Original Article

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

Francisco Macruz Baltazar Sampaio, Leilane Passoni Marçal, Diogo Gontijo dos Reis, Adolfo Watanabe Kasuo, Carlos Eduardo Cabral Fraga, Frederico Barra de Moraes

Universidade Federal de Goiás (UFG), Faculdade de Medicina, Goiânia, GO, Brazil

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).

© 2016 Sociedade Brasileira de Ortopedia e Traumatologia. Published by Elsevier Editora Ltda. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

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

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

Palavras-chave: Pseudoartrose
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 transplantation, 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 pseudarthrosis after a short compression period; (3) shortening followed by stretching away from the focus of pseudarthrosis through corticotomy; and (4) progressive vertical segmental bone transport after corticotomy.

The first reports describing limb stretching were provided by Codvila,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 Ledyaev⁵ 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),
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.

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               | 5  | 15.2|
| 21–40               | 17 | 51.5|
| 41–60               | 9  | 27.3|
| >60                 | 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 pseudoarthrosis | 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|

* Years.
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.1

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

Discussion

Distraction osteogenesis is a surgical technique widely used in orthopedic surgery for the treatment of various pathological

(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).

**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|

**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).
finally consolidate. The external fixator should be maintained for an extended period, until the consolidation, which can lead to surgical, social, and psychological complications. On average, the present patients underwent 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. Numerous complications have been described, including vascular changes that can result in

| Complications | Complication 1 | p | Complication 2 | p | Complication 3 | p |
|---------------|---------------|---|---------------|---|---------------|---|
|               | n  | %  | n  | %  | n  | %  | n  | %  |
| **Age**       |    |    |    |    |    |    |    |    |
| 10–20         | 4  | 19.0 | 4  | 20.0 | 0  | 0.0 |
| 21–40         | 10 | 47.6 | 11 | 55.0 | 3  | 75.0 |
| 41–60         | 6  | 28.6 | 4  | 20.0 | 1  | 25.0 |
| >60           | 1  | 4.8  | 1  | 5.0  | 0  | 0.0 |
| **Total**     | 21 | 100.0 | 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  | 0  | 0.0  | 1  | 5.0  | 0  | 0.0 |
| **Total**     | 21 | 100.0 | 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 | 20 | 100.0 | 0.625 | 4 | 100.0 | 0.500 |
| **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 | 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 | 20 | 100.0 | 1.000 | 4 | 100.0 | 1.000 |
| **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 pseudoarthrosis | 3 | 14.3 | 3 | 15.0 | 1 | 25.0 |
| Chronic osteomyelitis | 1 | 4.8 | 1 | 5.0 | 0 | 0.0 |
| **Total**     | 21 | 100.0 | 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 | 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 |
| Number of revision surgeries | 2.11 | 1.00 | 0.362 | 2.11 | 1.00 | 0.362 | 2.0  | 2.0  | 0.544 |
| Time of use | 2.33 | 2.0  | 0.12  | 2.15 | 2.0  | 0.263 | 2.25 | 1.00 | 0.549 |

Chi-squared test.

a Fisher’s exact test.
b Mann-Whitney’s U test.
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.  

During distraction osteogenesis, both bone and soft tissue injuries 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. 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.

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.

References

1. Rodrigues FL, Mercadante MT. Tratamento da falha óssea parcial pelo transporte ósseo parietal. Acta Ortop Bras. 2005;13(1):9–12.
2. Rigal S, Merloz P, Le Nen D, Mathévon H, Masquelet AC. Bone transport techniques in posttraumatic bone defects. Orthop Traumatol Surg Res. 2012;98(1):102–8.
3. Codivilla A. The classic: on the means of lengthening, in the lower limbs, the muscles and tissues which are shortened through deformity. Clin Orthop Relat Res. 2008;466(12):2903–9.
4. Ombrédanne L. Allongement d’un fémur sur unmembre trop court. Bull Mem Soc Chir Paris. 1913;39:1177–80.
5. Ilizarov GA, Ledyaev VI. The replacement of long tubular bone defects by lengthening distraction osteotomy of one of the fragments. Clin Orthop Relat Res. 1992;280:7–10.
6. Salihian F. Bone lengthening (distraction osteogenesis): a literature review. Osteoporois Int. 2011;22(6):2011–5.
7. Tuffi GJ, Bongiovanni JC, Mestriner LA. Tratamento das pseudartroses infectadas da tibia com fahlas ósseas pelo método de Ilizarov, utilizando o transporte ósseo. Rev Bras Ortop. 2001;36(8):292–300.
8. Picado CHF, Paccola CAJ, Andrade Filho EF. Correção da falha óssea femoral e tibial pelo método do transporte ósseo de Ilizarov. Acta Ortop Bras. 2000;8(4):178–91.
9. Ilizarov GA. Clinical application of the tension–stress effect for limb lengthening. Clin Orthop Relat Res. 1990;250:8–26.
10. Blum AI, Bongiovanni JC, Morgan SJ, Flierl MA, dos Reis FB. Complications associated with distraction osteogenesis for infected nonunion of the femoral shaft in the presence of a bone defect: a retrospective series. J Bone Joint Surg Br. 2010;92(4):565–70.
11. Sangkaew C. Distraction osteogenesis with conventional external fixator for tibial bone loss. Int Orthop. 2004;28(3):171–5.
12. Robert Rozbruch S, Weitzman AM, Tracey Watson J, Freudigman P, Katz HV, Ilizarov S. Simultaneous treatment of tibial bone and soft-tissue defects with the Ilizarov method. J Orthop Trauma. 2006;20(3):197–205.
13. Lavini F, Dall’Oca C, Bartolozzi P. Bone transport and compression–distraction in the treatment of bone loss of the lower limbs. Injury. 2010;41(11):1191–5.
14. Mekhail AO, Abraham E, Gruber B, Gonzalez M. Bone transport in the management of posttraumatic bone defects in the lower extremity. J Trauma. 2004;56(2):368–78.
15. El-Alfy B, El-Mowah H, El-Moghayz N. Distraction osteogenesis in management of composite bone and soft tissue defects. Int Orthop. 2010;34(1):115–8.
16. Dhar SA, Mir MR, Ahmed MS, Afzal S, Butt MF, Badoo AR, et al. Acute peg in whole docking in the management of infected non-union of long bones. Int Orthop. 2008;32(4):559–66.
17. Sakurakichi K, Tsuchiya H, Watanabe K, Takeuchi A, Matsubara H, Tomita K. Distraction osteogenesis of a fresh fracture site using an external fixator. J Orthop Sci. 2006;11(4):390–3.
18. Mahaluxmivala J, Nadarajah R, Allen PW, Hill RA. Ilizarov external fixator: acute shortening and lengthening versus bone transport in the management of tibial non-unions. Injury. 2005;36(5):662–8.
19. Grivas TB, Magnissalis EA. The use of twin-ring Ilizarov external fixator constructs: application and biomechanical proof–of principle with possible clinical indications. J Orthop Surg Res. 2011;6:41.
20. Song HR, Cho SH, Koo KH, Jeong YJ, Park YK, Jo JH. Tibial bone defects treated by internal bone transport using the Ilizarov method. Int Orthop. 1998;22(5):293–7.
21. Berner A, Reichert JC, Müller MB, Zellner J, Pfeifer C, Dienstknecht T, et al. Treatment of long bone defects and non-unions: from research to clinical practice. Cell Tissue Res. 2012;347(3):501–19.
22. Vidal PC, Humberto P, Benazzo F, Ciciliani F, Oliveira K. O método Ilizarov no tratamento das pseudartroses infectadas. Rev Bras Ortop. 1997;32(1):905–8.
23. Silva WN, Martins LH, Coutinho ECA. Transporte ósseo da tibia com o método de Ilizarov nos casos de pseudartrose com falha óssea. Rev Bras Ortop. 2012;47(4):805–10.