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# Femoral head augmentation in 3-4 part proximal humerus fractures plating in elderly population and it's failure predictors

*Roberto Enrique López Cervantes,* Dietmar Krappinger,‡ Markus Riedl,§ Dominik Knierzinger,‡ Whido Wahler,§ Franz Kralinger‖*


## ABSTRACT

Bad bone quality and greater age are related to bad outcomes in proximal humerus fractures (PHF). In these patients the use of augmentation helps us to reduce the failure rate. The objective of this study was to evaluate the early complications and mechanical failures in 3 and 4 part PHF treated with femoral head allograft augmentation plating vs plating alone. **Methods:** We included 30 patients above 65 years old, with 3-4-part PHF treated with Proximal Humeral Internal Locking System (PHILOS) plating (9 augmented patients and 21 non-augmented patients). We evaluated as complication risk factors: deltoid tuberosity index, age, fracture type, calcar extension, varus, head fragment size, the reduction quality and type of fracture and time to surgery. Then we analyze the risk factors for complications, pain and range of motion in both groups. **Results:** The average age was 78.1 years, 63% of the patients had bad bone quality (DTI Less than 1.44). Of the risk factors we demonstrate that greater age p = 0.03, absence of calcar reconstruction

## *RESUMEN*

*La mala calidad ósea y la edad avanzada están relacionadas con los malos resultados en las fracturas proximales del húmero (FPH). En estos pacientes el uso del aumento nos ayuda a reducir la tasa de fracaso. El objetivo de este estudio fue evaluar las complicaciones tempranas y las fallas mecánicas en la FPH de 3 y 4 partes tratada con aloinjerto de cabeza femoral versus la placa sola.* ***Métodos:*** *Se incluyeron 30 pacientes mayores de 65 años, con una FPH de 3-4 partes tratada con sistema de placas con tornillos de bloqueo (PHILOS por sus siglas en inglés) (9 pacientes aumentados y 21 pacientes no aumentados). Se evaluaron como factores de riesgo de complicaciones: Índice de tuberosidad deltoides, edad, tipo de fractura, extensión del calcáreo, varo, tamaño del fragmento de cabeza, calidad de reducción y tipo de fractura y tiempo hasta la cirugía. Luego analizamos los factores de riesgo de complicaciones, dolor y amplitud de movimiento en ambos grupos.* ***Resultados:*** *La edad media fue de 78,1 años, el 63% de los pacientes tenían mala calidad ósea (DTI Menos de 1,44). De los factores de riesgo demostramos que la mayor edad p=.03,*



* Orthopedic surgeon, at CFO (Clínica de fracturas por Osteoporosis) Sanatorio San Francisco de Asís.
‡ Trauma Surgeon, Universitätsklinik, Innsbruck Anichstraβe 35, A-6020 Innsbruck, Austria.
§ Trauma Surgeon, Wilheminenspital der Stadt Wien Montleartstraβe 37, 1160 Vienna, Austria.
‖ Trauma Surgeon, Chief of Trauma Department of Hospital Wilheminenspital der Stadt Wien.

Hospital Wilheminenspital der Stadt Wien Montleartstraβe 37, 1160 Vienna, Austria.

Corresponding address:
Roberto Enrique López Cervantes, M.D.
Clínica CFO, Sanatorio San Francisco de Asís,
Av. Americas 1946, Col. Country Club, 45610, Guadalajara, Jalisco, México.
Phone: +52 33 3817 0771, Cell-phone: +52 1 33 1196 8254
E-mail: drrobertolc@gmail.com




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p = 0.05 and absence of augmentation p = 0.05 were 3 statistically significant risk factors for complications. **Conclusion:** In this study we can conclude that the use of osteosynthesis with plates must be reserved for selected patients on these ages due to the high incidence of complications. We confirm that with greater age the greater the chance for failure. The use of allograft augmentation is a useful tool to use in these cases, but it doesn't replace the anatomical reduction of the medial calcar.

**Keywords:** Proximal humerus, proximal humerus fracture, plate fixation, augmentation, elderly.

*la ausencia de reconstrucción del calcáreo p=.05 y la ausencia de aumento p=.05 fueron 3 factores de riesgo estadísticamente significativos para las complicaciones.* ***Conclusión:*** *En este estudio podemos concluir que el uso de la osteosíntesis con placas debe reservarse para pacientes seleccionados en estas edades debido a la alta incidencia de complicaciones. Confirmamos que cuanto mayor es la edad, mayores son las posibilidades de fracaso. El uso del aumento con aloinjertos es una herramienta útil en estos casos, pero sustituye la reducción anatómica del calcar medial.*

***Palabras clave:*** *Húmero proximal, fractura proximal del húmero, fijación de la placa, aumento, ancianos.*

## INTRODUCTION

Proximal humerus fractures (PHF) are the third more common fragility fractures,[1] the internal fixation of these fractures in one of the treatment options, but it´s complication rate can be of up to 49%.[2,3] The plate fixation continues to be the first surgical treatment option, being the chosen one in the 48% of the cases in the national German registry of 642,556 cases.[4] The main failure modes are the «cut-out» and the mechanical failure, both during the first weeks.[5,6]

Different types of treatment for PHF in elderly population have been described, but none of them have shown clear superiority or less complications over the others.[6,7]

Several risk factors for complications in the fixation of PHF have been described: age, calcar extension, bone mineral density (BMD), Varus collapse, calcar reconstruction, Neer fracture type.[6,8,9]

The BMD is a risk factor that can be measurable and modifiable. Nowadays DXA scan is the best available method to measure the BMD,[8,10] The Deltoid tuberosity index (DTI) has shown to be a reliable method to measure the BMD in a simple X-ray for preoperative planning.[7,11] To modify the BMD, different augmentation techniques have been developed, being the allograft augmentation one that have shown good outcomes in the proximal humerus.[12,3]

Femoral head allograft augmentation in the proximal humerus was first described by Euler in 2015 3 in the treatment of 2 parts PHF with good results. This technique prevents varus collapse and a better bone union.[5]

For the treatment of 3 and 4 part PHF in elderly population this type of augmentation has never been described. That's why we retrospectively review elderly patients with 3 and 4 part PHF treated with Proximal Humeral Internal Locking System (PHILOS) plating and compare to those treated with PHILOS plating and humeral head freeze dried allograft augmentation. The purpose of

this study was to analyze the early risk factors for failure and complications in both groups, to see if the Humeral head allograft augmentation can be useful to treat this population with high-risk for failure.

## METHODS

In this case control study we retrospectively reviewed a case series of consecutive patients treated between 2016 and 2017 with the following inclusion criteria: 1) age above 65 years old 2) the diagnosis of PHF of three or four parts, fracture dislocations and head splits. 3) treated with PHILOS plating 4) minimum follow-up of 6 months. We excluded: 1) two part PHF 2) other fixation techniques besides plating 3) Other augmentation techniques beside femoral head allograft augmentation. 4) patients with incomplete records. 5) patients with previous ipsilateral shoulder osteosynthesis.

The case group were the patients with PHILOS plating and augmentation with femoral head frozen-dried allograft. The control group were the patients treated only with PHILOS plating. Both groups were done by the same 5 surgeons (2 shoulder experienced surgeons and 3 general trauma surgeons) at the same medical unit.

We include 3 type of risk factors *(Table 1)*, including a new measure called Head Fragment Size (HFZ) which purpose is to measure the width of the remaining head fragment, using a CT scan in axial and sagittal planes *(Figure 1)*. The obtained numbers were divided in 2 and that is the average HFZ. This measure can objectively provide us with the remaining amount of bone to be purchased by the screws. The calcar reconstruction and tuberosities reconstruction were defined as an anatomical reduction in the postoperative X-rays in both planes (true AP and axial), if a rotational, angulation or a reduction step were detected the reduction was taken as non-anatomical.

Then we defined as complications the absence of consolidation, mechanical failure, cut-out, infection, constant pain and reoperations. Then we gathered the shoulder ranges of motion of all the patients and use the program (SPSS version 22) metric scaled data is reported as arithmetic mean and standard deviation, and categorical data as absolute frequency. Depending on the distribution form a T-test for independent variables or a nonparametric Mann-Whitney U-test was used for the analysis of metric scaled data. Distribution form was determined

**Table 1: Risk factors origin.**

| Risk factors for Failure | | |
|---|---|---|
| Patient related | Fracture related | Surgeon related |
| Age<br>Deltoid tuberosity index<br>Gender | Fracture type<br>Calcar loss<br>Head fragment size (HFZ) | Calcar reconstruction<br>Tuberosity reconstruction<br>Augmentation<br>Time to surgery<br>Surgeon specialization |

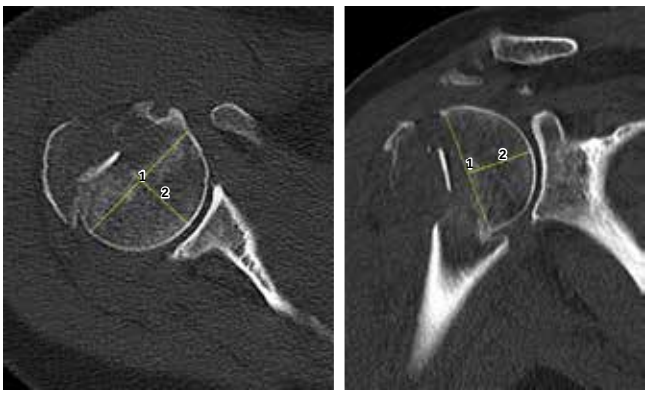


***Figure 1:***

*Head fragment size (HFZ) measurement.*
*We first obtain the center of the humeral head (marked in line 1) and from that point we measure the distance with a perpendicular line to the end of the humeral head (line 2). The line 2 has to measure from the most lateral bone area to the medial cortical.*

using Kolmogorov-Smirnov test. A $\chi^2$ test or Fischer's Exact test was used for the categorical data analysis. The probability level was set at $p \leq 0.05$.

## SURGICAL TECHNIQUE AND REHABILITATION PROTOCOL

In all the cases a complete preoperative protocol was followed, including a preoperative shoulder CT scan, and DTI measured in the shoulder AP radiograph.

After inter-scalenic blockade and general anesthesia were made, the patient was positioned supine with 30º of forward flexion. A deltopectoral approach was made and sutures were passed through the rotator cuff and fracture reduction was made and pinned under fluoroscopic guidance. In the augmentation cases, a frozen dried femoral head allograft was molded to a hemi-mushroom shape *(Figure 2)* to fill the void in between the head fragment an the tuberosities. We introduce the graft through the fracture interval behind the bicipital groove. Tuberosities reduction is made afterwards over the graft. Plate is then fixed to the humeral shaft and locking screws and sutures are placed and secured to the plate *(Figure 3)*. Control transoperative X-rays are made to confirm anatomical reduction and fixation. *(Figure 4)*.

Postoperative protocol is to allow pendular and passive movements from first week and progress to active movements at week 3, also taking them out of the sling. At week 6 we start movements against resistance.

Most of the patients started active movements from first week.

X-rays were taken monthly until month six, and then every 6 months in the patients who keep going to their follow-up checks.

## RESULTS



After analyzing our sample, 30 cases were included *(Table 2)*, we analyze the mean and compare the complication (15 patients) vs the non-complication group (15 patients) (2). The mean age was 78.1 years, older patients had more complications ($p = 0.03$). of our patients 63% had low BMD according to DTI, not being a significant factor for complications ($p = 0.26$). Calcar loss was found in

36% of the cases, seventeen patients had 3-part fractures and 13 patients had (4-part/fracture dislocations/ head splits). Smaller HFZ was related to increase the complications rate even though a significant difference wasn't found between the complication and no complication group. (p = 0.13).

Regarding surgical technique, 9 cases were treated with Allograft + PHILOS plating and 21 with PHILOS plating only. The augmented group had less complications than the non-augmented (p = 0.05).

No differences (p = 0.05) regarding age, DTI or fracture type between the Augmented and non-augmented group were found.

The calcar reconstruction was another important factor to avoid complications (p = 0.05). Tuberosity reconstruction, time to surgery and surgeon specialization

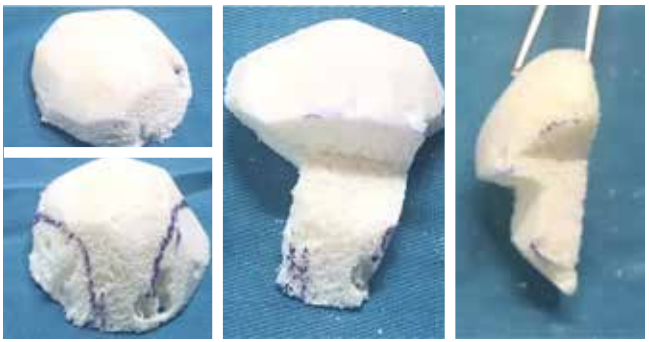

***Figure 2:***

*The hemi-mushroom shape allograft.*

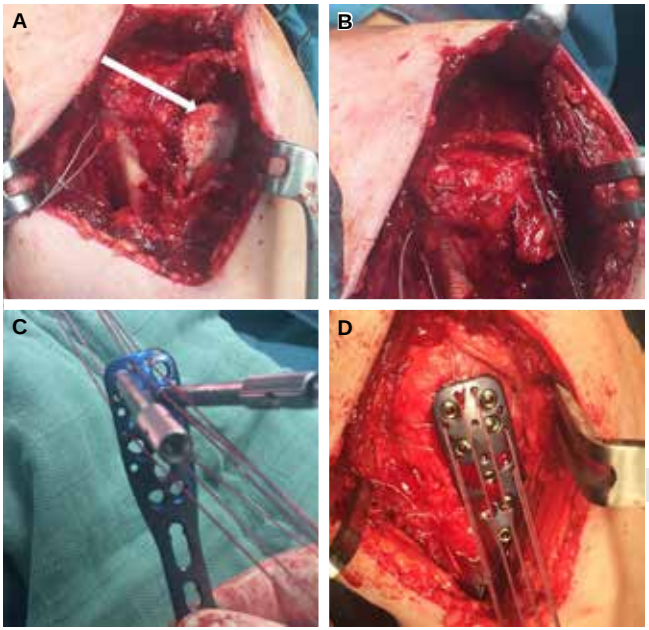


***Figure 3:***

*Surgical technique. **A)** We introduce the allograft through the intertuberosity fracture line. **B)** closure of the tuberosities with non-absorbable suture like 2 circular cerclages from anterior to posterior. **C)** plate fixation with the tuberosity sutures. **D)** Anatomical reduction with the plate and sutures.*

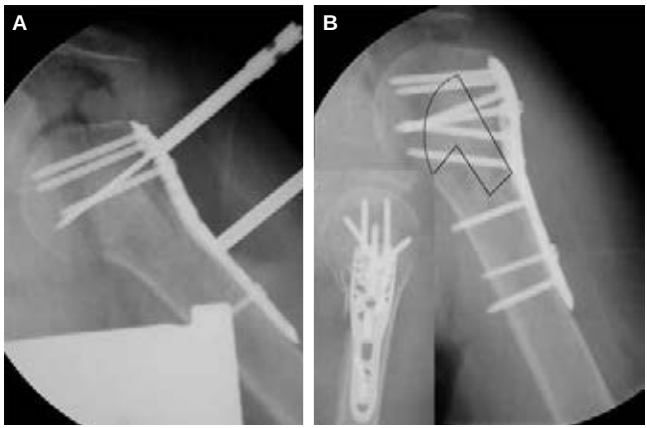


***Figure 4:***

*Trans operative X-ray in AP and axial views to verify medial anatomical reduction with the allograft in:* ***A)*** *accurate reduction and plate fixation,* ***B)*** *we demonstrate the position of the allograft, and how the humeral head rest on in.*

does not show to have a significant difference. However, absence of Surgeon specialization in shoulder surgery seems to have greater complication rate in this surgery: 12 complications in trauma surgeon group vs 3 complications in shoulder surgeons' group (p = 0.12).

We analyze the complication accuracy for all the parameters, showing us that 3 above mentioned significant risk factors also showed a high accuracy for complications with values between .66 and .70. This tells us that these 3 risk factors can be defined as the most important ones in this population with these types of fractures.

By means of $\chi^2$ test (p = 0.03) we conclude that with more risk factors, more chances to face complications *(Table 3)*. By having 0-1 of this significant risk factors our complication rate can be of 31.3%, and having 2 or 3 risk factors it increases to 71.4%.

## DISCUSSION

Proximal humerus fractures in the elderly are a decision making challenge, we have several treatment options, but none of them with uniformly good results. Previous studies confirms that surgical plate fixation + augmentation is better than plate fixation alone.[13]

The BMD, greater age, female gender and absence of anatomical reduction have been found as risk factors.[2]

In our study all our population is 65 years or older, and more than 63% have bad BMD. In the literature we only a few studies which compare the treatment options in this specific population. Repetto y cols.[10] published a case series with 3 and 4 part fractures, having a complication rate of about 36.8% in the surgical fixation group and 37.5% in the patients treated with hemiarthroplasty and 31.5% in the group treated with reverse prosthesis. In compare to our group, we had more complications in the non-augmented group (62%) in compare with the augmented group (22%).

Several studies have described different augmentation techniques, the best known one is the Fibula strut allograft. Berkes and cols. described fibular strut allograft in proximal humerus fractures of 2, 3 and 4 fragments with calcar extension, reporting a complication rate of 21.4%.[14]

Other techniques are available as the one described by Somasundaram y cols. who used calcium phosphate and plating in 22 patients with proximal humerus fractures, obtaining no mechanical failure, 4 rigid shoulders and an average Constant score of 64.[12]

Another available technique is the one described by Somasundaram y cols, who used a calcium phosphate augmentation and plate fixation in 22 patients with PHF, with no failures, 4 rigid shoulders and an average constant of 64.[15]

The use of screw cement augmentation has also been described without demonstrating a reduction in the failure rate.[16]

We decide to use the augmentation technique first described by Euler and cols. in 2 part PHF in 2015. In his series, no failure cases were reported, using fresh frozen femoral head allografts.[3] In our series the cases were 3- and 4-part fractures and we use a frozen dried allograft (Biomet Allo 440).

We had a statistically significant reduction in the complications incidence in between groups (p = 0.047) and a better internal rotation in the augmented group (p = 0.021).

## CONCLUSION

In this study we can conclude that the use of osteosynthesis with plates must be reserved for selected patients on these ages due to the high incidence of complications. We confirm that with greater age the greater the chance for failure.

**Table 2: Risk factors incidence.**

| Risk factors | | All patients | Complication (15) | No complication (15) | p |
|---|---|---|---|---|---|
| Gender | Woman | 23 | 11 | 12 | 0.66 |
| | Man | 7 | 4 | 3 | |
| Age | Years | 78.1 ± 8.3 | 81.1 ± 8.3 | 75.0 ± 7.2 | 0.03 |
| Bone mineral density | Low | 19 | 11 | 8 | 0.26 |
| | Normal | 11 | 4 | 7 | |
| Fracture type | 3 | 17 | 8 | 9 | 0.71 |
| | 4/Head-split/ dislocation | 13 | 7 | 6 | |
| Calcar extension | Yes | 11 | 6 | 5 | 0.71 |
| | No | 19 | 9 | 10 | |
| Head fragment size (HFZ) | Millimeters | 20.6 ± 5.9 | 19.0 ± 4.6 | 22.2 ± 6.6 | 0.13 |
| Calcar reconstruction | Yes | 19 | 7 | 12 | 0.05 |
| | No | 11 | 8 | 3 | |
| Tuberosity reconstruction | Yes | 24 | 11 | 13 | 0.36 |
| | No | 6 | 4 | 2 | |
| Augmentation | Yes | 9 | 2 | 7 | 0.05 |
| | No | 21 | 13 | 8 | |
| Time for surgery | Days | 4.4 ± 5.8 | 4.9 ± 7.7 | 3.9 ± 3.1 | 0.62 |
| Surgeon specialization | shoulder | 10 | 3 | 7 | 0.12 |
| | General | 20 | 12 | 8 | |

**Table 3: Risk factors and prediction for failure precision.**

| | Risk factor | Yes | No | Precision |
|---|---|---|---|---|
| Patient factors | Gender | Woman | Man | 0.47 |
| | Age | ≤ 78 | ≥ 78 | 0.70 |
| | Osteoporosis | Yes | No | 0.60 |
| Fracture personality | Fracture type | 4/Head-split/dislocation | 3 fragments | 0.53 |
| | Calcar extension | Yes | No | 0.53 |
| | Head fragment size (HFZ) | < 18.65 mm | > 18.65 mm | 0.53 |
| Surgery related | Calcar reconstruction | No | Yes | 0.66 |
| | Tuberosity reconstruction | No | Yes | 0.57 |
| | Augmentation | No | Yes | 0.66 |
| | Time for surgery | > 3 days | ≤ 3 days | 0.40 |
| | Surgeon specialization | General | Shoulder | 0.63 |

The use of allograft augmentation is a useful tool to use in these cases, but it doesn´t replace the anatomical reduction of the medial calcar and a good surgical technique.

We require bigger and prospective longer studies to see the results in a long term.

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