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Original Article

Clinical evaluation of patients submitted to osteogenic distraction in the lower limb at a university hospital☆

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ABSTRACT

Objective: To evaluate the clinical characteristics from patients submitted to osteogenic distraction to correct bone gap at a university hospital.
Methods: Retrospective transversal study, with a convenience sample, from 2000 to 2012, evaluating clinical aspects of patients treated, submitted to osteogenic distraction (bone transport) with Ilizarov's external fixation device. The chi-squared, Fisher's, and Mann–Whitney's *U* tests were used with a 5% level of significance ($p < 0.05$).
Results: 33 patients were studied, of whom 28 men (84.8%). The more frequent age was from 21 to 40 years. Most patients were from the metropolitan region of the capital (57.6%). The leg was the most affected limb (75.8%), and the left side was the most affected (66.7%). The most common cause was infected pseudoarthrosis (75.8%). The most common bone transportation type was bifocal (75.8%). Mean previous surgery at others institutions were 2.62 (1.93 standard deviation), and mean surgeries after treatment were 1.89 (1.29 standard deviation). Ilizarov's external fixation device was used for 1.94 years (1.34 mean deviation), from one to six years. The most common complications were pin infection (57.6%), equinus (30.3%), deep infection (24.2%), and shortening (21.2%).
Conclusion: Osteogenic distraction for bone gaps were more frequent in young adults, men, in the leg, with bifocal transportation, after several previous surgeries, treated for a mean of two years, with many complications (infections were the most common).

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Avaliação clínica de pacientes submetidos à distração osteogênica no membro inferior em hospital universitário

Palavras-chave:
Pseudoartrose

RESUMO

Objetivo: Avaliar as características clínicas dos pacientes submetidos à distração osteogênica por falha óssea em hospital universitário.

☆ Study conducted at the Department of Orthopedics and Traumatology, Hospital das Clínicas, Faculdade de Medicina, Universidade Federal de Goiás, Goiânia, GO, Brazil.

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Osteogênese por distração
Técnica de Ilizarov

Métodos: Estudo transversal, retrospectivo, com amostra de conveniência, de 2000 a 2012, das características clínicas de pacientes tratados e submetidos à distração osteogênica (transporte ósseo) com uso de fixador externo circular tipo Ilizarov. Foram usados os testes de qui-quadrado, exato de Fisher e U de Mann–Whitney, com nível de significância de 5% ($p < 0,05$).

Resultados: Foram 33 casos, 28 homens (84,8%). A idade mais frequente foi entre 21 e 40 anos. A maioria dos pacientes (57,6%) era da região metropolitana. O segmento mais afetado foi a perna (75,8%) e o lado foi o esquerdo (66,7%). A causa mais frequente foi a pseudoartrose infectada (75,8%). O tipo de transporte ósseo feito foi principalmente o bifocal (75,8% dos casos). A média de procedimentos prévios em outra instituição foi de 2,62 cirurgias (desvio padrão de 1,93) e a dos feitos após o início do tratamento foi de 1,89 cirurgia (desvio padrão de 1,29). O tempo de uso de fixador externo foi de 1,94 ano (desvio padrão de 1,34), com mínimo de um ano e máximo de seis. As quatro complicações mais encontradas foram infecção de base de pinos (57,6% dos casos), equino (30,3%), infecção profunda (24,2%) e encurtamento (21,2%).

Conclusão: A necessidade de distração osteogênica por falhas ósseas foi mais frequente em adultos jovens, homens, na perna, com transporte bifocal, após múltiplas cirurgias prévias, com média de aproximadamente dois anos de tratamento e com várias complicações (as infecções foram as principais).

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Introduction

Injuries to the appendicular skeleton due to high-energy trauma show a high prevalence of severe bone lesions, which can develop complications such as delayed union, pseudarthrosis, infection, malunion, or bone gap. The challenge posed by the treatment of bone gaps has instigated researchers to find appropriate solutions for the different types of injury.[1]

Among the main techniques used for diaphyseal bone loss reconstruction are the use of traditional bone graft, tibialization of the fibula, vascularized bone transposition, and bone transport (distraction osteogenesis).[2] The latter is divided into: (1) isolated shortening; (2) shortening followed immediately by stretching through distraction in the focus of pseudoarthrosis after a short compression period; (3) shortening followed by stretching away from the focus of pseudoarthrosis through corticotomy; and (4) progressive vertical segmental bone transport after corticotomy.

The first reports describing limb stretching were provided by Codvilla,[3] in 1905, and the use of external fixator to produce bone lengthening began in 1913, with Ombredanne.[4] However, this technique did not gain widespread acceptance until Ilizarov identified the mechanical and physiological factors governing bone regeneration during distraction osteogenesis. In 1969, Ilizarov and Ledyaev[5] were able to fill the bone defect and extend the limb after debridement of the infected bone and, at the same time, correct deformities. Their method was revolutionary by the standards of orthopedic treatments of the time.[1,6,7]

Ilizarov recommended this technique for correcting bone defects secondary to congenital abnormalities, tumor resections, traumatic bone loss, or as a result of debridement in osteomyelitis with unviable bone tissue.[8,9]

This study aimed to evaluate the clinical characteristics of patients undergoing distraction osteogenesis due to bone gap in a university hospital.

Methodology

This was a cross-sectional study, with a retrospective convenience sample, from 2000 to 2012, which included treated patients who underwent distraction osteogenesis (bone transport) using an Ilizarov circular external fixator. The present research was approved by the University Hospital Ethics Committee.

Data were collected from a review of medical charts and stored in an Excel 2007 spreadsheet. Statistical analysis was performed using SPSS for Windows, version 16.0. The chi-squared test, Fisher's exact test, and the Mann–Whitney *U* test were used to assess the influence of the variables on the types of complications, with a significance level of 5% ($p < 0.05$).

Review of medical charts retrieved 33 cases treated in this period using this method. The following data were collected: sex; age of patients at the beginning of treatment, a variable which was divided into age groups; area of origin; affected segment (tibia and/or femur); side; cause; type of bone transport performed (bifocal, or trifocal convergent or trifocal tandem bone transport); number of previous surgeries and number of surgeries after the treatment was instituted; time of external fixator use; and complications observed during treatment.

Complications were specified as: pin infections, deep infection, equinus, knee flexion, ROM limitation, axial deviation, re-fracture, amputation or disarticulation, shortening, impingement of the soft tissues, and any complication other than those mentioned. These were grouped into complications that did not require surgery for correction (Group 1),

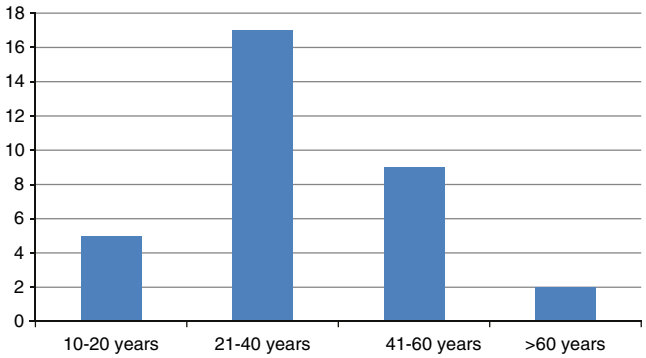

Fig. 1 – Distribution according to age groups.

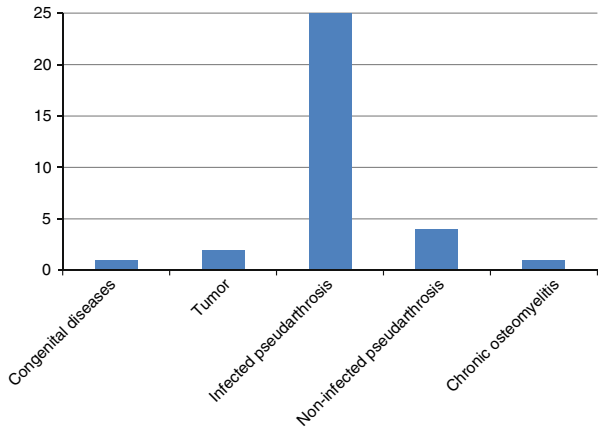

Fig. 2 – Distribution of cases treated according to cause.

those that required surgery for correction (Group 2), and those considered as sequelae due to treatment failure (Group 3).

Results

Thirty-three subjects were included, 28 men (84.8%) and five women (15.2%). Age was stratified into groups (Fig. 1); the most frequent age group was 21–40 years.

Most patients (57.6%) came from Greater Goiânia; the remainder came mainly from countryside Goiás. The most affected segment was a single leg injury (75.8%), and most affected side was the left side in two thirds of cases (66.7%).

The causes that led to the choice of treatment method were stratified into five subgroups (Fig. 2); the most frequent was infected pseudarthrosis (75.8% of cases).

The type of bone transport (Fig. 3) was mainly bifocal (75.8% of cases).

The variables were distributed and organized in Table 1.

The number of previous surgeries performed and those made during the treatment through bone transport method are listed in Table 2. Mean number of previous procedures at other institutions was 2.62 (standard deviation 1.93) and that of the procedures performed after treatment onset was 1.89 (standard deviation 1.29). Mean time of external fixation device use was 1.94 years (1.34 standard deviation), ranging from 1 to 6 years.

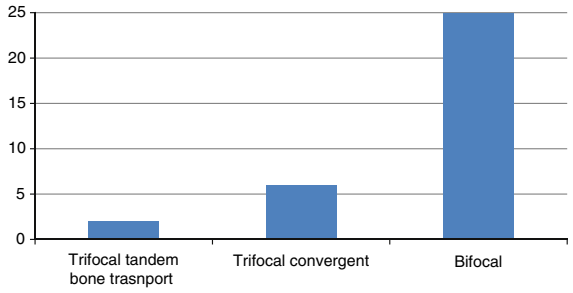

Fig. 3 – Type of bone transport performed.

The most common complications were pin infection (57.6%), equinus (30.3%), deep infection (24.2%), and shortening (21.2%). There was a positive correlation between complications and the number of surgical procedures ($p = 0.041$) and time of external fixation device use ($p = 0.012$)

Table 1 – Distribution of the sample according to the variables.

Factor	*n*	%
Age		
10–20[a]	5	15.2
21–40[a]	17	51.5
41–60[a]	9	27.3
>60[a]	2	6.1
Total	33	100.0
Origin		
Greater Goiânia	19	57.6
Countryside Goiás	12	36.4
Other states	2	6.1
Total	33	100.0
Sex		
Male	28	84.8
Female	5	15.2
Total	33	100.0
Topography		
Femur	6	18.2
Tibia	25	75.8
Tibia and femur	2	6.1
Total	33	100.0
Side		
Right	11	33.3
Left	22	66.7
Total	33	100.0
Causes		
Congenital diseases	1	3.0
Tumor	2	6.1
Infected pseudoarthrosis	25	75.8
Non-infected pseudarthrosis	4	12.1
Chronic osteomyelitis	1	3.0
Total	33	100.0
Type of transport		
Bifocal	25	75.8
Trifocal convergent	6	18.2
Trifocal tandem bone transport	2	6.1
Total	33	100.0

[a] Years.

Table 2 – Mean and standard deviation of the number of surgeries in the sample.

Factor	n	Mean	SD	Min	Max
Number of prior surgeries	29	2.62	1.93	1	10
Number of revisions	28	1.89	1.29	1	6

Table 3 – Distribution of the sample according to complications.

Factor	n	%
Complications		
1. Screw infection	19	57.6
2. Deep infection	8	24.2
3. Equinus	10	30.3
4. Knee flexion	2	6.1
5. ROM limitation	1	3.0
6. Axial deviation	6	18.2
7. Repeated fracture	1	3.0
8. Amputation or disarticulation	3	9.1
9. Shortening	7	21.2
10. Soft tissue impingement	2	6.1
11. Others	5	15.2

(Fig. 4). Complications were listed and compared in Tables 3–5, in which they were divided into three groups, not including superficial pins infections: group 1, minor complications that did not require further surgery for correction (e.g., mild equinus); group 2, complications requiring surgical correction (e.g., pronounced axial deviation); and group 3, complications requiring amputation (e.g., serious, deep infections).

Discussion

Distraction osteogenesis is a surgical technique widely used in orthopedic surgery for the treatment of various pathological conditions such as limb length discrepancy, bone deformities, and large bone defects secondary to trauma, infection, or resection of malignant tumors, a profile similar to that observed in the present study. The basic principle of the technique is a process of bone regeneration from the gradual distraction of two vascularized surfaces, thus forming new bone tissue.[6]

New bone is generated in the space between two bone segments, which are gradually and progressively distracted. The distraction rate may vary according to the distraction site, usually around 11 mm/day. Distraction can be done with an external fixator, such as a circular Ilizarov fixator or a longitudinal monoplanar fixator, which fills the interim defect, whereas in the place subjected to distraction, a new bone formation occurs, known as bone regenerate.

One limitation of this technique is the long time required for the newly formed bone tissue mature, mineralize, and

Table 4 – Distribution of complications per group according to the sample.

Factor	n	%
Complication 1		
No	12	36.4
Yes	21	63.6
Total	33	100.0
Complication 2		
No	13	39.4
Yes	20	60.6
Total	33	100.0
Complication 3		
No	29	87.9
Yes	4	12.1
Total	33	100.0

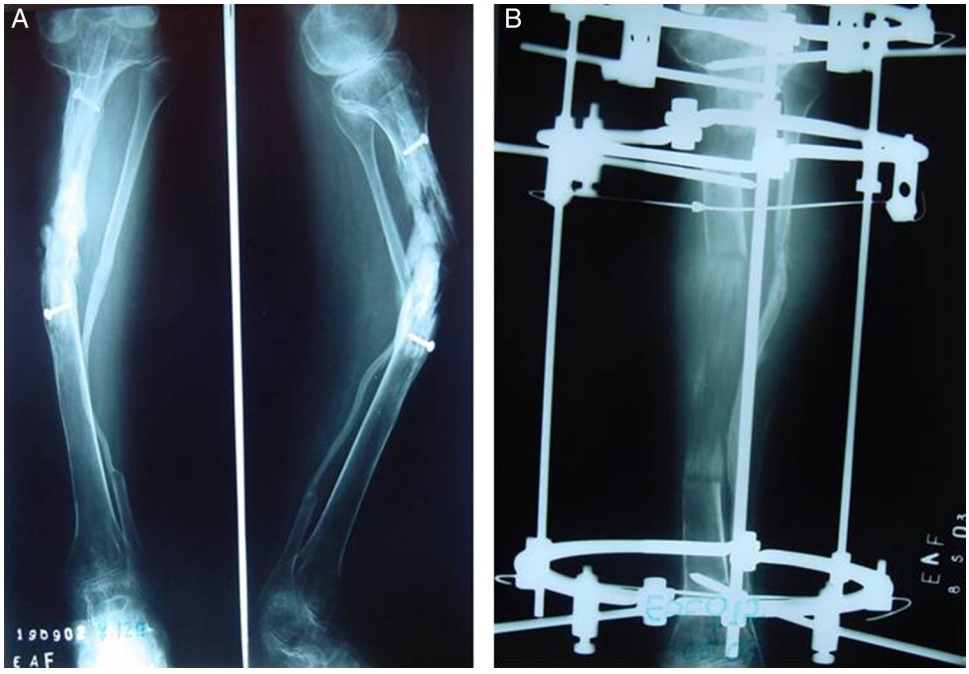

Fig. 4 – Radiographs in anteroposterior and profile of a chronic osteomyelitis that had been operated several times (A) and after diaphysectomy and bone transport to fill the gap (B).

Table 5 – Comparison of the variables regarding the types of complications.

Complications	Complication 1		p	Complication 2		p	Complication 3		p
	n	%		n	%		n	%	
Age									
10–20[a]	4	19.0		4	20.0		0	0.0	
21–40[a]	10	47.6		11	55.0		3	75.0	
41–60[a]	6	28.6		4	20.0		1	25.0	
>60[a]	1	4.8		1	5.0		0	0.0	
Total	21	100.0	0.815	20	100.0	0.575	4	100.0	0.691
Origin									
Greater Goiânia	16	76.2		12	60.0		1	25.0	
Countryside Goiás	5	23.8		7	35.0		3	75.0	
Other states[b]	0	0.0		1	5.0		0	0.0	
Total	21	100.0	0.009	20	100.0	0.918	4	100.0	0.225
Sex									
Male	19	90.5		16	80.0		3	75.0	
Female	2	9.5		4	20.0		1	25.0	
Total	21	100.0	0.328	20	100.0	0.625	4	100.0	0.500[a]
Topography									
Femur	4	19.0		3	15.0		2	50.0	
Tibia	15	71.4		16	80.0		2	50.0	
35 + 41.16	2	9.5		1	5.0		0	0.0	
Total	21	100.0	0.520	20	100.0	0.780	4	100.0	0.201
Side									
Right	8	38.1		7	35.0		1	25.0	
Left	13	61.9		13	65.0		3	75.0	
Total	21	100.0	0.703	20	100.0	1.000	4	100.0	1.000[a]
Causes									
Congenital diseases	1	4.8		1	5.0		0	0.0	
Tumor	1	4.8		2	10.0		0	0.0	
Infected pseudoarthrosis	15	71.4		13	65.0		3	75.0	
Non-infected pseudarthrosis	3	14.3		3	15.0		1	25.0	
Chronic osteomyelitis	1	4.8		1	5.0		0	0.0	
Total	21	100.0	0.796	20	100.0	0.445	4	100.0	0.882
Type of transport									
Bifocal	15	71.4		14	70.0		4	100.0	
Trifocal convergent	5	23.8		5	25.0		0	0.0	
Trifocal tandem bone transport	1	4.8		1	5.0		0	0.0	
Total	21	100.0	0.520	20	100.0	0.446	4	100.0	0.483
	Mean	Median	p	Mean	Median	p	Mean	Median	p
Number of prior surgeries	2.84	2.0	0.599	2.88	2.0	0.368	3.50	4.0	0.041[b]
Number of revision surgeries	2.11	1.00	0.362	2.11	1.00	0.362	2.0	2.0	0.544[b]
Time of use	2.33	2.0	0.12	2.15	2.0	0.263	2.25	1.00	0.549[b]

Chi-squared test.

[a] Fisher's exact test.

[b] Mann–Whitney's *U* test.

finally consolidate. The external fixator should be maintained for an extended period, until the consolidation, which can lead to surgical, social, and psychological complications.[6,10–12] On average, the present patients underwent over four surgeries until the end of treatment, using a dynamic fixator for 2 years and with several complications, but approximately 90% of them did not experience serious sequelae. This method often eliminates the need for surgery for skin and amputation coverage, as the skin accompanies the transported bone; it also allows for the correction of bone deformities and dysmetria, and cures infections.

This method is based on the principle of "traction tension", which has allowed for bone lengthening in a new biological vision, but also has lead to the development of a new technique called compression-distraction osteosynthesis. Technically, bone transport is difficult to perform and requires careful monitoring of the bone pathway. It often requires additional surgeries to correct deviations in the coupling of the transported fragments or bone graft placement to increase contact at those sites.[13–20] Numerous complications have been described, including vascular changes that can result in

amputation, similar to what was observed in the present sample.

In many cases, ablative techniques such as limb amputation are the best option for the treatment of bone loss, since they obtain results faster and are less costly to the patient and the health system. During the choice of treatment, in addition to biological aspects, social and psychological factors of the patient should be analyzed. The biological factors that need to be considered include blood supply, joint and muscle function, and presence, location, and severity of nerve damage. Reconstruction is indicated only if it can provide a good functional prognosis and if patient has good psychosocial condition.[1,5]

During distraction osteogenesis, both bone and soft tissues are stretched; this can help spontaneous closure of soft tissue injuries without the need for skin coverage through plastic surgery. Some authors consider that the restoration of the envelope of soft parts must be done before or at the time of bone reconstruction.[7] The use of an Ilizarov external fixator allows for the simultaneous correction of pseudarthrosis, bone gap, shortening, and angular deformities; it also provides an adequate environment for resolution of the infection, evidenced by numerous publications as superior to other methods of treatment, which was confirmed by the present results.[20–23]

Conclusion

The need for distraction osteogenesis due to bone defects was most frequent in young adults (21–40 years), male, coming from Goiânia, for the tibia, due to infected pseudarthrosis after multiple previous surgeries. The most used method of transport was bifocal, with a mean of approximately 2 years of treatment, and with several complications, of which infections were the most frequent. Most patients did not present serious sequelae at the end of treatment.

Conflicts of interest

The authors declare no conflicts of interest.

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