

CORRELATION BETWEEN AVASCULAR NECROSIS AND EARLY STABILIZATION OF PROXIMAL FEMORAL FRACTURES IN CHILDHOOD

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ABSTRACT

Objective: We developed this study with the aim of evaluating the results from treating patients with proximal femoral fractures, in a series of cases. We sought to observe the influence of the most prevalent complications on the final results after a minimum follow-up of two years. We especially considered the relationship between establishment of avascular necrosis and the time between the accident and the therapeutic intervention. *Method:* We retrospectively studied proximal extremity fractures of the femur in 29 patients under 14 years of age between 1988 and 2007. We analyzed the following variables: sex, age, mechanism of injury, fracture classification (Delbet), treatment administered, complications (pseudarthrosis, varus deformity, leg length discrepancy and avascular necrosis), duration of surgery and results (Ratliff). We carried out individual descriptive analysis on each variable. The tests were used in accordance with the premise that normality applied. For the evaluation, we used Fisher's exact test. *Results:* Five patients (17.2%) had avascular necrosis, and three of them (60.0%) were over 10 years of age. 73.3% of the patients treated within the first 24 hours showed good results. The most common cause of fractures was traffic accidents (44.8%). The best results were observed among patients who were treated surgically. 41.4% developed some type of complication. *Conclusions:* Among the 29 patients treated, 58.6% had good, 27.6% had regular and 13.8% had poor results, according to the Ratliff criteria. When conservative treatment was applied, only 17.0% had good results, while 69.3% had good results from surgical intervention. Likewise, 73.3% of the results were good results when surgery was performed within the first 24 hours and only 42.8% of the results were good among patients who underwent surgery after this period. Patients operated within the first 24 hours developed necrosis of the femoral head in 13.3% of cases, while 21.4% of those operated after this period developed this complication.

Keywords – Femoral fractures/epidemiology; Femoral fractures/surgery; Child

INTRODUCTION

Proximal femoral fractures in children are serious and associated with high complication rates. They are generally caused by trauma involving high kinetic energy, such as falls from a height, traffic accidents and practicing radical sports. Such events may also cause significant injuries to soft tissues (nerves, arteries, viscera and the genitourinary tract)⁽¹⁻⁴⁾. Fortunately,

these injuries are infrequent during childhood and represent less than 1% of all fractures that affect the immature skeleton⁽⁵⁾.

From outset of the treatment, the approach adopted should aim to prevent immediate complications and, especially, those that may occur later on, such as pseudarthrosis, coxa vara, defective consolidation and premature growth plate closure⁽⁶⁻⁸⁾.

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Among these avascular necrosis is the only one that, from the moment when it starts its course, cannot be avoided, even when it is rapidly and adequately attended to. It needs to be emphasized that, depending on the extent and topography of this condition, it may give rise to unfavorable future results. Considering that in this age group, the proximal femur is developing rapidly, the deformities resulting from these complications may worsen with age progression and growth.

The correlation between the appearance of avascular necrosis of the proximal femur and the time that elapses until the fractures stabilize is unclear in the literature. Some authors have considered that the development of this necrosis would become established at the time of the accident, and that the initial displacement between the fractured fragments would be the determining factor for occurrences of complications, because of the damage to the circulation in this region. When surgical stabilization is needed for fractures of the femoral neck in adult individuals, it is known that early institution of therapy is the determining factor for minimizing the rate of avascular necrosis. However, this premise has still not been widely studied in children.

We developed this study with the aim of evaluating the results from treating patients with proximal extremity fractures of the femur, in a series of cases. We sought to observe the influence of the most prevalent complications on the result, after a minimum period of two years of follow-up. We especially considered the relationship between establishment of avascular necrosis and the time between the accident and the therapeutic intervention.

MATERIAL AND METHODS

The design for this study was firstly submitted for evaluation and approval by the Research Ethics Committee of our institution.

This was a retrospective study in which we presented 29 patients under 14 years of age, with proximal extremity fractures of the femur that were treated between 1988 and 2007. Out of this total, 18 (62.1%) were male and 11 (37.9%) were female. The patients' mean age was 8.68 years, with a range from six months to 14 years (Table 1).

Traffic accidents were the main cause of injuries, involving 13 patients (44.8%). This was followed by falls from a height, with 11 patients (37.9%); accidents with

bicycles, with three patients (10.3%); and convulsive crises, with two patients (6.9%).

To characterize these injuries, we used the classification of Delbet *apud* Colonna⁽⁹⁾, and its distribution is illustrated in Figure 1.

All the patients underwent treatment for their fractures at the surgical center, under general anesthesia, in accordance with their age and the characteristics of the fracture. Non-surgical treatment was administered, consisting of construction of a plaster cast from the pelvis to the foot, preceded by closed reduction of the fracture when necessary. Surgical stabilization was achieved by means of internal fixation with spongy, cannulated or sliding screws (Figure 2). All the patients were kept immobilized with the plaster cast from the pelvis to the foot for between six and eight weeks, and the consolidation of the fractures was monitored over this period.

The minimum period of outpatient follow-up was two years and the maximum was eight years, with a mean of three and a half years. The evaluation on the results was based on the descriptive classification proposed by Ratliff⁽¹⁰⁾:

– Good: patients without pain, with minimal restrictions on hip movements, normal day-to-day activities and normal radiological images, or with slight deformity of the femoral neck.

– Regular: patients with occasional pain, significant hip restriction but with a range of motion greater than 50%, normal day-to-day activities, significant deformity of the femoral neck and slight signs of necrosis of the femoral head.

– Poor: patients with debilitating pain, hip range of motion of less than 50%, restrictions on activities and severe necrosis of the femoral head, with significant hip arthrosis.

For the descriptive analysis, the following were calculated: mean, standard deviation, median for age and length of follow-up. Through applying Fisher's exact test, we sought to establish correlations between the results obtained and the following parameters: classification, type of treatment and time that elapsed until the treatment (up to 24 hours and > 24 hours). In the same way, we applied Fisher's exact test with the aim of seeking to establish correlations between the presence of avascular necrosis of the femoral head and the following parameters: classification, type of treatment and time that elapsed until the treatment (up to 24 hours and > 24 hours).

Table 1 – The 29 patients and the characteristics of the fractures studied

Name	Sex	Age	Trauma mechanism	Classification	Treatment	Fixation method	Coxa Vara	ANISO	Necrosis	Follow up	Surgery	Result
MAJ	F	5+6	Fall from height	II	ORIF	CS + KW				5	+	G
CFA	M	10	Run over	II	PFPC		+			3	-	R
CJG	M	12	Run over	II	ORIF	CS				4	+	G
CSC	F	14	Run over	II	PFPC				I	2	+	P
MMS	F	7	Fall from height	II	ORIF	CS				7+6	+	G
ECM	F	11+4	Run over	II	ORIF	CS				5	+	G
RJG	M	6+2	Run over	II	ORIF	CS	+	+		3+6	+	R
WPD	M	7+6	Run over	II	ORIF	CS				3+6	+	P
FSB	M	6+9	Bicycle accident	II	ORIF	CS				4	+	G
RLO	F	7+6	Run over	III	PFPC	CS	+			3	-	R
DAS	M	7	Fall from height	II	ORIF	CS				8	+	G
SS	M	14	Convulsive crisis	IV	ORIF	CS + KW				7+6	-	G
GTS	F	0+6	Convulsive crisis	I	PFPC		+		+	2	-	M
IMC	F	5+9	Fall from height	II	PFPC					3+6	+	G
IR	M	12+11	Fall from height	II	ORIF	CS			+	3+6	-	R
WLS	M	12	Run over	II	ORIF	CS				3	-	G
RRP	M	8	Fall from height	II	ORIF	CS				2	-	G
MAS	F	5	Fall from height	II	ORIF	CS				2	+	G
JCS	M	7	Fall from height	III	ORIF	CS	+	+		2+1	-	R
MMS	M	5	Fall from height	III	ORIF	CS				2	+	G
THBS	M	14	Run over	III	ORIF	CS				3	-	G
CFS	M	14	Bicycle accident	II	ORIF	CS				2	+	G
AAR	F	14	Run over	I	ORIF	KW			+	2	+	R
DS	M	5	Fall from height	IV	ORIF	CS	+	+		4	-	G
VBSO	M	6	Fall from height	III	ORIF	CS				5	+	G
SOS	F	12	Run over	IV	ORIF	Plate + screw				5	-	R
RS	M	7	Run over	II	ORIF	CS	+	+		2	-	G
LRFS	F	8	Bicycle accident	II	ORIF	CS		+	+	2	-	P
JSC	M	7	Run over	II	PFPC	CS	+	+		6+2	-	R

Source: Data gathered from 29 patients with proximal extremity fractures of the femur.

M: male, F: female, Classification: according to Delbet and Colonna, Treatment: type: ORIF (open reduction and internal fixation), PFPC (pelvis-to-foot plaster cast), Treatment method: CS (cannulated screw), KW (Kirschner wire), plate + screw (DHS, dynamic type), Coxa vara: hip evolution in varus (+) or not in varus (-), ANISO: presence of leg length discrepancy (+), absence of this abnormality (-), Necrosis: presence of aseptic necrosis of the femoral head (+) absence of this condition (-), follow up: length of follow-up, Surgery: performed within the first 24 hours (+), performed after this period (-), result: G – good, R – regular, P – poor.

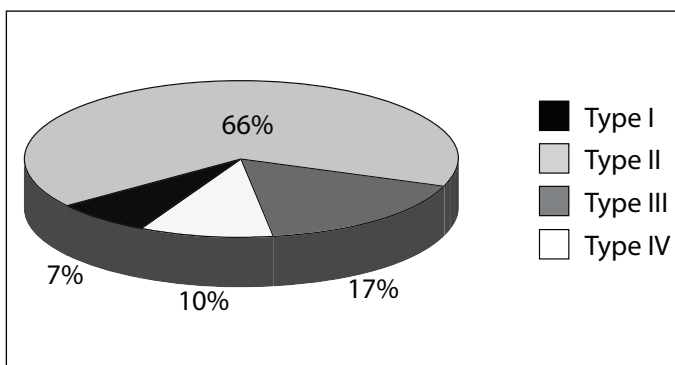


Figure 1 – Distribution of fracture patterns according to Delbet and Colonna classification

RESULTS

In our sample, surgical treatment predominated (79.3%) in relation to non-surgical treatment (20.7%). With regard to the time that elapsed until the treatment, 15 patients (51.7%) underwent the surgical procedure within the first 24 hours.

Among the 29 patients treated, 58.6% of the results were good, 27.6% were regular and 13.8% were poor, according to the criteria of Ratliff⁽¹⁰⁾ (Table 2).

Considering the non-surgical treatment, 17.0% of the results were good, 50.0% were regular and 33.0%

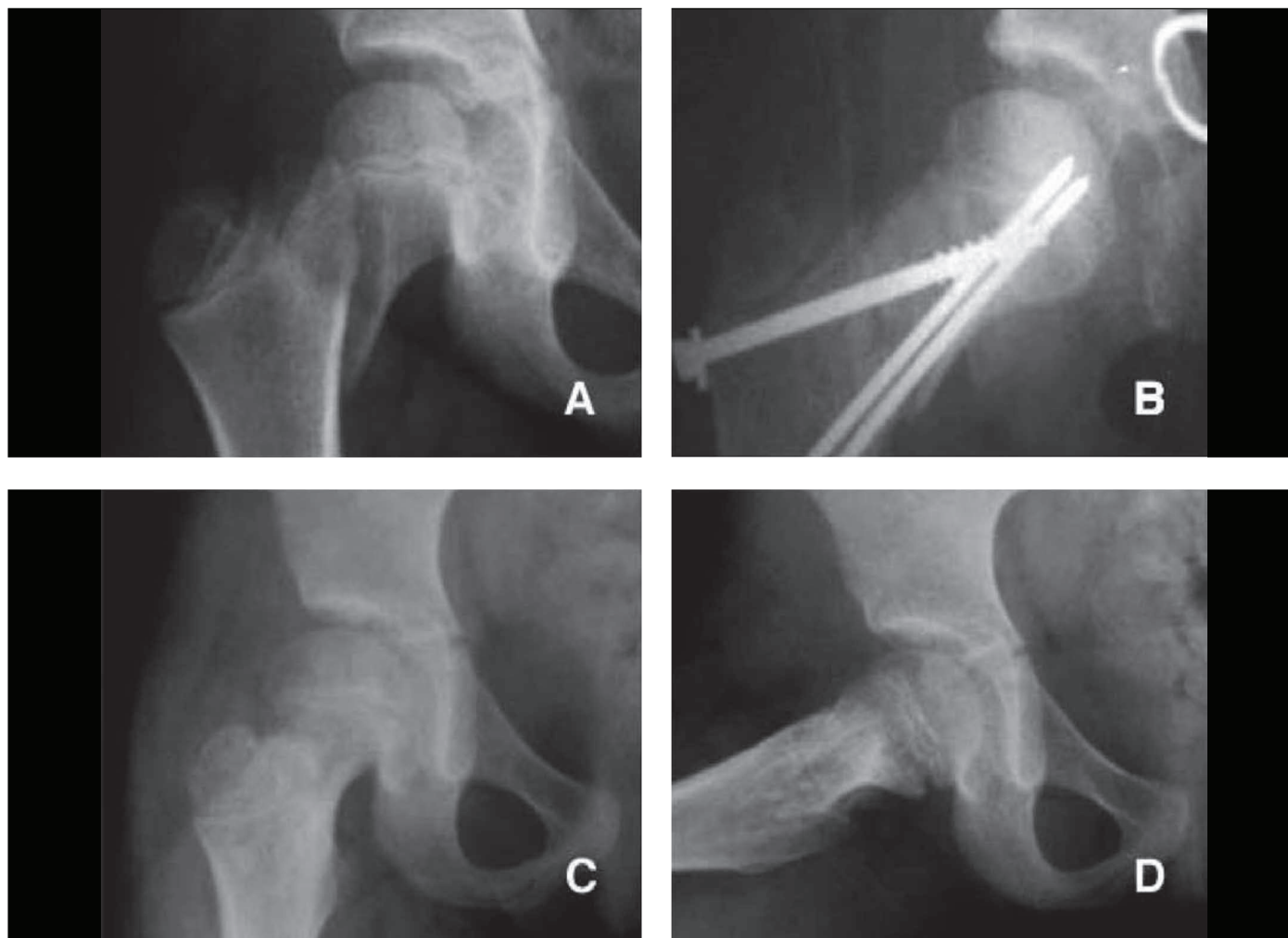


Figure 2 – Patient MAJ, a female aged five years and six months, presenting proximal fracture of the right femur. (A) Before the operation. (B) Immediately after the operation. (C and D) Five years after the operation, after removal of the synthesis material.

Table 2 – Delbet and Colonna classification correlated with the results based on Ratliff parameters

Classification versus result	Good	Regular	Poor	Total
I	0	1 (50 %)	1 (50 %)	2
II	12 (63.5%)	4 (21%)	3 (15.7 %)	19
III	3 (60%)	2 (40%)	0	5
IV	2 (66.7%)	1 (33.3%)	0	3
Total	17 (58.6%)	4 (13.7%)	8 (27.7%)	29

were poor. Among those who were surgically treated, 69.3% of the results were good, 21.0% were regular and 8.7% were poor.

We observed that 12 (41.4%) of our patients evolved with complications, among whom eight patients (27.6%) presented coxa vara, six (20.7%) had leg length discrepancy and five (17.2%) had avascular necrosis of the proximal femur, of which one (3.4%) was type IA of

Delbet *apud* Colonna⁽⁹⁾, two (6.9%) were type II and two (6.9%) were type III.

In relation to the time that elapsed until the surgery, 73.3% of the results were good, when the surgery was performed within the first 24 hours. For the individuals who underwent the operative therapy only after this period, 42.8% presented good results.

A comparative analysis was conducted between the types of fracture, in accordance with the classification of Delbet *apud* Colonna⁽⁹⁾, showing whether the femoral head evolved to necrosis (Table 3).

In relation to type of treatment, the necrosis rate among the patients treated only with a plaster cast from pelvis to foot was 34.0%. Among the patients who underwent open reduction and internal fixation, 13% evolved with necrosis.

Among the patients who underwent surgery within the first 24 hours, 13.3% evolved with necrosis of the femoral head, while among those who underwent an operation after this period, 21.4% had this complication.

Table 3 – Distribution of the fractures according to Delbet and Colonna classification, correlated with presence or absence of aseptic necrosis of the femoral head

Type	No	Yes	Total
I	0	2 (100%)	2
II	16 (84.2%)	3 (15.8%)	19
III	5 (100%)	0	5
IV	3 (100%)	0	3
Total	24 (82.8%)	5 (17.2%)	29

Delbet and Colonna classification – Patient distribution

We did not observe necrosis of the femoral head among the patients who achieved good results. We found three cases of necrosis (75.0%) among those whose results were poor. Among the results considered regular, two (25%) evolved with necrosis.

DISCUSSION

According to data from the Seade foundation, being run over is the third biggest cause of death among children in the state of São Paulo. These numbers have been falling over the last decade, but they still represent a potential source of high-energy trauma for the ages ranges of 5-9 and 10-14 years. In our case series, the patients were predominantly victims of being run over and falling from a height, which coincides with what is reported in the literature⁽¹¹⁻¹³⁾. However, we also noted in our study that there were four patients whose injuries occurred through lower-energy trauma (falling from a bicycle and convulsive crises), which is uncommon.

We found that the worst results were in two cases of transphyseal injuries (type I). Among individuals with fractures of types II, III and IV, we noted good results in two thirds of the cases. However, we emphasize that because of the low number of type I fractures, we did not reach a statistically significant result when we used Fisher's exact test ($p = 0.446$).

Fractures of the femoral neck often evolve with circulatory damage to the femoral head because the blood flow is compromised both inside and outside of the bone. Although 11 to 40% of these fractures are accompanied by capsule rupture, most of them evolve with hemarthrosis, which produces an increase in intracapsular pressure. This phenomenon may

increase the risk of avascular necrosis, according to some authors.

We do not perform arthrocentesis routinely to minimize the intracapsular pressure. There are no relevant indications in the orthopedic literature that would support the use of this procedure to reduce necrosis rates. It is believed that capsule rupture is associated with high-energy trauma, as postulated by Crawford *et al*⁽¹⁴⁾, who found greater blood flow to the femoral head in fractures classified as Garden I and II, among elderly people. In fact, fractures classified as Garden III and IV in adults present necrosis rates of 75% and 100%, respectively, when the treatment is instituted more than 24 hours after the accident.

The best results in this series were also observed in individuals who were treated surgically. These patients presented satisfactory evolution in 69.3% of the cases, and this correlation was statistically significant when Fisher's exact test was applied ($p = 0.045$). Although 64.71% of the patients with good evolution were in the group with an early operation, this finding did not present statistical significance ($p = 0.183$).

In our study, we sought to evaluate the factors that were potentially associated with the appearance of avascular necrosis. It was not possible to establish a correlation between occurrences of this condition and the therapeutic method used ($p = 0.651$).

As long ago as 1936, Mitchell⁽¹⁵⁾ emphasized the importance of early treatment of proximal femoral fractures, with the aim of improving the prognosis. In our study, we sought to correlate possible reductions in the rate of avascular necrosis with fracture stabilization within 24 hours, as presumed by this author. However, we did not observe any correlation between occurrences of this complication and the time that elapsed between the fracture event and the treatment ($p = 0.269$). These results coincide with reports by other authors⁽¹⁶⁾, who also did not observe this association. The only reported predictive factors for the development of necrosis are the patient's age and the type of fracture^(10,13,17).

However, from individual analysis on our surgically treated patients who evolved with unfavorable results and avascular necrosis (patient numbers 13 and 28), we saw that by applying the prognostic classification of Boitzy⁽¹⁸⁾, the displacement between

the fractured fragments on the initial radiographs was such that the contact between them was less than 50%. This meant that the high kinetic energy had dissipated throughout the proximal region of the femur, thereby causing circulatory damage at the time of the accident.

Only five of our patients (17.2%) developed necrosis of the proximal femur, of whom three (60.0%) presented regular results and only two (40.0%) presented unfavorable evolution. However, when we correlated our functional findings with the presence of necrosis, we found a statistically significant association between the two variables, since there was a greater number of good results (70.83%) in the group that did not develop this complication ($p = 0.002$).

The study by Ratliff⁽¹⁰⁾ affirmed that there was no way of preventing or avoiding the development of avascular necrosis, which was observed in 42.0%⁽⁶⁾. Nonetheless, more recently, necrosis has been reported in smaller proportions. The factors most commonly implicated in the appearance of this complication have been the type of fracture, initial displacement, treatment used, patient's age and time that elapsed until the treatment^(13,16,19).

We observed in our sample that the majority of the cases of necrosis (60.0%) occurred in patients over the age of 10 years, which coincides with other reports^(10,13,17). However, this finding did not present statistical significance. On the other hand, we found a positive association between the type of fracture and occurrences of necrosis, given that necrosis was more common in fractures of Delbet type I *apud* Colonna⁽⁹⁾ ($p = 0.047$). Moon⁽¹⁶⁾ established that the risk of necrosis for type I, II and III fractures was respectively fifteen, six and four times greater than in type IV fractures.

Because these are uncommon injuries, the published data on this topic is limited to retrospective series with few cases. Over recent decades, there has been a series of innovations within orthopedic

surgery, such as the introduction of techniques that are less traumatic, the use of image intensifiers, improvements in the responsiveness of hospital services and improvements in synthesis materials. All these factors have caused changes in the evolution and prognosis for these fractures, such as the lower rates of avascular necrosis that have been reported in some recent published papers^(16,17).

Through increasing our sample size, we hope to be able to better establish some points that were unclear in the present analysis, such as the importance of early treatment and the type of treatment used. In this way, we will be able to institute therapeutic protocols aimed towards minimizing the complications and improving the long-term functional results.

CONCLUSIONS

Among the 29 patients treated, there were 17 patients with good results (58.6%), eight with regular results (27.6%) and four with poor results (13.8%), according to the Ratliff classification.

Through non-surgical treatment, there was one patient with a good result (17.0%), three with regular results (50.0%) and two with poor results (33.0%), according to the Ratliff classification.

Through surgical treatment, there were 16 patients with good results (69.3%), five with regular results (21.0%) and two with poor results (8.7%), according to the Ratliff classification.

When the surgery was performed within the first 24 hours, 73.3% of the results were good.

Among the patients who underwent operative therapy after the first 24 hours, the rate of good results was 42.8%.

Among the patients who underwent surgery within the first 24 hours, 13.3% evolved with necrosis of the femoral head, while this complication occurred in 21.4% of those who were operated after this period.

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