress

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DISCLOSURE STATEMENT

We have no financial relationship to disclose

We have no commercial interest related to the content of activity of this study

We have no other potential conflict of interest

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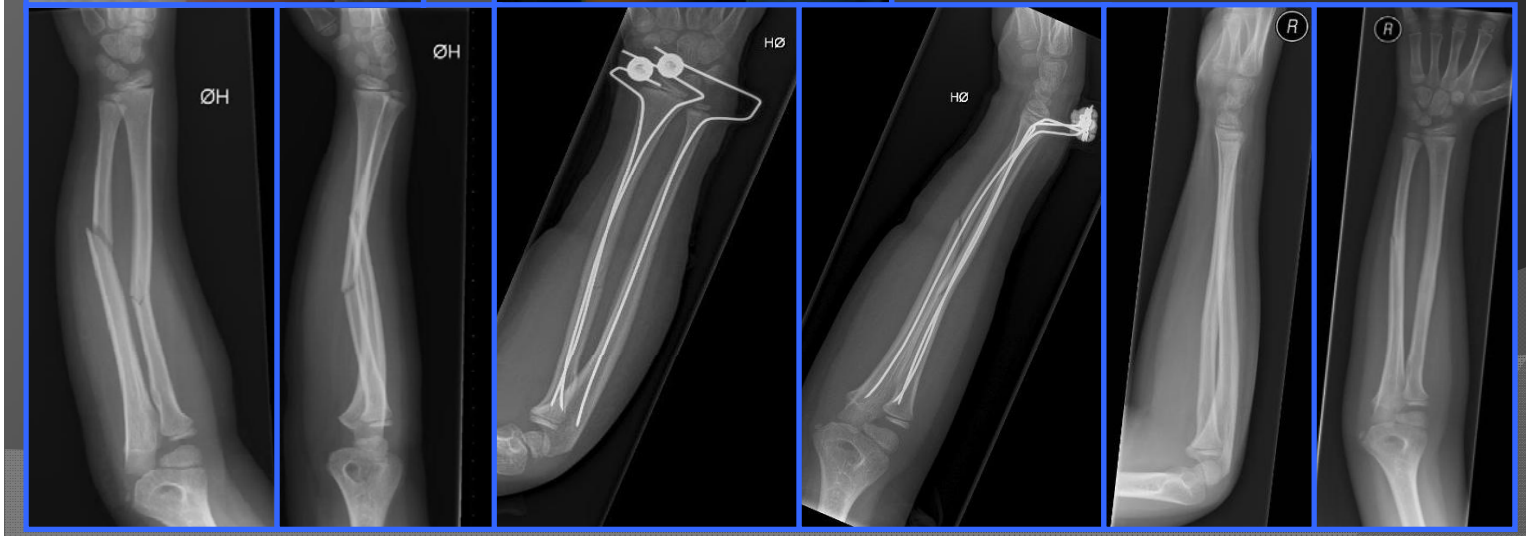
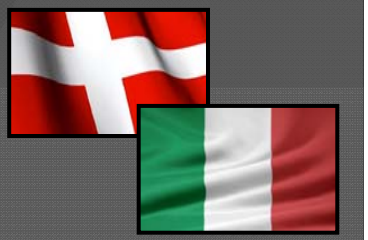


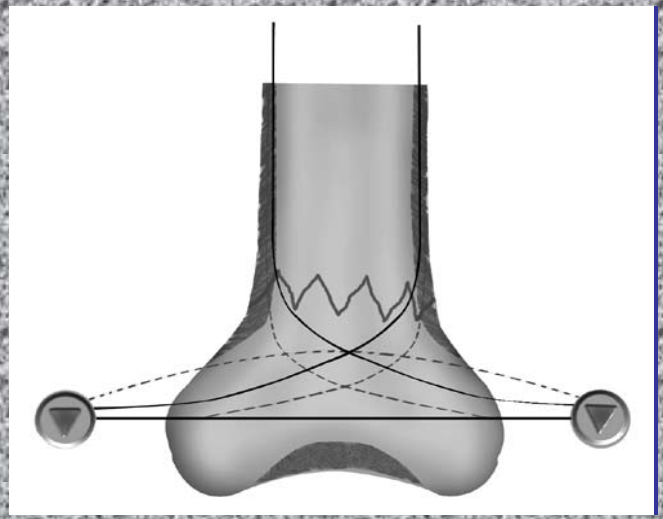


Metoda MIROS – naše zkušenosti v léčbě zlomenin

V.Bartl, B.Hnilička, Š.Bibrová, L.Plánka
Dětská nemocnice
FN Brno

Metoda MIROS :

Minimally
Invasive
Reduction and
Osteosynthesis
System)



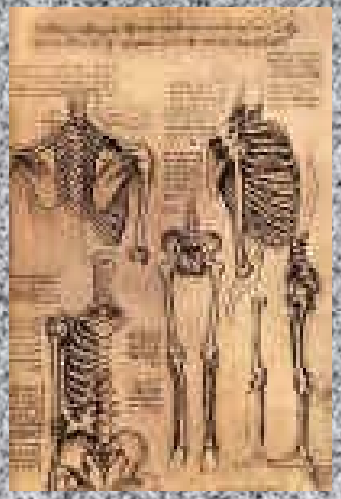
"L'arco è una costruzione nata da due debolezze dalla cui unione risulta una grande forza".

Leonardo da Vinci

Tangari M. *Personale tecnica di applicazione del Sistema Epibloc*. Giornale Italiano di Ortopedia e Traumatologia 2002;28:2-10.

MIROS (Delta systém)

- Vychází z šetrnosti nitrodřeňové osteosyntézy pomocí Kirschnerova drátu.
- Oproti výše uvedené metodě má však výhodu předpětí Kirschnerova drátu pomocí patentovaných speciálních svorek, které mohou být až třítažové a na Kirschnerův drát se nasazují snadno a rychle.
- Umožňuje intramedulární, hybridní i externí konfiguraci.
- Jedná se vlastně o spojení nitrodřeňové osteosyntézy se zevním fixátorem, bez sádrové fixace. Výhodou je široká variabilita.



Indikační spektrum:

- Zlomeniny dlouhých kostí HKK i DKK
- Zlomeniny skeletu ruky a nohy

Kasuistika č.1

18-letý pacient, nehojící se zlomenina základního článku 3.prstu pravé ruky

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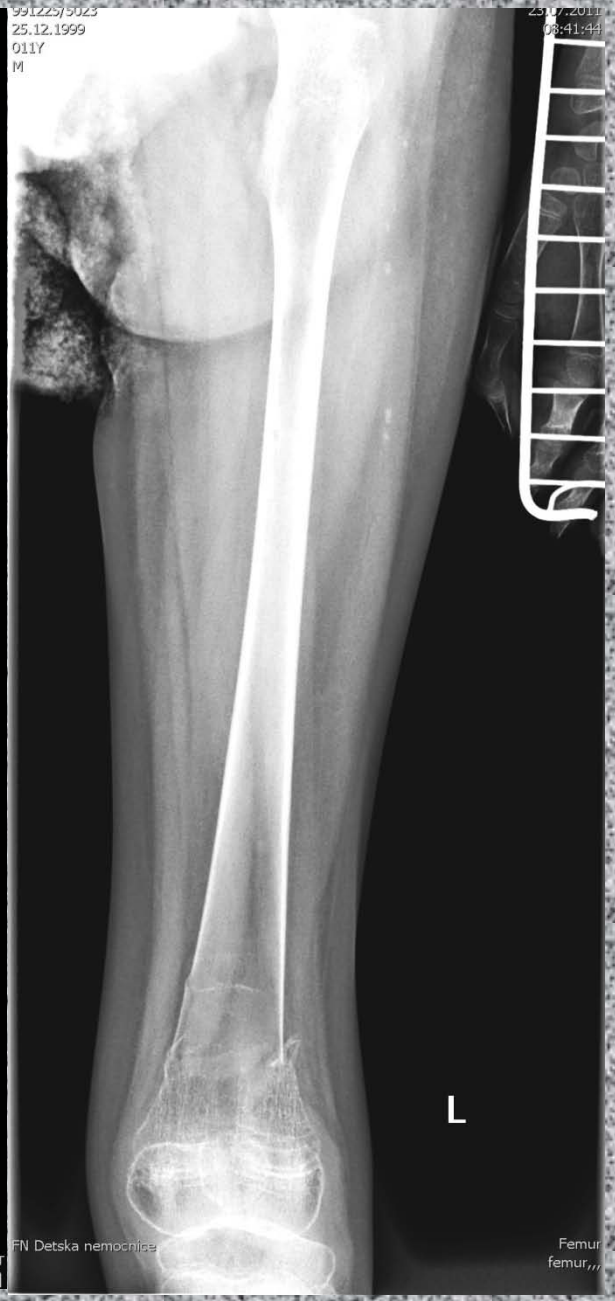
Kasuistika č.2

12-letý pacient: por.hm.:750g/32 cm
ICH(V-P shunt)
Epilepsia
stp.KPR (opak.)
DMO
PMR(inkontinence)
PEG
Tracheostomia
Bronchopneumonia recid.

22.7.2011


L
Hip Joint AP/LAT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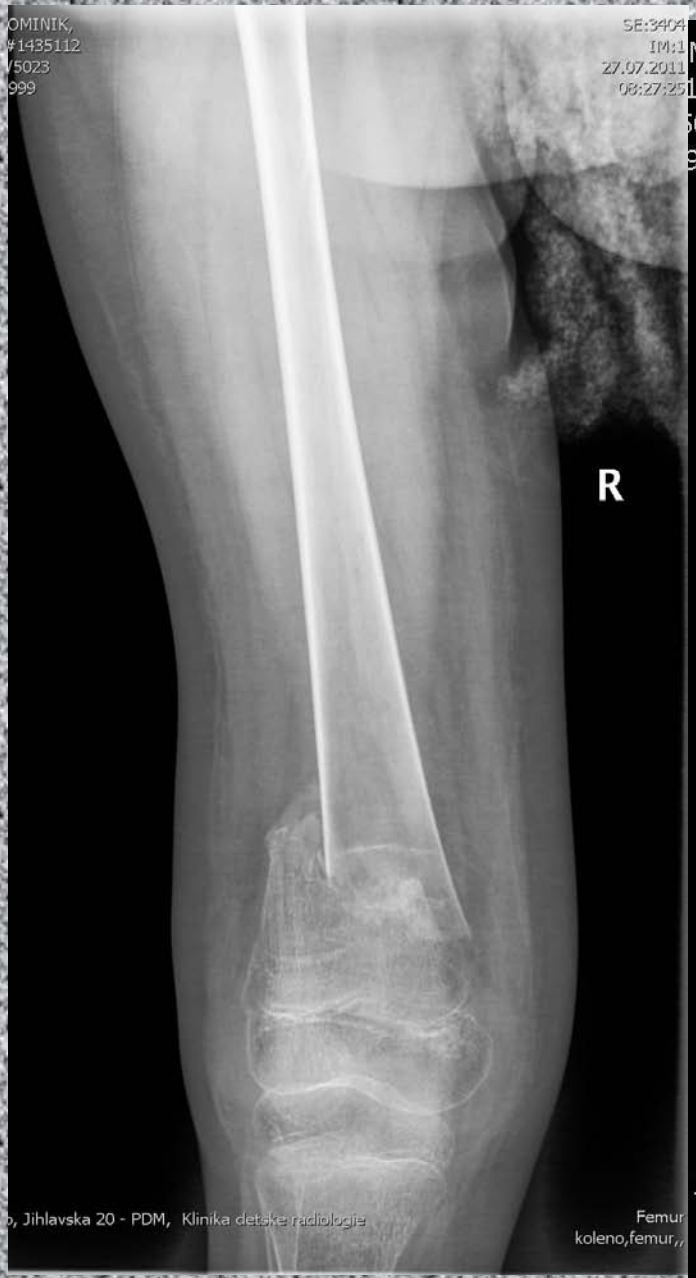
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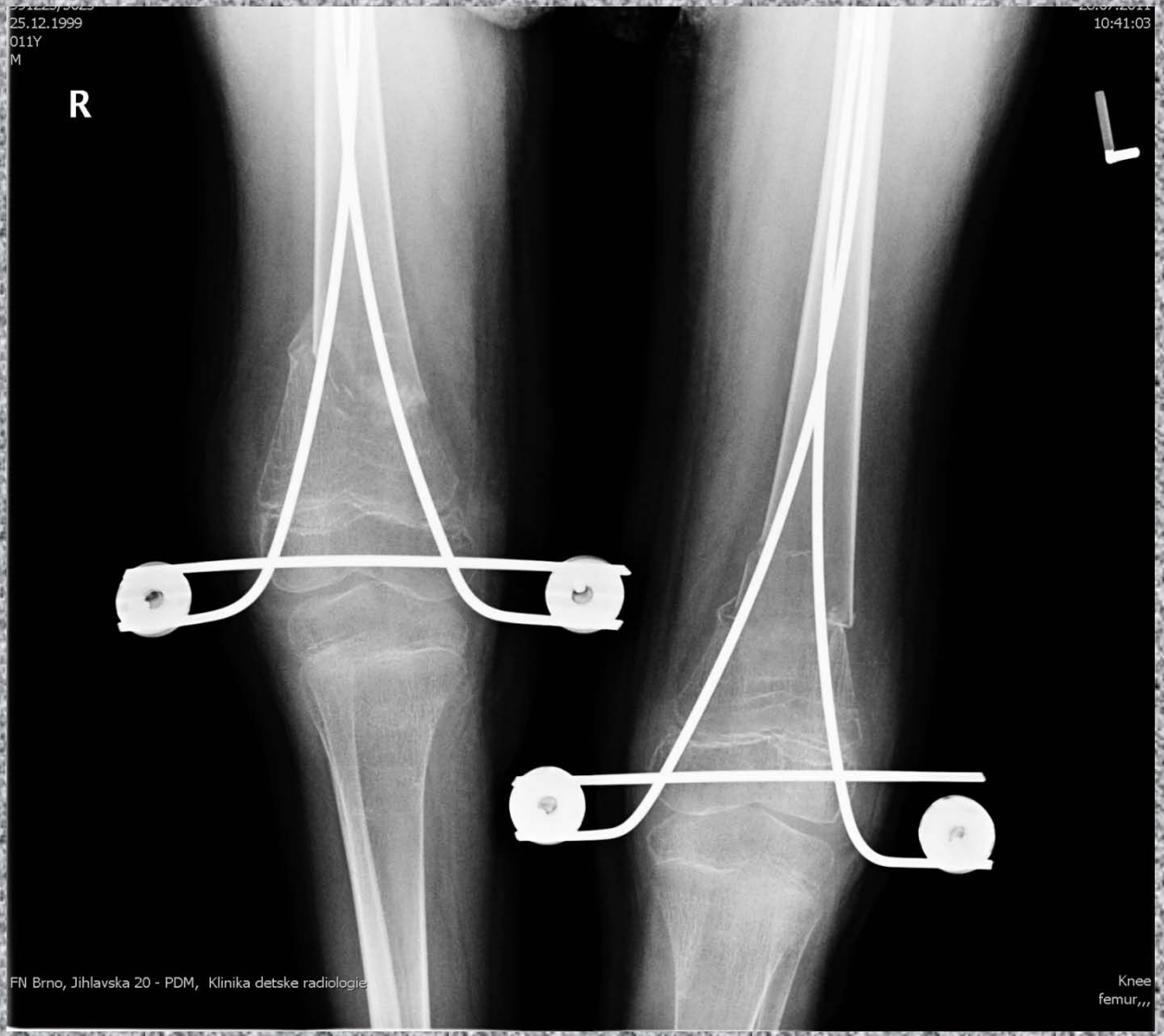
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FN Brno, Jihlavska 20 - PDM, Klinika detske radiologie
Knee
femur,,,

Jednoduchá aplikace
Variabilita
\+
Bez sádrové fixace

Získání jakékoli vědomosti je pro rozum vždy užitečné, protože bude moci ze sebe vypudit věci neužitečné a uchovat ty dobré.

Protože žádnou věc nemůžeme milovat ani nenávidět, aniž jsme ji napřed poznali.

Leonardo da Vinci

Abstract for
Congresso Nazionale S.I.T.O.P.
Roma 21-23 novembre 2013
Ospedale Bambino Gesù
I.R.C.C.S. – Roma
Auditorium San Paolo

TITLE
Testing A New Type Of Osteosynthesis And After Care ˆ In Treatment Of Antebrachium Fractures in Children, Preliminary Result Of A Prospectiv Case-Control Study.

AUTHORS
Author 1: Karbo, Ture
Organisation 1: Pediatric orthopaedic section, Hvidovre University Hospital

Author 2: Sonne-Holm, Stig
Department, Institution/hospital 2: Pediatric orthopaedic section, Hvidovre University Hospital

Author 3: Wong, Christian
Department, Institution/hospital 3: Pediatric orthopaedic section, Hvidovre University Hospital

Presenter: Karbo T.

CONTENT
Topic: Pediatrics
Topic second choice: Trauma

Background: Fractures of the lower arm in children are the most common, comprising about 40% of all pediatric fractures. Generally there is consensus regarding treatment, but the displaced distal dia-metaphyseal fractures (DDMF) are there no apparent adequate surgical option.
A new type of combined internal elastic nail and external fixation (MIROS®) was applied in 10 patients compared with 10, age and fracture type matched, children.

Purpose / Aim of Study: To compare MIROS® to the conventional osteosynthesis methods in treatment of children with DDMF of the antebrachium.

Materials and Methods: The prospective case-control study including 20 children, age 4-15, operated on with standard treatment - with elastic nails / Kirschner wires or MIROS® for DDMF.
Follow-up at 3 month after removal of osteosynthesis material including x-rays of both

antebrachii, systematic testing of bilateral range of motion, visual analogue pain scale and strength measurements.

Findings / Results: There were minor differences in clinical and radiological outcome after 3 month follow up. Operating for insertion and removal time of the MIROS was faster with a smaller surgical incision. All Miros® had a plaster-cast-free aftercare.

Conclusions: MIROS® is as good as conventional osteosynthesis methods at 3 month follow-up, having advantages like faster operating time, less surgical scaring, faster removal, no plaster cast and early movement of elbow-/wrist-joints. However, prospective randomized trials should be performed.

CONTACT INFORMATION
Name: Ture Karbo
E-mail 1: turekarbo@gmail.com
Office Phone: 56516508
Cell Phone: 30256797
Address: Askevangen 50, DK-3450 Allerød

11th International Congress of Shoulder and Elbow Surgery

3rd International Congress of Shoulder and Elbow Therapists

Edinburgh, Scotland
5 – 8 September 2010

ICSES EDINBURGH 2010

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ABSTRACT BOOK

O7.7

The Application of Locking Intramedullary Nails and Locking Plates in the Treatment of Two-part Proximal Humeral Surgical Neck Fractures: A Prospective Randomized Trial with a Minimum of 3-year Follow-up

Chunyan Jiang[1]

[1]Beijing Jishuitan Hospital, 4th Medical Center, School of Medicine, Peking University, Shoulder Service, Beijing, China

Background: Locking intramedullary nails and locking plates that specially designed for proximal humeral fractures are widely used. The purpose of our study is to compare the outcomes between these two types of implants in treating patients with 2-part surgical neck fractures.

Methods: A prospective randomized study was performed. Fifty-one consecutive patients with a fresh 2-part surgical neck fracture were randomized into locking intramedullary nails group (n =25) or locking plates group (n = 26). Clinical and radiographic assessments were conducted at 1 year and 3 years after the surgery. A visual analogue scale (VAS) was used to assess the shoulder pain. American Shoulder and Elbow Surgeon (ASES) scores and Constant-Murley scores were recorded to evaluate patients' shoulder function.

Results: Fracture union was achieved in all patients within 3 months postoperatively. The complication rate of the locking plates group was higher than that of the intramedullary nails group. The average ASES score, VAS score and strength of the supraspinatus of the locking plates group was significantly better than the intramedullary nails group in post operative 1-year follow-up. No significant difference could be found with regard to all parameters between two groups at 3-year follow-up. Significant improvement regarding the VAS pain scores, ASES scores and Constant scores were found between 1-year follow-up and 3-year follow-up in each group.

Conclusion: Satisfactory results can be achieved with both implants for the treatment of 2-part surgical neck fractures. There is no difference found regarding final outcomes between these two implants at 3-year follow-up. The complication rate is lower in the locking intramedullary nails group while fixation with locking plates has the advantage of quick recovery of shoulder function. The shoulder functional recovery can still be improved beyond one year after operation.

O7.8

The Hot-air-Balloon Technique for Treatment of Three-part Proximal Humerus Fractures: Effects on Medial Load Sharing and Important Prognostic Factors of Complications

Jin-Young Park[1], Sang-Hoon Lhee[1], Jeong Han Kim[2]

[1]Konkuk University, Orthopaedic Surgery, Seoul, Korea, Republic of, [2]Pusan Baek Hospital, Orthopaedic Surgery, Pusan, Korea, Republic of

Objectives: The purpose of this study was to evaluate the effects on medial stress sharing and complication prevention following the use of the Hot-air-balloon technique for the treatment of displaced, three-part fractures of the proximal humerus. Additionally, we studied whether restoring the medial buttress and inferomedial screw insertion affect bone-nail construct stability.

Design: This was a retrospective study.

Patients: Forty-three consecutive patients with displaced, three-part fractures of the proximal humerus treated with open, antegrade, proximal, intramedullary nailing with lock sutures were included in the study.

Intervention: All patients were classified into 4 subgroups based on the presence or absence of medial buttress restoration and inferomedial screw insertion.

Main outcome measures: We measured changes in the neck-shaft angle from immediate postoperative radiographs to the final clinical follow-up appointment. We also evaluated range of motion, the Neer score, and the American Shoulder and Elbow Surgeons (ASES) score based on shoulder examination at the final clinical follow-up. Complications were also assessed.

Results: The mean immediate postoperative and final clinical follow-up neck-shaft angles were 140.810 (SD = 9.990) and 136.530 (SD, 11.120), respectively; there was no statistical difference between groups (p = 0.000). The subgroup in which the medial buttress was not restored and inferomedial screws were not inserted, demonstrated the most negative results in neck-shaft angle change, the ASES, and the Neer score; there was a significant statistical difference found between this group and all other groups ($p<0.05$).

Conclusion: The open, antegrade, intramedullary nailing technique with locking and tension band sutures is especially effective for sharing of the medial buttress load. Medial buttress restoration and inferomedial screw insertion affect bone-nail construct stability. Additionally, at least one of these techniques should be utilized in order to prevent complications.

O7.9

Three and Four Part Humeral Head Fractures in 3-4 ASA Status Patients Treated with Closed Reduction and Percutaneous Pinning (MIROS System)

Mario Tangari[1], Stefano Carbone[2], Stefano Gumina[2], Mimmo Gallo[3], Pompeo Catania[3], Andrea Campi[3]

[1]Ospedale S. Giovanni-Addolorata, Unit of Hand Surgery, Rome, Italy, [2]University of Rome Sapienza, Orthopaedics and Traumatology, Rome, Italy, [3]Ospedale S.Giovanni-Addolorata, Orthopaedics and Traumatology, Rome, Italy

Introduction: Closed reduction and percutaneous pinning for displaced humeral head fractures offer advantages over open techniques that limit the exposure, minimizing surgical trauma and reducing the risk of necrosis. The aim of this study is to evaluate results of three and four part humeral head fractures in 3-4 ASA(American Society of Anesthesiologists)status patients treated with closed reduction and percutaneous pinning.

Materials and methods: From 2007 and 2009, 26 patients mean aged 78 years old(range:70-87)were enrolled for this study. Criteria of inclusion were three or four part displaced humeral head fracture(fractures classified radiographically following Neer's system),ASA status of 3 or 4(open reduction highly non recommended)and absence of vascular or nervous deficits. All patients were treated with the MIROS(Minimally Invasive Reduction and Osteo synthesis System)system, which consists in 4 k-wires, 2 introduced from the proximal humeral metafisis and 2 from the fragments of the humeral head, and then threatened by a single external device.Post-operatively, 30° of abduction and flexion were allowed. At a mean follow-up of 13 months(range: 8-24), patients were clinically valued with the Constant Score and a radiograph of the shoulder in two view was obtained.

Results: At the follow-up, Constant scores were 58.8 +-18 points for the injured shoulder and 68.9 +-9 points for the opposite shoulder. Reduction and healing of the fracture was good in 22 cases(84.6%); in 4 cases, resorption of the greater tuberosity was observed.

Discussion: Open reduction-internal fixation is usually recommended in displaced 2- and 3-part proximal humeral fractures, whereas hemiarthroplasty is commonly accepted for the management of 4-part fractures and complex fracture-dislocations. In our series of patients, open reduction was not possibile and only conservative treatment or percutaneous pinning was allowed. With this technique, we obtained good results with very low morbidity. The MIROS system should be considered as a valid treatment in these challenging cases.

O7.10

Reverse Total Shoulder Arthroplasty for Proximal Humerus Fractures in Patients over the Age of Seventy

Minoo Patel[1,2], Kishen Nara[1], Navin Nara[1], Bonato Luke[1]

[1]Monash University, Orthopaedic Surgery, Richmond, Australia, [2]Epworth Hospital, Orthopaedics, Richmond, Australia

Introduction: Irreparable comminuted 3 and 4 part fractures of the proximal humerus pose management challenges in the geriatric population. Results after shoulder hemiarthroplasty are often unsatisfactory with poor function. The reverse total shoulder arthroplasty does not depend upon a functional rotator cuff, has greater inherent stability and requires little formal rehabilitation. We present a series of 28 consecutive cases of reverse total shoulder arthroplasty for irreparable proximal humerus fractures in patients over 70.

Methods: Patients over 70 with irreparable proximal humerus fractures treated with a reverse total shoulder arthroplasty were included in this study. Only primary arthroplasties were included. Reverse arthroplasties for failed hemiarthroplasties were excluded. Tuberosity repair was attempted in 6 cases. Shoulders were immobilized in a sling for two weeks, and patients allowed to mobilize thereafter with minimal physiotherapy.

Results: Outcome measures used were range of motion, dislocation and revision rates radiological signs of loosening and glenoid notching, DASH and Constant scores. Results were compared to another series of cases of reverse shoulder arthroplasty for sequelae of trauma and failed hemiarthroplasties. At an average follow-up of 26 months (minimum 12 months) all patients were satisfied with their results. Average forward elevation was 132 deg., and abduction 128 deg. The average Constant score was 62. All notching had stabilized after 12 months. There were no cases of dislocation. There was no evidence of humeral stem loosening. No case needed revision, or awaits revision. All cases were pain-free at last review. Overall results for this group of primary reverse arthroplasties for fractures was much better than for reverse arthroplasties for sequelae of trauma.

Conclusions: The reverse total shoulder arthroplasty is very attractive option for elderly patients with irreparable proximal humerus fractures. They require little rehabilitation and can give reproducibly good functional results which do not deteriorate with time.

11th INTERNATIONAL CONGRESS on
SHOULDER AND ELBOW SURGERY
3rd INTERNATIONAL CONGRESS of
SHOULDER AND ELBOW THERAPISTS
EICC EDINBURGH INTERNATIONAL CONFERENCE CENTRE
5TH - 8TH SEPTEMBER 2010

M. Tangari, S. Carbone*,
S. Gumina*, M. Gallo, A. Campi

Three and four part humeral head fractures in 3-4 ASA status patients treated with closed reduction and percutaneous pinning (MIROS System)

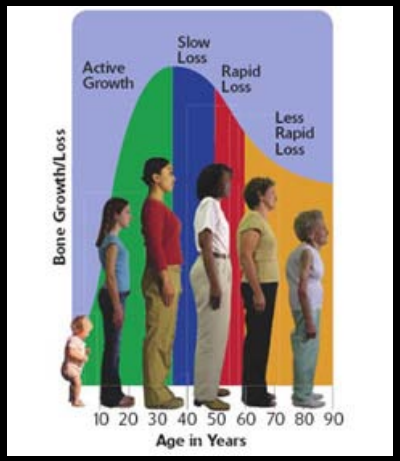
Department of Orthopaedics and Traumatology.
Azienda Ospedaliera S. Giovanni-Addolorata; * University of Rome Sapienza; Rome, Italy.

Three and four part humeral head fractures in 3-4 ASA status patients treated with closed reduction and percutaneous pinning (MIROS System)

The prevalence is 405 per 100000 population/year over the age of 70 years.

Bengner U et al. Changes in the incidence of fracture of the upper end of the humerus during a 30-year period: a study of 2125 fractures.

Clin Orthop 1988



Department of Orthopaedics and Traumatology.
Azienda Ospedaliera S. Giovanni-Addolorata; * University of Rome Sapienza; Rome, Italy.

Three and four part humeral head fractures in 3-4 ASA status patients treated with closed reduction and percutaneous pinning (MIROS System)

Elderly patients ask for performing activities of daily living

1°
For first

Conservative treatment for 3-4 fragment humeral head fractures: poor results

2°
Secondary

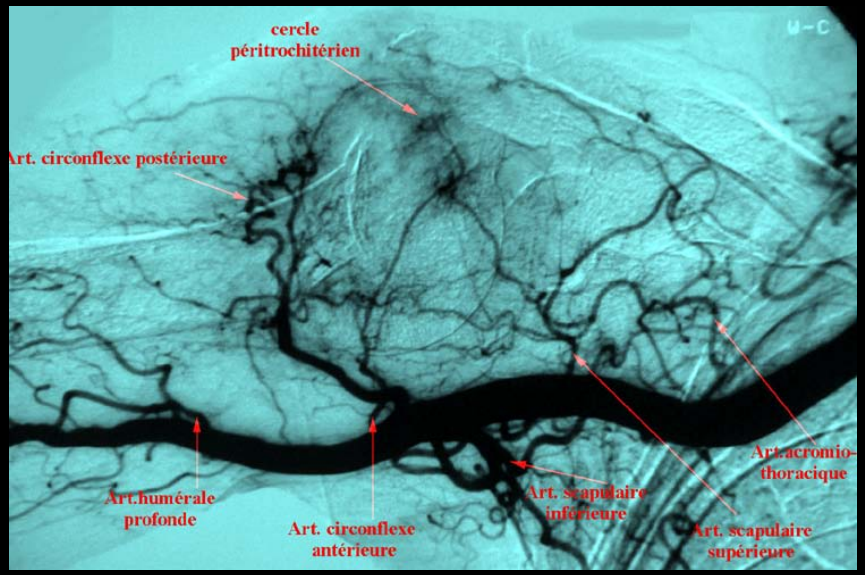
BUT…
there is no consensus on the type of surgical fixation that should be used.

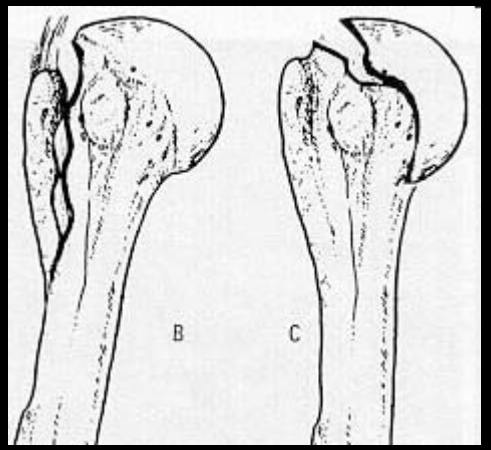
Department of Orthopaedics and Traumatology.
Azienda Ospedaliera S. Giovanni-Addolorata; * University of Rome Sapienza; Rome, Italy.

Three and four part humeral head fractures in 3-4 ASA status patients treated with closed reduction and percutaneous pinning (MIROS System)

Recently, a better knowledge of the vascular anatomy of the humeral head and of the extent of the periosteal tears for various fracture patterns, has brought head salvage procedures with reconstruction and osteosynthesis more to fore.

Resch et al. Injury 2001; 32: 25-32.
Resch et al. J Shoulder Elbow Surg 1995; 4: 73-80.
Resch et al. Surg Tech Orthop Traumatol 2000; 55: 170-B-10.

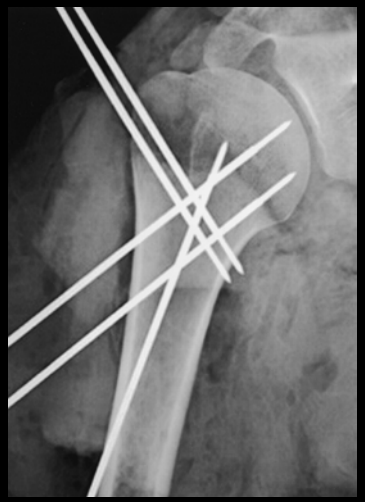


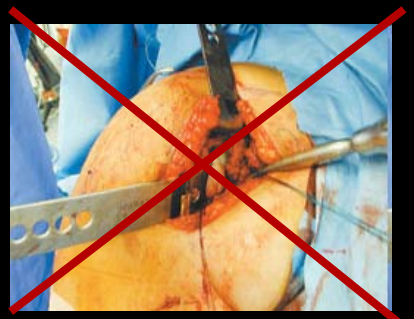


Department of Orthopaedics and Traumatology.
Azienda Ospedaliera S. Giovanni-Addolorata; * University of Rome Sapienza; Rome, Italy.

Three and four part humeral head fractures in 3-4 ASA status patients treated with closed reduction and percutaneous pinning (MIROS System)

Surgical trauma is minimised with percutaneous pinning. ⟶
Less blood loss and scar tissue and better preservation of fracture biology ⟶
Consider these elements when treating patients with precarious anaesthesiologist conditions, such as 3-4 ASA (American Society of Anaesthesiologist) status patients.





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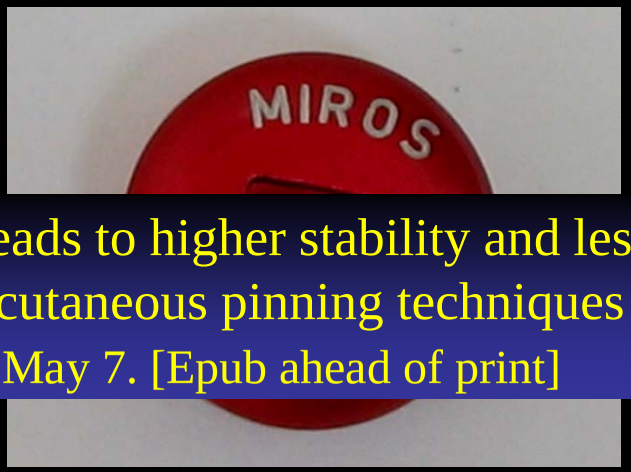
Three and four part humeral head fractures in 3-4 ASA status patients treated with closed reduction and percutaneous pinning (MIROS System)

Minimally Invasive Reduction and Osteosyntesis System



Externally locked modified K-Wires leads to higher stability and less complications compared to simple percutaneous pinning techniques
Blonna et al. J Shoulder Elbow Surg 2010 May 7. [Epub ahead of print]

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Objective of the study

To evaluate results after closed reduction and percutaneous fixation of three and four parts humeral head fractures in 3-4 ASA (American Society of Anaesthesiologist) status patients using the MIROS system

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Azienda Ospedaliera S. Giovanni-Addolorata; * University of Rome Sapienza; Rome, Italy.

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Materials and method

Characteristic	Data
No. of patients	31*
Gender (men/women)	2/29
Mean age (time of injury)(range)	79.3 (68 to 93)
Dominant extremity	17/31
Mechanism of injury	
-fall while walking	25
-road traffic accident	6

*= of 157 total patients referrred in our Emergency Department between 2007 and 2009

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- Mean time between injury and surgery 1.9 day (1 to 4)
- No pre operative vascular or nervous defect

Imaging

If possible

+

+

Pre-operatively and
at each follow-up
(1,3,6 and 12 months)

Fractures were classified according to the Neer classification

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Operative technique (previous brachial plexus block)

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Depending on the degree of stability achieved,
active mobilization of the elbow and 20°-30° passive and active abduction and forward elevation of the arm is started on the first post-operative day.

After five to six weeks the k-wires are removed, usually under partial sedation of the patients, in no cases under brachial plexus block or total anaesthesia.

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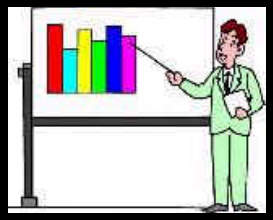
Final follow-up: 1 year

Objective evaluation of the shoulder: Constant Score
Rx views: Ap, transthoracic, axillary (if possible)
Patients asked whether satisfied or not with the results.



Statistical analysis: Chi-square test ($p<0.05$ significant)

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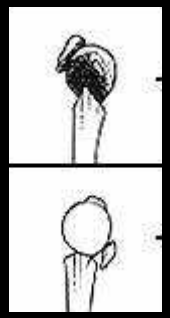
Results

Average operation time was 27.3 minutes (range: 10-44)
No cases of intra-operative complications.
Mean fluoroscopy time was 76 seconds (range: 32-125)

3 patients died at the final follow up leaving 28 fractures available for the study.
Of the 28 fractures, 17 were three-part and 11 were four-part fracture.



Injured side CS= 61.6

Uninjured side CS= 70

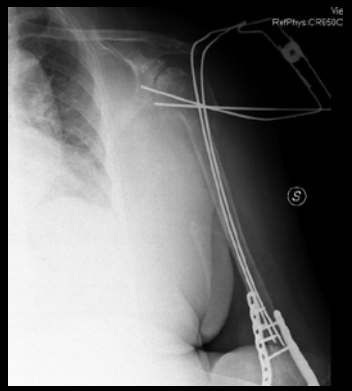
Injured side CS= 53

Uninjured side CS= 72

Fifteen of the 17 patients with three-part humeral head fracture (88.2%) and eight of the 11 patients with four-part humeral head fracture (72.7%) were satisfied of the final result.

Three and four part humeral head fractures in 3-4 ASA status patients treated with closed reduction and percutaneous pinning (MIROS System)

Complications



Perforation of the articular surface 1 case (3.5%)

Three cases of resorption of the greater tuberosity (10.7%)

Humeral head osteonecrosis in two cases (of the 28, 7.14%).

No case of infection

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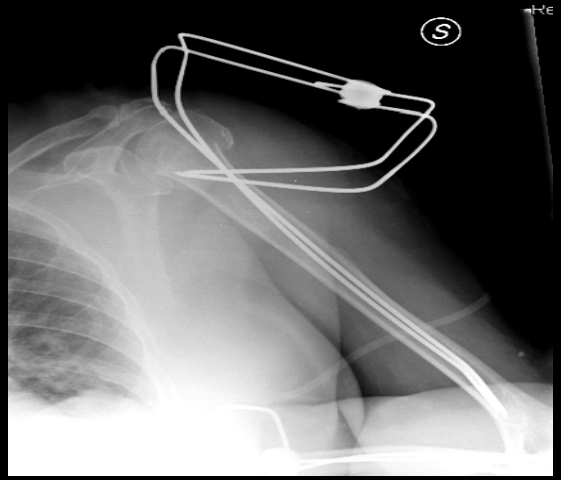
Three and four part humeral head fractures in 3-4 ASA status patients treated with closed reduction and percutaneous pinning (MIROS System)

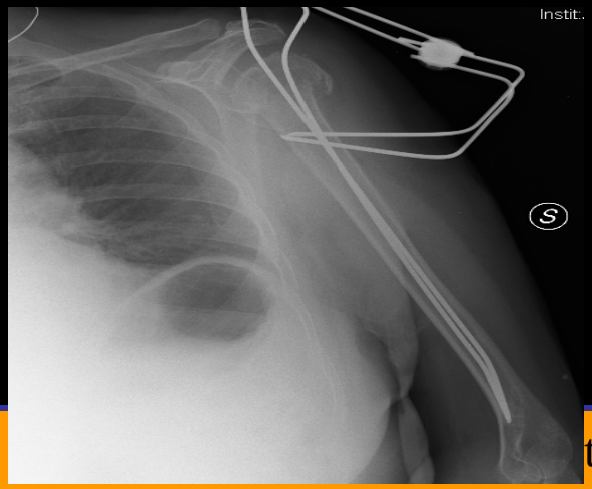
Clinical cases: 1

Pre

Post



One month



Final result

tment of Orthopaedics and T
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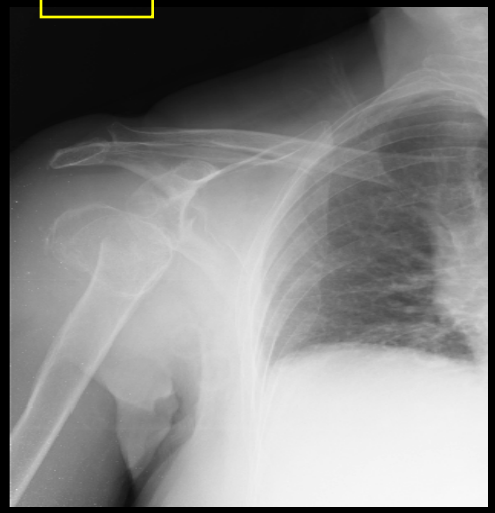
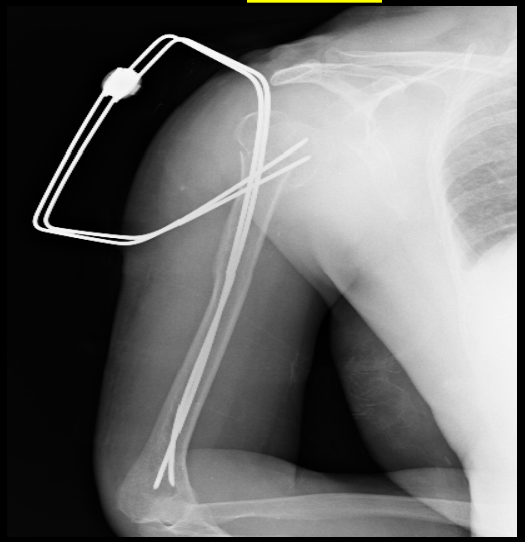
Three and four part humeral head fractures in 3-4 ASA status patients treated with closed reduction and percutaneous pinning (MIROS System)

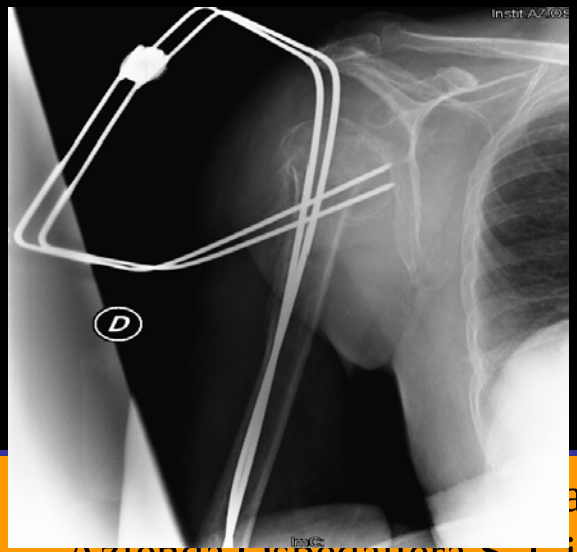
Clinical cases: 2

Pre



Post





One month

Final result: clinically good despite Rx images

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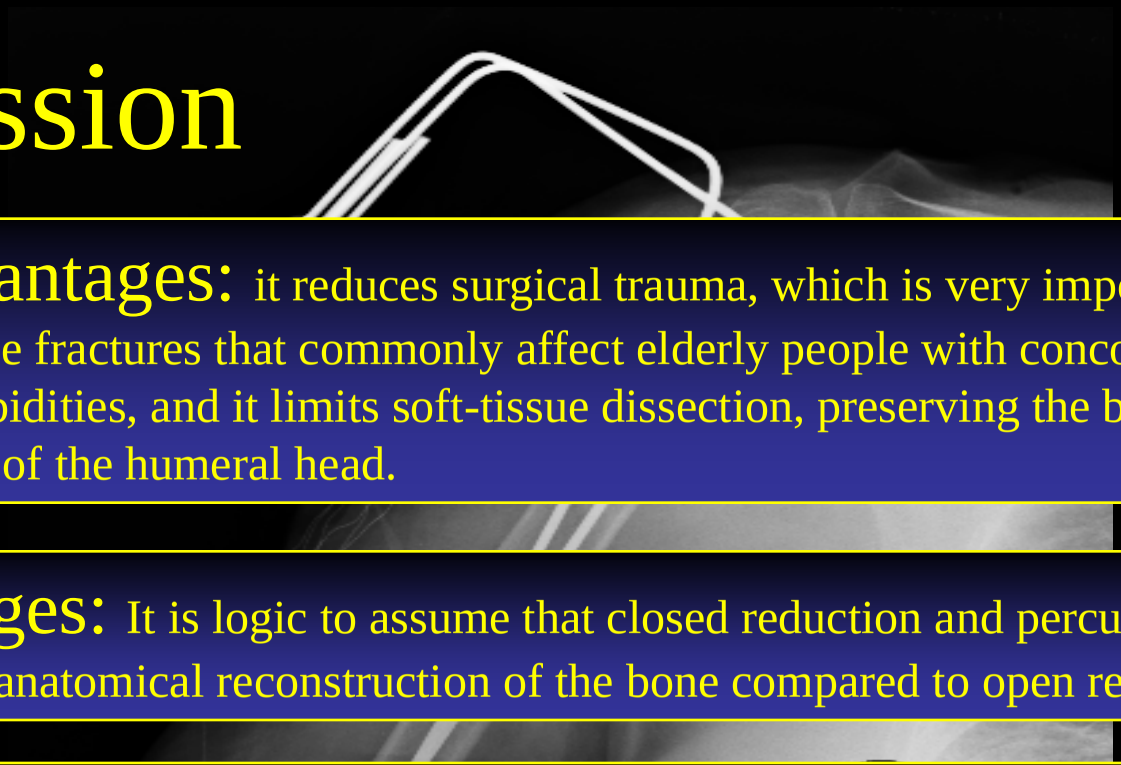
Discussion



Advantages: it reduces surgical trauma, which is very important in these fractures that commonly affect elderly people with concomitant comorbidities, and it limits soft-tissue dissection, preserving the blood supply of the humeral head.

Disadvantages: It is logic to assume that closed reduction and percutaneous pinning allows to a lower anatomical reconstruction of the bone compared to open reduction

In elderly people, it does not importantly constitute a major drawback, because satisfactory results can be achieved without fully reconstructing the anatomy of the proximal humerus.

Resch et al. J Bone Joint Surg (Br) 1997; 79: 295-300.
Jaberg et al. J Bone Joint Surg Am 1992; 74: 508-14.
Neer CS. J Bone Joint Surg Am 1970; 52: 1090-103.
Young et al. J Bone Joint Surg Br 1985; 67: 373-7.

Three and four part humeral head fractures in 3-4 ASA status patients treated with closed reduction and percutaneous pinning (MIROS System)

The technique of closed reduction and percutaneous pinning with the MIROS system has demonstrated to be a valid treatment option in elderly patients with a precarious anaesthesiologic condition and a concomitant reduced bone mass.

The MIROS technique does not need long operative and fluoroscopy time. In fact, in our series, those time were respectively about 27 and 1.12 minutes, similar to Resch's Humerusblock technique, but much lower that what has been reported for open reduction and fixation (operative time: 87-110 minutes).

Three and four part humeral head fractures in 3-4 ASA status patients treated with closed reduction and percutaneous pinning (MIROS System)

The angular stable k-wire fixation allows for retention of reduction with a high percentage (88.2% and 72.7%) of satisfaction of patients.

Postoperative rates of avascular necrosis is lower than that reported after non operative treatment or open reduction and internal fixation.

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Azienda Ospedaliera S. Giovanni-Addolorata; * University of Rome Sapienza; Rome, Italy.

Thank you

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