
ORIGINAL ARTICLE

Osteosynthesis of three parts valgus-impacted proximal humeral fractures: comparison between deltoid-pectoral approach and minimally invasive transdeltoid

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ABSTRACT

BACKGROUND: Proximal humerus fractures are widespread injuries. They are the third most common non-vertebral fracture pattern in older patients with osteoporotic bone. The treatment of these fractures is often tricky, and indications constantly evolve. Among the various possible surgical options, plate osteosynthesis is the most used. In addition to the traditional deltopectoral approach, a minimally invasive technique (minimally invasive plate osteosynthesis [MIPO]) is introduced. This retrospective case-control study compared these two approaches' clinical outcomes and complications. **METHODS:** From June 2015 to June 2020, 36 patients (28 women, 8 men) with a mean age of 62.26 years (range: 41-80) were surgically treated for three parts valgus-impacted proximal humeral fractures. Twenty patients were treated with open reduction-internal fixation (ORIF), while 16 patients were with MIPO. Surgical time, functional scores (the Constant-Murley, the Simple Shoulder Test, and the Disabilities of the Arm, Shoulder, and Hand Scores), ROM and complications were used to compare these two different procedures.

RESULTS: Thirty-six patients were available for clinical evaluation at a mean follow-up of 16.03 months (6-33 months). We found three complications in our study, all in patients treated with ORIF. The mean surgery time was 103.53 minutes: MIPO required less surgery time (mean 93.64, range 57-150, SD±26.273) than ORIF *via* deltopectoral approach (mean 110.45, range 46-255, SD±51.316). The SST, CS and DASH were higher in the MIPO group, but there was not a statistically significant difference. Likewise, no significant differences from a statistical point of view were found in the range of motion values by comparing the two types of intervention. However, patients in the MIPO group have experienced a greater ROM.

CONCLUSIONS: Several options are available for the treatment of proximal fractures of the humerus. However, no standardized treatment algorithm based on scientific evidence is currently in the literature. According to the analysis of the results, the surgical treatment of three parts proximal humeral fractures impacted in valgus shows good clinical re-

sults. The MIPO technique is safe and offers good clinical outcomes comparable to the traditional technique. A significant superiority of a procedure does not emerge compared to the other in treating this type of fracture.

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KEY WORDS: Humeral fractures; Bone plates; Minimally invasive surgical procedures; Open fracture reduction.

Proximal humerus fractures are widespread injuries; they can be caused by direct or indirect trauma. Their higher incidence is in the elderly age (caused by low energy trauma, while at a young age, these fractures are caused by high energy trauma).¹ They are the third most common non-vertebral fracture pattern in older patients with osteoporotic bone and the second most common type of fracture in the arm.¹⁻⁴ Proximal humerus fractures are 10% of the fractures in the population with the age >65 years, while they are 4.5-7% of all the fractures.⁵⁻⁸ They are more common in females.⁹ Treating proximal humerus fractures is often tricky, and indications are constantly evolving. About 80% of these fractures are caused by low-energy trauma, and they are minimally displaced. In this case, conservative treatment is the first choice.^{10, 11} Surgery treatment is the choice for the remaining 20%. The main aims of the surgical treatment of proximal humerus fractures are the early mobilization of the limb, essential for functional recovery of the shoulder, and the restoration of the anatomy as normal as possible. The type of fracture, the quality of the bone tissue, the patient's general condition, and his functional requests must be considered for the therapeutic choice. The specific competence and experience of the surgeon are equally important. Plate osteosynthesis is the most used among the various possible surgical options.¹² Despite improving surgical techniques and implants, failures and complications are not yet negligible. In addition to the traditional deltopectoral approach, a minimally invasive procedure (minimally invasive plate osteosynthesis [MIPO]) was introduced.¹³ This surgical approach is based on biological healing processes respected and a more straightforward reduction of humeral tuberosities.¹⁴ Also, to achieve the best clinical results, an adequate function of the rotator cuff is desirable and could be assessed by means of an ultrasound

examination.^{15, 16} In this retrospective study, the results of treatment with angular stability plate and screws of 3-part valgus impacted fractures of the proximal humerus were evaluated by comparing the clinical outcomes of patients treated with traditional intervention *via* deltopectoral approach *versus* patients treated with minimally invasive surgery *via* trans-deltoid access (MIPO), at the Department of Orthopedics and Traumatology of the ASST Sette Laghi in the hospitals of Varese and Cittiglio.

Materials and methods

This was a retrospective case-control study including two groups of patients. Between June 2015 and June 2020, 45 patients were surgically treated for displaced proximal humerus fractures in Varese and Cittiglio Hospital, Orthopedics and Traumatology of ASST Sette Laghi, University of Insubria. Three-part valgus-impacted proximal humeral fracture is the only pattern of fracture considered in this study. Only the data of 36 patients are available because 9 did not participate in the follow-up. Of 36 patients, 20 were treated with ORIF *via* a traditional deltopectoral approach, while 16 were treated with MIPO *via* an anterolateral deltoid splitting approach. 8 Arthrex plates and 2 ALPS plates (Zimmer Inc., Warsaw, IN, USA) were used for the traditional approach, while 16 NCB plates were used for the MIPO *via* anterolateral deltoid splitting approach. For both groups, patients were positioned in the beach chair position and performed under general anesthesia. In the first group, ORIF was performed using a standard deltopectoral approach. The incision of 10-15 cm started at the tip of the coracoid process and ran laterally in the direction of the insertion of the deltoid muscle on the humerus. It followed the line of the deltopectoral groove, splitting the two muscles apart

and exposing the conjoined tendon of the short head of the biceps and coracobrachialis muscle. After that, it was necessary to incise the fascia on the lateral aspect of the conjoined tendon. Care should be taken when placing the retractors on the medial aspect to avoid excessive traction on the vascular structures and nerves near the shoulder. The long head of the biceps, anterior to the humeral head, is a key reference point to verify the correct reduction of the fracture's fragments. A moderate abduction of the limb allows retraction of the deltoid muscle exposing the humeral head. In the second group, the anterolateral deltoid splitting approach, the incision started at the lateral acromial border and ended distally 5 cm. The area between a line 5 cm distal to the tip of the acromion and another 7 cm distal contained the axillary nerve and was considered the unsafe zone. The deltoid muscle was split along the anterior rafe. The axillary nerve was palpated on the deep surface of the deltoid approximately 2-3 cm below the inferior end of the wound (Figure 1). At discharge, a sling was prescribed for all the patients. They could remove it during physiotherapy, clothing, and personal hygiene. In the beginning, only pendular and passive movements were allowed. Patients were evaluated with a radiological study, in the postoperatory, at one, two, six months, and one year after the surgery. Clinical evaluation was performed us-

ing the Simple Shoulder Test (SST) and the Constant-Murley Score (CS) for all the patients and the Disabilities of the Arm, Shoulder, and Hand Score (DASH) for twenty-two patients.¹⁷⁻²¹ Also, the surgical time was evaluated, comparing it to the two different techniques.

Statistical analysis

Data were analyzed with IBM SPSS statistics 24.0 software (IBM Corp., Armonk, NY, USA). Descriptive statistics (in particular frequency tables) were used to describe the information. P values <0.05 were considered statistically significant.

Results

Thirty-six patients were available for the study at a mean follow-up of 16.03 (range 6-33 months, $SD \pm 8.159$), in particular, 11.43 months for MIPO technique (range 6-26, $SD \pm 7.398$) and 19.25 for the ORIF technique (range 6-33, $SD \pm 7.188$). The average age of the patients was 62.26 years (range 41-80 years, $SD \pm 9.173$); 52.9% of the patients had an age between 41 and 61 years, while the 47.1% were between 61 and 80. 28 patients were female (77.8%), and 8 were male (22.2%). Fractures involved the right shoulder in half of the patients; the dominant arm was involved in 19 patients (52.77%) (Supplementary Digital Material 1: Supplementary Table I). Our

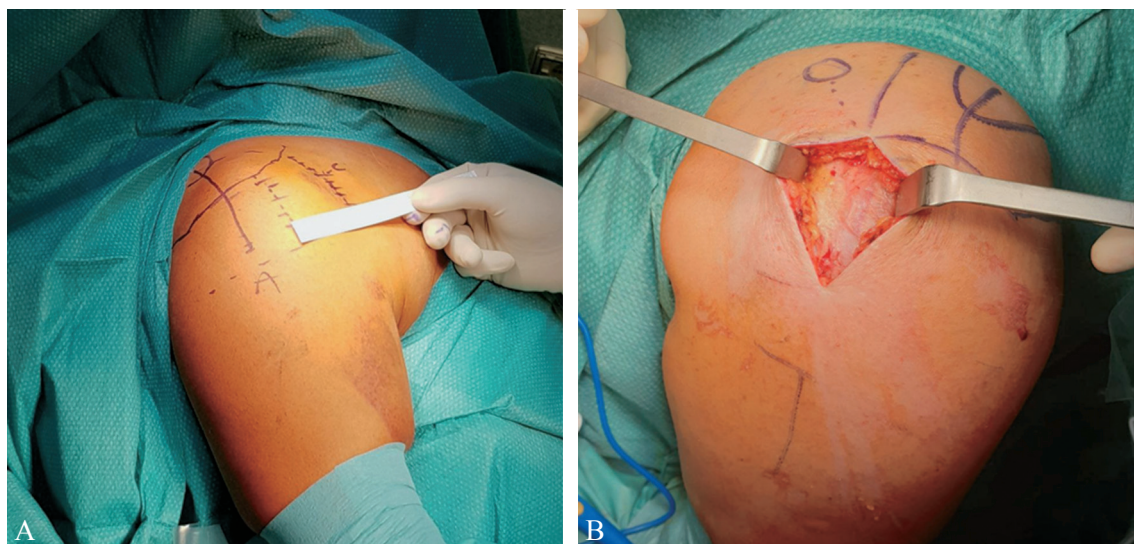


Figure 1.—A) Marked safe and unsafe zones; B) the anterolateral deltoid splitting approach.

study did not see major complications, such as infection, implant failure, axillary nerve injury, malunion, non-union or avascular necrosis. No intraoperative complications occurred. Only one early complication – a homolateral axillary vein thrombosis – was found. One patient was surgically treated with a side-to-side suture of the supraspinatus tendon six months after the trauma. Only a patient had a range of motion limitation (diagnosed as adhesive capsulitis) one year after the surgery. All these complications occurred in the group of patients treated with the deltopectoral approach. The complication incidence of our study was 8.3%. The mean surgery time was 103.53 minutes (range 46-255 minutes, SD±43.230): 58.8% of the surgeries lasted between 46 and 104 minutes, and the remaining surgeries lasted between 105 and 255 minutes. MIPO required less surgery time (mean 93.64, range 57-150, SD±26.273) than ORIF *via* deltopectoral approach (mean 110.45, range 46-255, SD±51.316), but there was not a statistically significant difference between the two techniques (P value 0.223) (Figure 2). The SST, CS and DASH were higher in the MIPO group, but there was not a statistically significant difference. In particular, the average score of SST was 9.69 for all the patients (range 3-12), 9.81 (range 3-12, SD±2.588) for the MIPO group, and 9.60 (range 6-12, SD±1.847) for the ORIF group (P value 0.784). The average score of CS was 71.31 (range 39-95) for all the patients, 73.25 (range 51-95, SD±13.339) for the MIPO group and 69.75 (range 39-85, SD±13.494) for the ORIF group (P value 0.442). The average score of DASH was 40.32 (range 30-63) for all the patients, 38 (range 30-54, SD±8.155) for the MIPO group and 41.92 (range 30-63, SD±12.868) for the ORIF group (P value 0.392). Statistical analysis revealed a significant correlation between the female gender and worse CS and SST in the

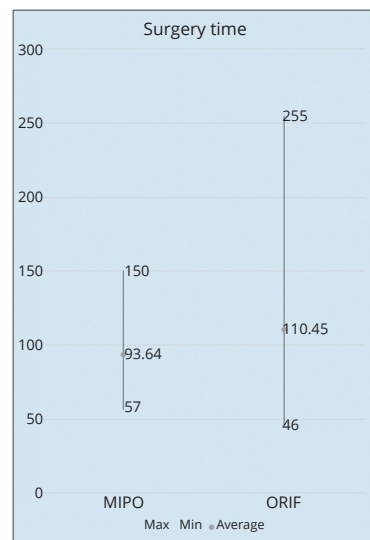


Figure 2.—Range and the average of the surgery time in MIPO and ORIF groups.

traditional group (SST P value 0.010; CS P value 0.021) (Table I; Figure 3). Patients in the MIPO group experienced a more excellent range of motion, but there was not a statistically significant difference. In particular, the mean active elevation was 148.35 for MIPO and 140.25 for ORIF; the mean passive elevation was 158.75 for MIPO and 152.5 for ORIF. Mean abduction was 141.80 for MIPO and 135.75 for ORIF. IR was 5.19 for MIPO and 5.35 for ORIF; ER was 39.06 for MIPO and 38.50 for ORIF (Table II; Figure 4).

Discussion

Our study aims to compare two techniques, MIPO and ORIF, in treating three parts impacted in valgus proximal humerus fracture. Other authors compared the two techniques, but none of them compared ORIF and MIPO by a fracture pattern. The MIPO technique obtained satisfactory clinical and radiologic outcomes in proximal humeral

TABLE I.—Data of functional scores in the study.

	Surgical technique				P value
	MIPO		ORIF		
	Average±SD	Range	Average±SD	Range	
SST	9.81±2.588	3-12	9.60±1.847	6-12	0.784
CS	73.25±13.339	51-95	69.75±13.494	39-85	0.442
DASH	38.00±8.155	30-54	41.92±12.868	30-63	0.392

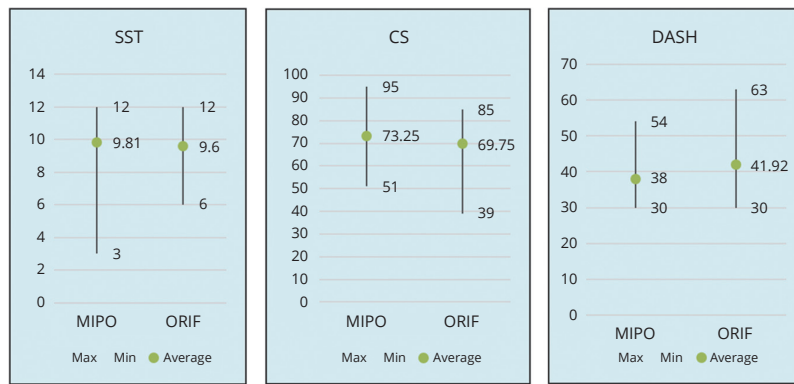


Figure 3.—Range and the average of SST, CS, and DASH in MIPO and ORIF groups.

TABLE II.—Data of ROM in the study.

ROM	Surgical technique				P value
	MIPO		ORIF		
	Average±SD	Range	Average±SD	Range	
AE	148.13±31.458	90-180	140.25±37.783	75-180	0.500
PE	158.75±29.441	100-180	152.50±31.393	75-180	0.543
IR	5.19±0.655	4-6	5.35±1.040	2-6	0.572
ER	39.06±19.682	0-60	38.50±14.699	15-60	0.925
Abduction	141.88±36.918	80-180	135.75±35.440	90-180	0.618

fractures, but this is not true for all patterns of fractures; the MIPO technique for 4-part fractures showed relatively inferior results compared with 2- and 3-part fractures. Fracture patterns had the most significant impact on the incidence of complications.²² The incidence of postoperative complications in treating proximal humerus fractures is between 10 and 34%.²³ In our study, the incidence was lower. In literature, the most frequent complications are intra articular screw penetration (9.5%), followed by secondary displacement, varus collapse (6.8%), subacromial impingement (5.0%), AVN (4.6%), adhesive capsulitis (4.0%), non-union (1.5%) and deep infection (1.4%). Reoperation occurred at a rate of 13.8%.²³⁻²⁷ The most dangerous complication is axillary nerve injury. In our study, there was no axillary nerve injury, whereas, in other studies, the incidence of this complication is between 1 and 4%.^{28, 29} To minimize the risk of this complication, the proximal incision should be 5 cm because the axillary nerve is located 6.1 cm±0.7 from the acromion.³⁰⁻³² Many studies indicate that, compared to ORIF, MIPO had advantages in functional outcomes, operation time, blood loss, postoperative pain, and fracture union time for

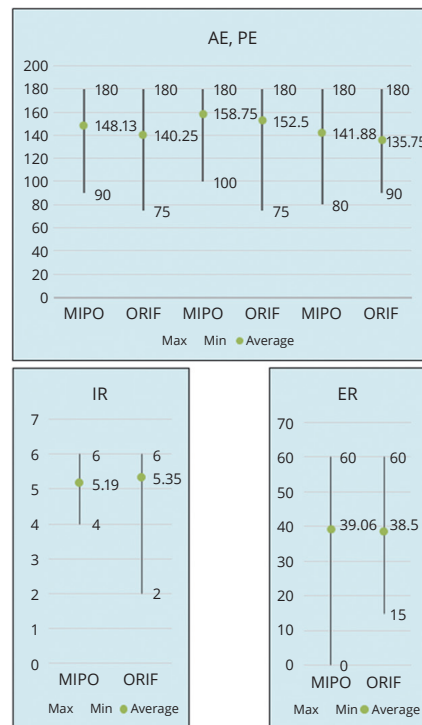


Figure 4.—Range and the average of ROM Internal rotation: lateral aspect of the thigh (0), behind the buttock (2), sacroiliac joint (4), waist (6), 12th thoracic vertebra (8), interscapular level (10).

treating proximal humerus fractures. However, the MIPO technique had a higher rate of axillary nerve injury and longer radiation time than ORIF. In many studies, MIPO patients had better functional results at 3 and 6 months, with better outcomes, less pain, higher satisfaction in activities of daily living, higher range of motion, and higher CS, DASH, and SST when compared to ORIF. The results become comparable in one year.^{23,33-36} These results could be due to shorter surgical time, less adhesion and better soft tissue management.³³ MIPO for proximal humeral fractures is an effective and safe surgical procedure. The limited tissue dissection minimizes the incidence of non-union, avascular necrosis, and infection. The technique is not easy, requires experience to achieve mastery, and should be reserved for selected fracture patterns. Furthermore, this approach's advantage is direct access to the greater tuberosity, thus facilitating its anatomic reduction and fixation.³⁰ This direct approach to the proximal humerus may minimize iatrogenic vascular injury when treating these fractures. MIPO of humerus proximal fractures allows the preservation of blood supply in fracture fragments, owing to less soft tissue and periosteal injury.³⁷⁻⁴⁰ In our study, the operation time is better in the MIPO group, but there is not a statistical difference between the two techniques, although there is a difference of 16.81 minutes. Our study detected a significant difference in clinical results according to gender; women showed worse outcomes than men. Thus, it must be highlighted that this difference might be biased by the small sample size and the numerical disparity between the two groups.³⁰ In many studies, there is a follow-up at 3, 6 and 12 months; on the contrary, in our research, we have done only a valuation, and the follow-up time is different between patients. This did not allow us to highlight the superiority of MIPO to ORIF in faster and better recovery. However, in our study, the range of motion and clinical scores are better in the MIPO group, although the differences are not statistically significant.

Conclusions

Several options are available for the treatment of proximal fractures of the humerus. However,

no standardized treatment algorithm based on scientific evidence is currently in the literature. According to the analysis of the results, the surgical treatment of three parts proximal humeral fractures impacted in valgus shows good clinical results. The MIPO technique is safe and offers good clinical outcomes comparable to the traditional technique. A significant superiority of a procedure does not emerge compared to the other in treating this type of fracture. New studies are desirable to create standardized guidelines.

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Conflicts of interest.—The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Authors' contributions.—Sergio Ferraro and Michele F. Surace have given substantial contributions to study conception and design; Michele F. Surace, Felice Buggè, Dario Felotti, Luca Faoro and Mattia Corti contributed to data acquisition, analysis, and interpretation; Dario Felotti and Mattia Corti contributed to the manuscript draft, Michele F. Surace and Giorgio Ippolito revised it critically. All authors read and approved the final version of the manuscript.

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