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Research Article

Descriptive Analysis and Results of Patients Operated on for Periprosthetic Hip Fracture

Manuel Becerra[1], Héctor Foncea[1]*, Carolina Becerra[2], Leonardo Villarroel[1], Nicolás Rojas[1], Sebastián Cuellar[1], Paulo Villarroel[1] and Enrique Cifuentes[1]

[1]*Department of Orthopedic Surgery, Traumatological Institute, Chile*

[2]*University of Valparaiso, Chile*

***Corresponding Author:** Héctor Foncea Department of Orthopedic Surgery, Traumatological Institute, Chile.

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Abstract

Introduction: Periprosthetic fractures (PPF) are those that occur around a prosthesis, being a catastrophic complication. They are the fourth most frequent cause of hip surgery revisions, accounting for 9.9% of cases in the Australian registry. Its treatment is complex and the results are often poor with high morbidity and mortality rates.

Objective: To perform a descriptive analysis and identify factors associated with the results in patients operated on for hip PPF.

Materials and Methods: A retrospective study was carried out by obtaining data from patients operated on for PPF between January 2015 and December 2019 in a public hospital in the central area of Chile. Patients of all ages with femoral or acetabular fracture related to previous total hip arthroplasty (TCA) were included. Patients with arthroplasty due to tumor causes were excluded. Demographic, clinical, and radiographic data were obtained from the clinical record, and patients were cataloged according to their independence to move around as a measure of functional capacity. The results were analyzed using statistical models, hypothesis tests and machine learning models.

Results: A total of 53 patients with PPF were identified between the period described. 79.2% were women and 20.8% men, with a mean age of 76.8 years. The most frequent fractures, according to the Vancouver classification, were B1 (41.5%), followed by B2 (32.1%) and FA (11.3%). All fractures were explained by a low-energy mechanism. The initial indication for CTA was femoral neck fracture in 47.2% of cases, followed by hip osteoarthritis (41.5%). A difference was observed between the time between CTA and PPF, being lower for patients with hypertension and type 2 diabetes mellitus (mean 2 years) compared to patients without comorbidities (mean 9.5 years). The treatment of choice was reduction and osteosynthesis in 49% of cases and prosthetic replacement in the remaining percentage. A longer hospitalization period for PPF was significantly correlated with higher incidence of infection, with worse functional outcomes. The average follow-up was 23 months and after rehabilitation, 20.8% managed to walk without technical aids, 34% walked with assistance, 24.5% moved only in a wheelchair and 7.5% ended up bedridden. There were no patients with B3 or C fractures who managed to return to their previous ability to move, and all bedridden patients presented after a B1 fracture. When performing a decision tree model, the most relevant variables to arrive at the different functional outcomes were pain, cementation, years between surgery and PPF, days of hospitalization, and gender. The analyses of the importance of variables revealed that those that best explained the dispersion of the data were type of review, functionality, number of previous surgeries and time between PPF and surgery. At the end of follow-up, 32.1% of patients had died.

Conclusion: PPF occurred in a shorter period of time since the last surgery in patients with type 2 diabetes mellitus and arterial hypertension compared to those without comorbidities. A longer hospitalization time was correlated with greater infection of the new implant and worse prognosis. Walking ability was seriously impaired in a large percentage of patients. We found variables that could explain the large dispersion of the data. Our results were similar to those reported in the literature and give rise to further studies on the identified variables.

Keywords: Hip Fractures; Joint Revision; Periprosthetic Fracture

Introduction

In recent decades, total hip arthroplasty (TCA) has established itself as the most effective solution to treat fractures and degenerative joint disorders, offering significant improvements in patients' quality of life. However, the increase in the prevalence of the intervention has been accompanied by an increase in associated complications, with periprosthetic fracture (PPF) being one of the most challenging due to its clinical complexity and its high associated morbidity and mortality [1].

PPFs are those that occur around the implant and are the fourth most common cause of hip revision surgery. Its frequency can vary between 0.1% and 2.1% in primary TCAs, rising to 4% after a first revision surgery [2,3]. In the coming years, an increase in their incidence is expected due to the aging of the population and improvements in the quality of implants, which gives them a longer shelf life [4-6].

PPF can be intraoperative or postoperative, the latter occurring from 2.1 to 7.4 years after primary surgery, with an average of 5.5 years [7-9]. They occur 10 times more often in the femur than in the acetabulum [10], being 14 times more frequent after an uncemented CTA than in a cemented one [11]. 86% of cases are the result of a low-energy mechanism [12] and risk factors have been identified such as: age, female sex, osteoporosis, dysplasia of hip development, type of implant, aseptic loosening and number of previous interventions [13-16].

The Vancouver classification [17] is the most widely used to describe these fractures, dividing them into three main types according to their location with respect to the implant: Type A (greater or lesser trochanter), Type B (around the stem) and Type C (distal to the stem). Each of these types has subclassifications based on implant stability and bone quality, which is critical to directing proper management. In general terms, fractures B1, C and some GA fractures can be managed with reduction and osteosynthesis, while B2 and B3 fractures will require a revision of the femoral component, except for some B2 fractures that have shown, in selected cases, satisfactory results with reduction and osteosynthesis [18]. Figure 1 shows the fracture patterns, with their corresponding treatments. Although studies have supported the validity and reproducibility of this classification, it has been seen that up to 20% of B1 fractures present instability in the Pavilion [19], moreover, in a Swedish registry it was reported that 47% of the offspring were "unknown loose", referring to the fact that they were found loose in a way that was not expected by the surgeon [20].

Figure 1: Vancouver fracture classification patterns and treatments performed at our center. B1 and C: reduction and osteosynthesis. B2 and B3 prosthetic replacement and augmentation. In the B3 fracture presented, there was an additional need to review the acetabular component.

Postoperative acetabulum fractures are rare. The principles of treatment are based on the displacement of the fracture and the stability of the cotyl. Minimally displaced fractures with a stable cup can be treated conservatively. Displaced fractures require revision of the implant, especially when the posterior wall is involved [21]. Although the prognosis will depend on factors such as lack of bone stock, pre-existing osteolysis or pelvic discontinuity, studies such as that of Resch., *et al*. have shown good results after revision surgery, with 6 out of 7 patients recovering to their previous state of mobility [22].

The prognosis of PPF is similar to that of femoral neck fracture in the elderly population, with a mortality rate of 9.7% at one year after surgery, which worsens if there is a waiting time of more than 72 hours [1]. Global complications reach up to 56% [23,24].

The objective of this study is to perform a descriptive analysis and identify factors associated with the results in patients operated on for hip PPF in the Chilean population.

Materials and Methods

Our study corresponds to a retrospective study carried out in a traumatology hospital in central Chile with a sample of patients diagnosed with PPF between January 2015 and December 2019. Patients of all ages with radiographically confirmed PPF in the emergency department were included. The exclusion criteria were TCA fracture in pathological bone and patients with no possibility of follow-up. Demographic data (age, sex), morbid history, energy involved, primary surgery and revision records, hospitalization time, functional outcomes (ability and mode of movement), and follow-up time were obtained from the clinical record. The dates of death were obtained from the local civil registry.

The results were worked using classic exploratory analysis, contingency tables, pooled data analysis, decision tree model, and Pearson's correlation model. A study of the importance of variables was carried out by means of principal component analysis for numerical variables and multiple correspondence analysis for categorical or nominal variables.

Results

Between January 2015 and December 2019, 53 patients diagnosed with PPF were identified. 79.2% were women and 20.8% men, with an average age of 76.8 years, slightly higher when broken down by sex (average age of women: 78 years, average age of men: 72.4 years). All fractures were explained by a low-energy mechanism. The first surgery was CTA due to fracture in 47.2% of cases, followed by osteoarthritis in 41.5%. 62.2% of the TCAs were performed with stem cementation. 11 patients (20%) had 2 or more surgeries prior to PPF, of these, most were previous replacements (7 patients).

The most frequent femoral fractures, according to the Vancouver classification, were B1 (41.5%), followed by B2 (32.1%) and GA (11.3%). There were 2 cases of acetabulum fractures. On average, AG and C fractures occurred in older patients, and the time between FFP and surgery was longer in B2 and C fractures. The treatment of choice was reduction and osteosynthesis in 49% of the patients and the remaining percentage was prosthetic replacement. The functional results of fractures of the femoral component are shown in Table 1. There were no B3 or C patients who managed to return to their previous ambulation capacity, and all bedridden patients originated after a B1 fracture. After surgery, there were 2 cases of instability and 3 cases with a new PPF.

8 patients (15%) developed an infection after revision surgery. Of these cases, none were able to walk without technical aids, 2 with help (25%), 5 were able to move alone in a wheelchair (62%) and 1 ended up bedridden (12.5%). 38.5% of the patients who ended up in a wheelchair and 25% of those who were bedridden had a history of infection. 25% of those infected had a history of type 2 diabetes mellitus.

Functionality/Vancouver	AG	B1	B2	B3	C
Walks (%)	18.2	45.5	36.4	0.0	0.0
Walks with aid (%)	11.1	33.3	38.9	5.6	11.1
Wheelchair (%)	8.3	41.7	33.3	16.7	0.0
Holdings (%)	0.0	100	0.0	0.0	0.0

Table 1: Percentage distribution of each functional level of gait according to FPP classified by Vancouver. The percentage reading is per row.

The number of previous surgeries was not related to worse functional outcomes. All bedridden patients and most of those who ended up in a wheelchair (69%) underwent a single revision surgery.

The average length of hospital stay was 21 days, with the lowest for GA (average 9 days) and the longest for type C (27 days). Patients with B3 fractures showed a greater dispersion in their days of hospitalization compared to the rest (Figure 2). In particular, B3 patients had a longer hospitalization time in quartile 75, which marks the greatest dispersion of this category (Figure 3). There was no longer hospitalization time in patients with type 2 diabetes mellitus or high blood pressure. When performing a Pearson correlation analysis between the infection variable (from revision surgery) and the days of hospitalization, a significant value of 0.51 (p=0.0019) was obtained.

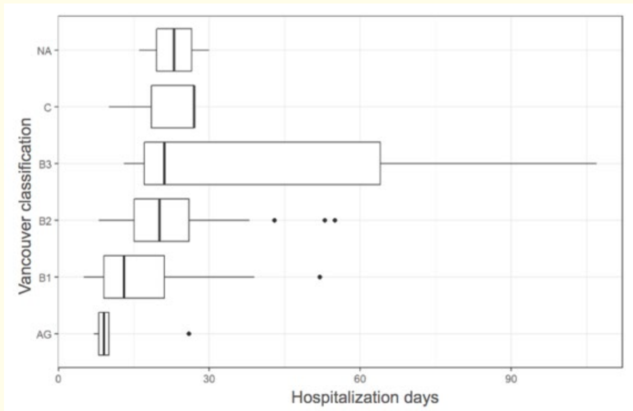

Figure 2: Box plot between Vancouver classification and days of hospitalization. It can be observed that patients with fractures classified Vancouver B3 have a greater dispersion of their days of hospitalization compared to the rest. NA: does not apply (acetabulum fracture).

vancouver <chr>	quant25 <dbl>	quant50 <dbl>	quant75 <dbl>
AG	7.75	9	14.00
B1	9.75	18	22.75
B2	15.00	20	24.00
B3	17.00	21	64.00
C	27.00	27	27.00

5 rows

Figure 3: Quartiles 25, 50, and 75 of the days of hospitalization for each Vancouver classification. It is observed that B3 have the longest hospitalization times in quartile 75, which marks the greatest dispersion of this category.

Differences were observed between the time between CTA and PPF, being lower for patients with a history of type 2 diabetes mellitus (mean 4 years) and even lower when associated with arterial hypertension (mean 2 years) compared to patients without comorbidities (mean 9.5 years). There was no relationship between the years since the last CTA and FFP when comparing by age, as shown in figure 4, where there is considerable dispersion of the data. The treatment of choice was reduction and osteosynthesis in 49% of patients, followed by replacement in 41% of cases.

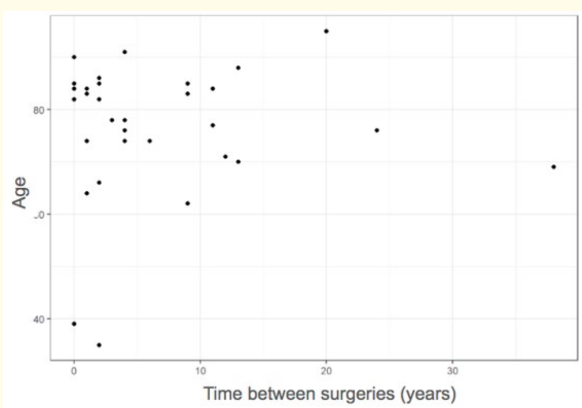

Figure 4: Scatterplot between the time between the last surgery and the PPF revision surgery versus the age of the patients.

The average follow-up was 23 months and after rehabilitation, 20.8% managed to walk without technical aids, 34% walked with help, 24.5% moved only in a wheelchair and 7.5% ended up bedridden. At the time of the last check-up, 36 patients (67%) were pain-free. At the end of follow-up, 32.1% of patients had died.

A decision tree model was made (Figure 5), where the most relevant factors to guide towards the different paths to the level of functionality were pain, cementation, years between surgeries, days of hospitalization and gender. The Principal Component Analysis (PCA) techniques were used to analyze the importance of the numerical variables and Multiple Correspondence Analysis (MCA) for the categorical or nominal variables. PCA analysis revealed that the number of previous surgeries and the time between PPF and revision surgery explained the variability of the data by 25.3% and 23.6%, respectively. By performing a biplot with these dimensions, it was found that these numerical variables have a high impact on patient behavior (Figure 6). On the other hand, in the MCA analysis, it was found that the categorical variables type of surgery (reduction and osteosynthesis vs. replacement) and functionality to move were the ones that had the greatest influence on the group of patients, with 18.2% and 13% of explanation of variability, respectively. With these data, a map of factors was created to create groups similar to each other that behave differently from the rest (Figure 7).

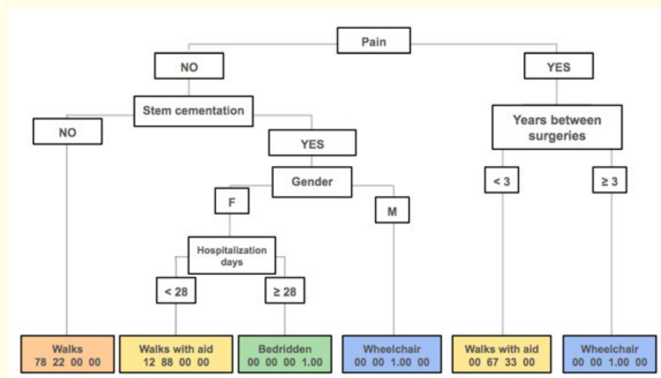

Figure 5: Decision tree model, where the paths that lead to each functional result are observed. Fijación_protesis: Reduction and osteosynthesis versus turnover; años_entre_cx: years between ATC and FPP.

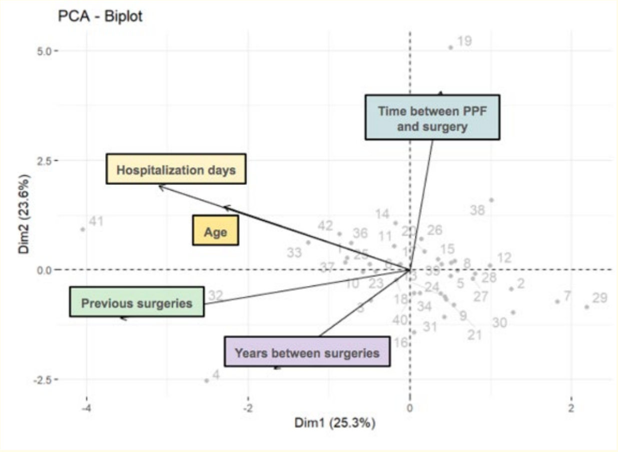

Figure 6: Biplot analysis with a Cartesian plane showing how the variables Dim 2 (number of previous surgeries) and Dim2 (time between PPF and surgery) influence data variance. It can be seen that the variables have a high impact on the behavior of patients. Tiempo_fx_cx: time between PPF and surgery; n_cx_previas: number of surgeries prior to PPF in the same hip; años_entre_cx: years between ATC and FPP. PCA: Principal Component Analysis

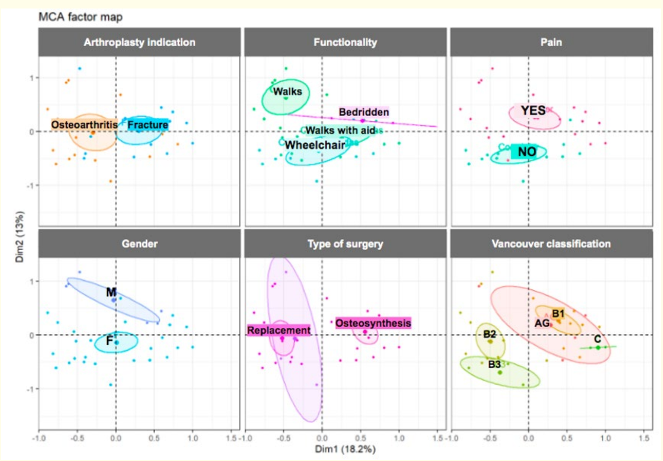

Figure 7: Map of factors based on some variables and the dimensions studied. Dim1: Type of surgery (reduction and osteosynthesis v/s replacement). Dim 2: Functionality for movement. The behavior shown has to do with groups of patients, according to similarity. Similar patients are close, different patients are far away. MCA: Multiple Correspondence Analysis; RED and OTS: Reduction and Osteosynthesis; M: male, F: Female; tipo_cx: Type of Surgery.

Discussion

Our study performed a descriptive analysis and tried to look for factors associated with the results in patients with PPF operated on in Chile.

Of the 53 patients, almost 80% were women, with an average age of 76 years, being slightly higher in the female gender (78 versus 72 years). In the literature, it has been seen that female sex is an independent risk factor for PPF, with reported ranges between 52% and 70% [8,25], however, the significance of gender is probably multifactorial since it is also associated with other conditions such as osteoporosis. Studies such as the Swedish arthroplasty registry have shown an equal distribution in the young population, which changes over the age of 80. However, there is still no consistency in the publications and there are studies that show that there is no difference between these groups [16].

20% of our patients underwent more than one intervention on the same hip prior to PPF, a finding consistent with the literature [13,15]. Although it could be assumed that these patients will have a poor prognosis due to soft tissue damage and bone stock deficit, we did not see worse functional outcomes and, on the contrary, all bedridden patients and most of those who ended up in a wheelchair (69%) were only reoperated on one occasion.

Studies propose that non-cementation is an independent risk factor for PPF, both intra- and postoperatively [26,27], however, 66.2% of our PPF were subsequent to CTA with cementation of the femoral component (hybrid). These results can be misinterpreted considering the advanced age of our group, which predisposes to indicate cementation in a higher proportion. Unfortunately, we do not have the total number of hybrid and uncemented ATCs performed in the period of time studied to be able to give conclusive results.

In our series, most of the fractures were Vancouver B1 (45%), followed by B2 (32.1%) and all were explained by a low-energy mechanism, which is a different finding from what was found in the literature, in which it has been seen that a fall in level is the cause of 75% to 86% of cases and that a spontaneous fracture occurs in 8% of patients [8,11,12,28]. Our low number of patients recruited may be a confounding factor. Of the acetabulum PPF, there were only 2 cases (3.7%), which is quite far from the publications, since their involvement is described in 1 in 10 patients with PPF [10].

Regarding the ability to move, it was not possible to associate a type of fracture with a particular outcome. For example, we found that all bedridden patients and 47.7% of those who ended up in a wheelchair originated after a B1 fracture, which tells us that the ability to walk not only depends on the severity of the fracture, but that there are other important factors to consider. In an attempt to isolate variables that influence prognosis, an analysis was carried out with the decision tree model, which showed that the most relevant factors to guide towards the different paths according to the level of gait functionality were pain, cementation, years between surgeries, days of hospitalization and gender. Figure 5 shows the result and we can see, for example, how 78% of patients without pain and with a PPF of an uncemented CTA managed to walk without technical aids. It is also shown how patients with pain after the revision had poor outcomes, as did some women with prolonged hospitalization time and PPF secondary to a cemented CTA. On the other hand, the PCA and CAM models (Figures 6 and 7) provided us with variables that explain the great variability of the data, that is, variables that could explain the very different behaviors and results among patients. From these, it was obtained that the number of previous surgeries and the time between surgeries explain the variability of the numerical data by 25.3% and 23.6%, respectively. On the other hand, the type of surgery (reduction and osteosynthesis v/s replacement) and gait functionality were the categorical variables with the greatest influence, explaining the variability in 18.2% and 13% respectively. Both the decision tree model and the analyses of the importance of PCA and MCA variables do not serve to find direct associations, but they provide us with guidelines on what we can study in a directed way. We propose to study these findings in future prospective studies in order to complement the list of risk factors and prognoses of patients with PPF.

We found that patients with a history of type 2 diabetes mellitus and hypertension had substantially less time on average between TCA and PPF (2 years versus 9 years, respectively) and that a longer hospitalization time during PPF resolution was associated with a higher incidence of infection. We believe that these variables could be used for subsequent analysis, provided that they can be isolated.

After rehabilitation, only 20% of operated patients managed to move without technical aids, 34% with help, 24.5% in a wheelchair and 7.5% ended up bedridden. 15% of the cases had an infection, 2 patients evolved to instability and 3 presented a new PPF. These discouraging percentages are similar to those published in various studies, where 56% of global complications, 44% of poor functional results (Harris Hip Score < 70) and 52% of inability to recover the previous gait have been seen. Our final mortality was 32.1%, in contrast to what was found in the literature, with a mortality of 9 to 17% at one year and up to 56% after follow-up [24,29,30].

The weaknesses of this study are the retrospective data collection and the low number of participants compared to other publications.

Conclusion

It was observed that PPF occurred in a shorter period of time since the last surgery in patients with type 2 diabetes mellitus and arterial hypertension compared to those without comorbidities. A longer hospitalization time was correlated with greater infection of the new implant and worse prognosis. Walking ability was seriously impaired in a large percentage of patients. We found variables that could explain the large dispersion of the data. Our results were similar to those reported in the literature and give rise to further studies on the identified variables.

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