Belangero-Livani Technique (MIPO) in the Treatment of Humeral Shaft Fractures. A Latin American Experience in Three Medical Centers

Pablo Enriquez Romo,[*] Jesús Palacios Fantilli,[**] Paulo C. Faiad Piluski,[#] Carlos H. Castillo Rodriguez,[#] Osvandré Lech[#]
[*]Shoulder and Elbow Surgery Service, "Manuel Ygnacio Monteros" General Hospital, Loja, Ecuador
[**]Hospital de Clínicas, School of Medical Sciences, Universidad Nacional de Asunción, Paraguay
[#]Shoulder and Elbow Surgery Service, São Vicente de Paulo Hospital Medical Residency, Institute of Orthopedics and Traumatology, Passo Fundo, Brazil

ABSTRACT

Objective: To determine the demographic data of the patients in relation to age, sex, profession, affected side, single or multiple lesions, type of material used, bone healing time and possible complications of the treatment of diaphyseal fractures of the humerus treated using the MIPO technique in a series of patients from three hospital units in Ecuador, Paraguay, and Brazil. **Materials and Methods:** A retrospective, longitudinal, observational study of data from 133 patients collected in 3 services in Quito, Ecuador; Asunción, Paraguay; and Passo Fundo, Brazil. The distributions between different services were compared using Pearson's chi-square test. **Results:** The age of the patients ranged from 17 to 76 years, with a mean of 36 years. The median time to union, which occurred in 126 of the 132 patients, was 11 weeks. Most of the patients were male (70.45%), the right side was the most affected (55.3%), most of the fractures were single (85.61%), consolidation occurred in 95.45 % of cases, complications occurred only in 9.09% of patients, 6.82% of them were severe. In relation to complications, they were divided according to the absence (87.12%) or presence of the following: post-surgical neuropraxia (0.76%), infection (3.03%), and pseudarthrosis (4.55%). **Conclusion:** The MIPO technique for the treatment of diaphyseal fractures of the humerus presents low rates of complications and morbidity, demonstrating good rates of consolidation.

Keywords: Humeral shaft fracture; internal fixation; MIPO technique.
Level of Evidence: IV

Técnica de Livani-Belangero (MIPO) en el tratamiento de las fracturas diafisarias de húmero. Experiencia latinoamericana en tres centros hospitalarios

RESUMEN

Objetivo: Evaluar los datos demográficos, como edad, sexo, profesión, lado afectado, lesión única o múltiple, tipo de material utilizado, tiempo de cicatrización ósea y posibles complicaciones de los pacientes con fracturas diafisarias de húmero tratados mediante la técnica MIPO en tres Servicios hospitalarios de Ecuador, Paraguay y Brasil. **Materiales y Métodos:** Estudio retrospectivo, longitudinal, observacional de los datos de 133 pacientes recolectados en tres Servicios en Quito (Ecuador), Asunción (Paraguay) y Passo Fundo (Brasil). Se compararon las distribuciones entre diferentes Servicios mediante la prueba x^2 de Pearson. **Resultados:** La edad de los pacientes varió entre 17 y 76 años, con una media de 36 años. El tiempo promedio hasta la consolidación fue de 11 semanas (126 de 132 pacientes). Predominó el sexo masculino (70,45%), el lado derecho era el más afectado (55,3%), la mayoría de las fracturas eran únicas (85,61%), se logró la consolidación en el 95,45%. Solo el 9,09% tuvo complicaciones y el 6,82% fueron severas. El 87,12% no tuvo complicaciones; el 0,76% sufrió neuropraxia posquirúrgica; el 3,03%, infección y el 4,55%, seudoartrosis. **Conclusión:** Con la técnica MIPO para el tratamiento de las fracturas diafisarias de húmero, se logran bajas tasas de complicaciones y de morbilidad, y buenas tasas de consolidación.

Palabras clave: Fractura diafisaria de húmero; fijación interna; técnica MIPO.
Nivel de Evidencia:IV

Received on January 18th, 2022. Accepted after evaluation on March 15th, 2022 • Dr. PABLO ENRIQUEZ ROMO • pablenq@gmail.com https://orcid.org/0000-0002-2327-0025

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INTRODUCTION

Currently, there are several treatment methods for humeral shaft fractures, either through surgical or non-surgical procedures. Conventional surgical methods to resolve humeral shaft fractures are not exempt from complications during and after the procedure.[1,2,3,] Most of these complications are related to the technique and others to the risks of surgical exposure.[2] On the other hand, there is a growing interest in publications on minimally invasive plate osteosynthesis (MIPO) in humerus fractures, in order to reduce complications and improve the rate of union.[1,2,3,4]

The method of choice for the current treatment of closed humerus fractures remains controversial. Thus, the non-surgical approach results in non-union rates of 12%. The use of the conservative method requires a prolonged period of immobilization, which generates tissue atrophy, and, in some cases, leads to prolonged physiotherapy treatment.

On the other hand, conventional surgical treatment has the apparent advantage of providing the patient with early range of motion, which reduces the risk of non-union and allows a quicker return to activities.[2,4,5-6] Among the advantages offered by this method, a higher degree of functionality of the elbow and shoulder joints can be mentioned. Regarding the disadvantages, the most problematic is the extensive deperiostization that alters the microcirculation and increases the risk of non-union, also associated with an increased risk of iatrogenic injury to the radial nerve.[7,8,11]

The objective of this study is to communicate the experience obtained in the treatment of humeral shaft fractures using the MIPO technique, with a focus on determining the average times to obtain radiologically visible consolidation and the possible complications that may arise during the procedure and after it.

MATERIALS AND METHODS

An observational, longitudinal, retrospective study was carried out. The data were collected in three services: one from Quito, Ecuador; another from Asunción, Paraguay; and the third from Passo Fundo, Rio Grande do Sul, Brazil.

Sampling by trial was carried out by the main authors, strictly adhering to the following inclusion criteria: patients with a humeral shaft fracture, treated using the MIPO technique in the participating hospitals, and with closed type 12A, 12B, or 12C (AO/OTA classification) fractures confirmed by radiographic evaluation, whose treatment had started up to 20 days after trauma.

We included skeletally mature patients aged 18 to 70 years with closed or open humeral shaft fracture who had undergone the MIPO technique performed by the researchers between 2016 and 2020, and whose minimum follow-up was 6 months and had complete health records.

Patients with a diaphyseal fracture with joint extension, a pathological fracture, previous surgery in the ipsilateral segment, a fracture whose treatment had started three or more weeks after trauma, or concomitant associated fractures in the ipsilateral limb were excluded. Those with disabling neurological or psychiatric disorders or who had not completed a follow-up of at least 6 months were also excluded.

Surgical technique

The patient is placed in the supine position under general anesthesia with a plexus block. Antibiotic prophylaxis with 1 g of intravenous cefazolin is administered shortly after anesthetic induction.

The surgical technique used follows that described by Livani and Belangero.[14] Proximal access was made 5 cm between the lateral border of the biceps brachii muscle and the deltoid tendon, thus exposing the proximal humeral diaphysis. In sequence, the distal access is also made 5 cm on the anterior aspect of the distal arm, 3 cm from the elbow crease. After the skin incision, the biceps brachii is retracted medially, exposing the brachialis muscle which is bluntly retracted (Figure 1).[12]

Figure 1. Sequence of steps to measure and place the plate on the anterior aspect of the humerus using the MIPO technique.

After making an extraperiosteal tunnel between the two incisions with a blunt dissection instrument, the plate is slid percutaneously from distal to proximal, and reduction is carried out aided by radioscopy.[12]

Narrow 4.5 mm dynamic compression plates with 12 to 14 holes are used. The plate is placed on the anterior surface of the humerus. (Figure 2).

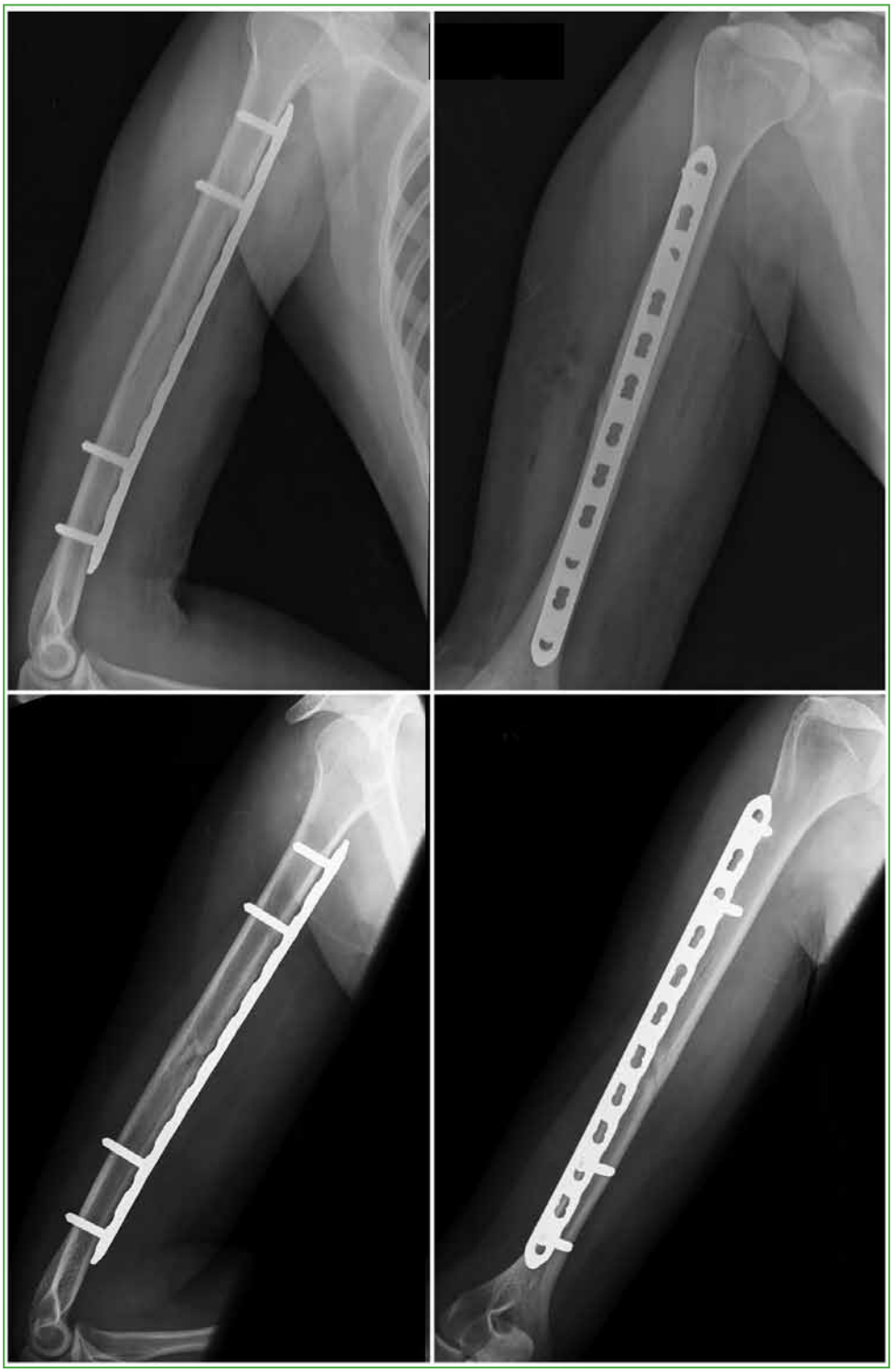

Figure 2. Post-surgical fixation with tolerable reduction. At follow-up, complete consolidation is seen.

Statistical analysis

Numerical variables are described with measures of central tendency, and categorical variables with absolute frequency. The distributions of sex, dominance, fracture type, implant type, success rate (i.e. union without complications), and complications were compared between different Services using Fisher's exact test. Age was compared between the different Services using the one-way analysis of variance (ANOVA). Factors potentially associated with success and complications were evaluated using two binary logistic regression models.

The information was collected through independent Excel spreadsheets for each hospital center with the chosen variables. This information was handled solely by the authors, preserving data confidentiality.

Postoperative management

The use of a sling was indicated for two weeks, and its removal was allowed three times a day for passive elbow range of motion. At the end of the second week, the removal of the sling was authorized and passive motion was indicated, with an increase in active motion in the third week and progressive gain of the motion arcs. Strengthening work was indicated after three months. The return to work depended a lot on the activity of the patients, it was early in the case of office workers (a month and a half) or late in the case of manual workers (2 or 3 months depending on whether there was consolidation). The return to sports was allowed once complete consolidation was achieved and after at least three months of convalescence (Figure 3).

The radiographic evaluation was carried out by the shoulder and elbow fellowship team made up of three medical specialists. Cortices with bone callus formation were considered to determine consolidation or resorption of the edges without consecutive advancement for non-union.

Figure 3. Clinical images of functional outcomes at the end of follow-up.

RESULTS

The age of the patients ranged between 17 and 76 years, with a mean of 36 years. The mean time to union (126 of 132 patients) was 11 weeks (range 6-36). (Table 1).

Table 1. Measures of central tendency and dispersion of numerical variables

Variable	Minimum	Median	Mean	Maximum	Standard deviation
Age (years)	17	35	36.23	76	13.67
Time to union (weeks)	6	11	11.45	36	3.67

Most of the patients were male (70.45%), the right side was the most affected (55.3%), most of the fractures were single (85.61%), and consolidation occurred in 95.45% of cases. Only 9.85% suffered complications and the most commonly used material was the dynamic compression plate (61.36%). Most of the patients were from Paraguay (80.3%) and success, that is, consolidation without serious complications (a complication requiring a new surgical procedure), was achieved in 91.67% of the patients. (Table 2).

In Table 3, it is observed that the majority of those who had some type of complication were men (66.67%), the percentage of the affected side was the same (50%) and the majority were single fractures (66.67%). Regarding the material used, 50% were dynamic compression plates; 41.67%, dynamic compression plates with limited contact and 8.33%, locking compression plates. Mild complications were defined as those that did not require a new procedure and serious complications were those that did require a new procedure.

The distributions of sex, dominance (laterality), type of fracture, type of implant, success and complications were compared between the different Services using Fisher's exact test. This test was chosen because, according to Giolo,[13] Fischer's exact test for RxC tables is more appropriate when the sample size is not large enough and there may be one or more values <5 in the contingency table.

In Fisher's exact test, if the p-value is less than a significance level (0.05), it leads to the rejection of the null hypothesis H0: the proportion of characteristic "X" is the same in all categories of variable Y.

In Table 4, it can be seen that there are significant differences in the proportion of the type of fracture (p 0.016) and type of material used (p <0.001) in the different Services.

The age of the patients was compared between the different Services using the one-way analysis of variance (ANOVA). The mean age was not significantly different (p 0.5613).

Factors potentially associated with success and complications were evaluated using binary logistic regression models. Logistic regression fitting effects were verified with the help of the simulated envelope and normal probability plot of the HNP library of R.

Table 2. Absolute frequency of categorical variables

Variable	Absolute frequency	Relative frequency - Brazil	Relative frequency - Ecuador	Relative frequency - Paraguay
Sex				
Female	39 (29.55%)	3 (2.27%)	4 (3.03%)	32 (24.24%)
Male	93 (70.45%)	11 (8.33%)	8 (6.06%)	74 (56.06%)
Side				
Right	73 (55.3%)	7 (5.3%)	9 (6.82%)	57 (43.18%)
Left	59 (44.7%)	7 (5.3%)	3 (2.27%)	49 (37.12%)
Type of fracture				
Multiple	19 (14.39%)	5 (3.79%)	3 (2.27%)	11 (8.33%)
Single	113 (85.61%)	9 (6.82%)	9 (6.82%)	95 (71.97%)
Consolidation				
No	6 (4.55%)	0 (0%)	1 (0.76%)	5 (3.79%)
Yes	126 (95.45%)	14 (10.61%)	11 (8.33%)	101 (76.52%)
Complication				
Severe	9 (6.82%)	0 (0%)	1 (0.76%)	8 (6.06%)
Mild	3 (2.27%)	0 (0%)	0 (0%)	3 (2.27%)
No	120 (90.91%)	14 (10.61%)	11 (8.33%)	95 (71.97%)
Type of material				
Dynamic compression plate	81 (61.36%)	14 (10.61%)	5 (3.79%)	62 (46.97%)
Limited Contact Dynamic Compression Plate	41 (31.06%)	0 (0%)	2 (1.52%)	39 (29.55%)
Locking Compression Plate	10 (7.58%)	0 (0%)	5 (3.79%)	5 (3.79%)
Success				
No	10 (7.58%)	0 (0%)	1 (0.76%)	9 (6.82%)
Yes	122 (92.42%)	14 (10.61%)	11 (8.33%)	97 (73.48%)

Table 3. Absolute frequency of categorical variables of patients with complications

Variable	Frequency	Percentage
Sex		
Female	4	33.33%
Male	8	66.67%
Side		
Right	6	50%
Left	6	50%
Type of fracture		
Multiple	4	33.33%
Single	8	66.67%
Consolidation		
No	5	41.67%
Yes	7	58.33%
Complication		
Severe	9	75%
Mild	3	25%
No	0	0%
Type of material		
Dynamic compression plate	6	50%
Limited Contact Dynamic Compression Plate	5	41.67%
Locking Compression Plate	1	8.33%
Service		
Brazil	0	0%
Ecuador	1	8.33%
Paraguay	11	91.67%
Success		
No	9	75%
Yes	3	25%

Table 4. Fisher exact test

Variable	p
Sex	0.82783640485
Side	0.39619935801
Type of fracture	0.01648996506
Complication	0.56003456881
Type of material	0.00005054684
Success	0.71174965658

DISCUSSION

The treatment of diaphyseal fractures includes several options, and surgery is usually indicated in the setting of significant displacement, neurovascular injury, open fractures, and multiple fractures.

In the last decade, global interest in minimally invasive osteosynthesis has increased with the use of bridge plates, whose fixation site can vary, most of them through the anterior safe zone, avoiding direct contact with the radial nerve.[14,15]

Several studies suggest that the MIPO technique achieves favorable results compared to other surgical techniques in terms of healing time and postoperative complications. According to the meta-analysis by Bin-feng Yu et al., one of its advantages is the reduction in the risk of radial nerve damage, a trend that was also observed in our study.[3,11,14,9,15,21,22,17]

One of the main issues to be studied is the reduction of the risk of radial nerve damage. In some cases treated with the conventional open technique, its mere identification and nerve protection can cause postsurgical neuropraxia. We believe that this is one of the main advantages of this technique, in which a muscle flap protects the aforementioned structure.[3,11]

To avoid the neurological damage associated with the MIPO technique, Benegas et al.[24] recommend adequate handling of the soft tissues and gentle retraction during the distal approach, in addition to avoiding lever-type retractors, placing the plate in an anterior position, keeping the forearm in a semi-flexed position, and inserting the plate from proximal to distal.[20,14] The incidence of neurological injury with this technique is low (around 2.8%);[1,14,16] however, when it occurs, it leads to poor functional outcomes and the need for additional procedures.

Based on our experience in this study, we believe that the MIPO technique approach works in a safe zone in relation to neurological structures by not manipulating nerve structures during the fixation pathway, which, in itself, may be a factor that contributes to reducing the injuries.[5,6,23,14]

The neurological damage verified before surgery was not a contraindication to perform this procedure, which can be deduced from the experience published by Shao et al., who recognized an 88.1% general recovery, with a spontaneous recovery of 70.7%. No differences were found between the groups treated initially with early exploration and with expectant management, suggesting that carrying out a procedure to explore the radial nerve does not have an impact on the degree of nerve recovery. In our series, most patients were treated with this approach and a low rate of neurological injury was achieved.[6]

Most cases of neuropathy are due to a distraction injury, which tends to improve. We would suggest open exploration in which a wide approach and surgical exploration of the radial nerve is performed and its possible repair only in cases of worsening or lack of improvement during patient follow-up.[4]

The nonunion rate after plate fixation can reach 5.8%[20] and the time to union, in some studies, ranges between 12 and 32 weeks, with a mean of 16.2 weeks.[9,12,16,20] This finding coincides with that of our study, in which the rate of nonunion was 4.5%.

The pooled data reflect consistently favorable outcomes, such as a nonunion rate of 2.6%, an infection rate of 1.5%, and an iatrogenic radial nerve injury rate of 2.8%. This compares very favorably with the reported complication rate for open reduction and internal fixation or intramedullary nailing, whose risk of iatrogenic radial nerve injury may be as high as 10-20%.[6,10]

We believe that an important factor that can directly influence the speed of union, its quality and the reduction of complications, such as nonunion, is an adequate reduction of the fracture, which also influences the healing of fractures by open techniques and is a factor that can act as a possible distractor. This fact makes comparisons difficult and we believe should be taken into account in future studies.

It is difficult to obtain data regarding follow-up and degree of consolidation in the public health system, which may prevent us from knowing the exact date on which consolidation occurred. This implies a limitation to our study, because clinical consolidation could possibly occur without a radiological image.

Regarding the type of plates used, they were mostly 12-hole dynamic compression plates (124 dynamic compression plates, 8 locking compression plates); locking plates were used only in some cases. We consider that this may be a factor that alters the biomechanics of fixation. The technique was originally described by Livani et al.,[2,5] with this implant, since the dynamic compression plate is an inexpensive, easily accessible and widely used implant that can effectively resolve this type of fracture, reproducible in the most centers.[1,2,5,19]

In our study, four screws were used to fix the plate, two proximal and two distal, distributed along the edges of the plate, which apparently provides adequate stability and flexibility to the plate to stimulate consolidation due to its relative stability. We believe that comparative biomechanical studies are needed to address this and contrast it with different screw configurations and different work areas.

Studies have been published on fractures treated with the MIPO technique with a locking compression plate,[1,6] we believe that this could offer benefits for elderly patients or patients with osteoporotic bone; however, more comparative biomechanical studies are needed to determine the best type of implant for this technique. Therefore, based on our experience, dynamic compression plating is recommended using the original technique described by Livani et al. whereas locking compression plating is recommended in patients with osteoporotic bone.[1,2,5,16]

As a disadvantage of this technique, we could mention that it requires the use of an image intensifier, which means extra resources, in addition to exposure to radiation.[1,2,5]

The MIPO technique also does not increase the risk of complications in general, according to the study by Bin-feng Yu et al., which is advantageous, because the comparison was made with the conventional plate fixation technique, considered the gold standard.[3,12,17]

In relation to the methodology of the study, we were struck by the disparity of cases within one Center (Paraguay). In the general statistics, this implies a dilution of the results of the other two Centers, which subtracts statistical power from our work. Thus it is mentioned that variables such as complications have mostly taken place in Paraguay, which could not be fully representative of the technique.

CONCLUSIONS

The MIPO technique for the treatment of humeral shaft fractures causes low rates of complications and morbidity, and good rates of union.

Conflict of interest: The authors declare no conflicts of interest.

J. Palacios Fantilli ORCID ID: https://orcid.org/0000-0003-4658-5641
P. C. Faiad Piluski ORCID ID: https://orcid.org/0000-0002-1887-8861
C. H. Castillo Rodriguez ORCID ID: https://orcid.org/0000-0002-4968-8390
O. Lech ORCID ID: https://orcid.org/0000-0002-9727-2330

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