Case Report
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Treatment of a Femoral Shaft Non-union in a Pediatric Patient with Focused Shockwaves

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Abstract

Non-unions of the femur in children are not frequent, but when they do occur they can be very difficult to manage. Shock wave therapy has emerged as an effective option for well-chosen pseudoarthrosis cases, however there are no reports of pediatric cases.

We report a 12-year-old male patient with a history of pathological fracture due to mid-diaphyseal osteomyelitis of the right femur at 8 years of age. After several surgical procedures the integrity of the femur was restored but an area of non-union persisted at mid-diaphyseal level. He was treated with 3 sessions of focused shock waves with an electrohydraulic generator. He presented a rapid healing avoiding a new endomedullary nailing surgery with bone graft.

Focused shock waves may be a useful therapeutic option in children with non-unions in well-selected cases.

Keywords: Pediatric, Fracture non-unions, Shock Waves.

Introduction

Femoral non-unions are not a frequent complication in pediatric population. They represent 15% of long bone nonunions in children [1].

They usually develop after open fractures, especially when associated with serious integumentary injuries and in cases of segmental bone defects.

Non-surgical treatment is almost never the surgeon's first choice. Plate fixation with autogenous bone grafting is the preferred indication. External fixators are also used, especially in septic non-unions.

The use of shock waves for non-healing fractures in humans was first reported in 1991 by Valchanou and Michailov [2].

Since then, several studies have supported the efficacy of shock waves for the treatment of nonunions and delayed healing of long bone fractures in adults [2-14], however, to date, no cases have been reported in the literature on the use of this therapy in pediatric patients.

The aim of this article is to report on the satisfactory results with the application of shock waves in a patient with femoral septic non-union, initially treated surgically.

Case report

This is a 12-year-old male patient with a history of pathological fracture due to mid-diaphyseal osteomyelitis of the right femur at 8 years of age.

He was treated in our center with Masquelet technique in two stages with the placement of an Ilizarov external fixator and an intramedullary fixation (Fig. 1a). When removing the external fixator, a clinical lower limbs discrepancy of 10 cm was verified (Fig. 1b). Subsequently, a mid-shaft non-union and alteration of the femoral axis were evidenced (Fig. 1c). This was treated with removal of osteosynthesis material, approach to the focus and placement of a locked intramedullary nail (Fig. 1 d).

Fourteen months later, the patient referred no pain and no signs of infection. X-rays showed closed proximal and distal physes, and evidence of non-union (Fig. 2 A).

The alternatives were to treat the patient with a new surgery or attempt healing with the application of focused shock waves. Facing a femoral shaft non-union, with stable osteosynthesis and both physes radiographically closed as a result of previous procedures, it was considered that the conditions were in place to treat the patient with shock waves.

Three applications of focused shock waves generated by an electrohydraulic device with a maximum energy level of 0.55 mJ/mm2, and a frequency of 2 Hertz were carried out. The patient tolerated the applications without the need for sedation. There were no complications or side effects during treatment. During the 1st month after shock wave application, the lower limb was unloaded. In the radiographic control at 8 weeks, complete healing of the non-union was evidenced (Figs. 2b and c).

Discussion

After the publication of Valchanou and Michailov in 1991, reporting on the benefits of the application of shock waves for the treatment of non-unions [1], numerous studies support the use of this therapy.

Haupt [4] published an experimental study

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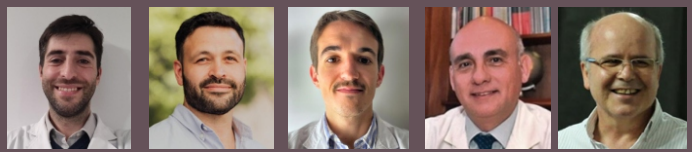

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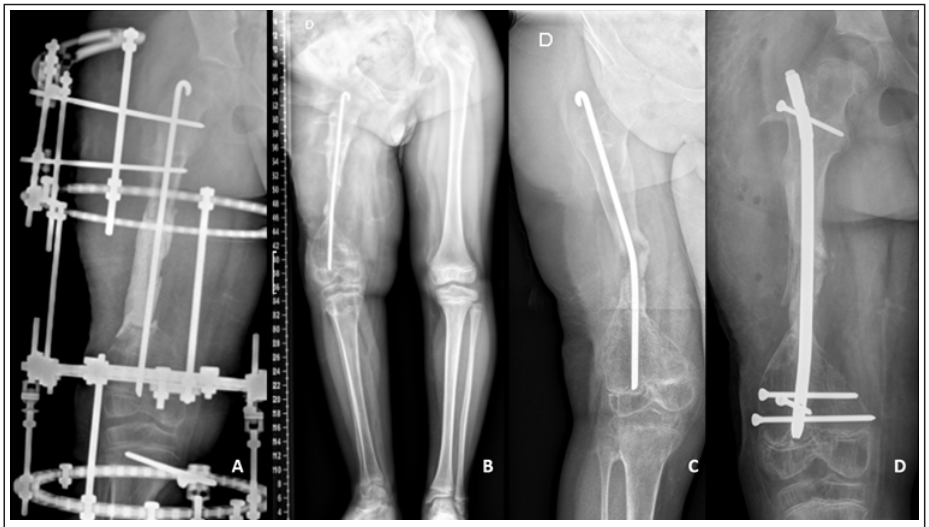

Figure 1: A: Ilizarov external fixator and an intramedullary fixation were initially used. B: Lower limbs discrepancy. C: Mid-shaft nonunion and alteration of the femoral axis. D: Locked intramedullary nail.

on fractures caused in rats in 1992, and in 1997 he published a review article on the satisfactory results of shock waves in patients with non-union or delayed union [5]. Most of the treated patients had at least one failed operation before shock wave therapy. Complete union occurred in 62-91% of cases.

In 2001, Rompe et al. [6] published a prospective study including 43 patients with tibial and femoral fractures treated conservatively or surgically in whom complete bone healing had not been achieved. The follow-up time was at least 9 months. Bone union was achieved in 31 of 43 cases (72%) after an average of 4 months (range, 2–7 months).

In the same year, Wang et al. [7] conducted a prospective clinical study and evaluated the efficacy of shock waves in 72 patients with non-unions of long bones (41 femurs, 19 tibias, seven humeri, one radius, three ulnae, and one metatarsal). The bone healing rate was 40% at 3 months, 60.9% at 6 months, and 80% at 12 months of follow-up. Shock wave therapy was more successful in hypertrophic non-unions and nonunions with segmental bone defects and less effective in atrophic non-unions. There were no systemic complications or device-related problems.

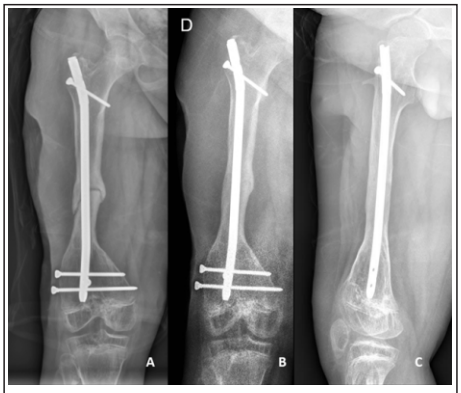

Figure 2: A: Nonunion before shock waves Treatment. B and C: Two months after shockwaves sessions.

Futhermore, in 2001, Schaden et al. [8] published a retrospective study including 115 patients and observed that after shock waves application, 87 patients (75.7%) achieved fracture healing.

Elster et al. [9] retrospectively evaluated a series of 172 cases of tibial non-unions treated with an electrohydraulic device in a single center, obtaining a success rate of 80%.

Kuo et al. [10], in 2015, showed similar results. They retrospectively analyzed 22 patients diagnosed with atrophic non-union of the femur, originally treated with an intramedullary nail. After the failure of the surgical treatment, shock waves were applied and it was shown that 14 fractures out of 22 (63.6%) achieved bone union with a mean union time of 9.2 months (range 6–13 months). The rate of union was 100% of cases when this therapy was performed within 12 months of intramedullary nail placement, versus 42.9% (6 of 14 cases) when performed after 12 months. Poor outcomes in patients receiving shock waves were associated with unstable fractures, a gap at the non-union site >5 mm, and atrophic non-unions.

There are also studies that compared the results of surgery with focused shock waves.

Cacchio et al. [11] published a randomized clinical study in 2010, they reported a comparable healing rate between patients treated with shock waves or surgery. A total of 126 patients with non-unions of long bones were randomly assigned to receive extracorporeal shock wave therapy (Groups 1 and 2) or surgical treatment (Group 3). Patients in the shock wave groups received four treatments with 4000 shock wave pulses at an energy flux density of 0.40 mJ/mm2 (Group 1) or 0.70 mJ/mm2 (Group 2). Patients in all three groups had similar demographic characteristics, duration of non-union, and duration of follow-up. A success rate of 70%, 71%, and 73%, respectively, was obtained at 6 months. There were no adverse effects in the shock wave groups, compared to a 7% complication rate in the surgical group.

Notarnicola et al. [12] reported a retrospective study comparing the results of application of three sessions of shock waves therapy with energy flux density impulses of 0.09 mJ/mm^2 emitted by an electromagnetic generator in 58 patients affected by pseudoarthrosis of the carpal scaphoid, with the results of nonunioin surgical treatment. They found no statistical differences in the results and concluded that in view of their minimal invasiveness, shock waves should be considered the treatment of choice for scaphoid non-unions.

Furia et al. [13] compared the results of shock waves with surgery in cases of non-unions of the base of the fifth metatarsal. Both intramedullary screw fixation and shock wave therapy were effective treatments but screw fixation was more often associated with complications that frequently resulted in additional surgery.

Schaden et al. [14], demonstrated an annual saving of 66 million Euros for the state insurance system for work injuries, by prioritizing the use of shock waves over surgery for the treatment of non-unions and delayed healing as long as they are well indicated. In our case, beyond lower costs, we managed to avoid a child who had already undergone numerous surgeries, anesthetic risks and the stress of a new hospitalization. There are no studies or reported cases, at least based on our literature search, reporting use in minors. Epiphyseal plate in the treatment area is considered a contraindication for shock wave application by the International Society for Medical Shock Wave Treatment [15]. The mid-shaft location in our case and

the fact that the physes were closed ruled out any potential complication in that area.

Conclusion

Shock wave therapy is a safe tool and there is a large bibliography in adult patients that supports its use for the treatment of pseudoarthrosis. In selected pediatric patients, it could become a therapeutic option to conventional surgery.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his/her consent for his/her images and other clinical information to be reported in the Journal. The patient understands that his name and initials will not be published, and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.

Conflicts of Interest: Nil. **Source of Support:** None.

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