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EFFECTIVENESS OF THE USE OF HEXAPOD FIXATOR IN THE TREATMENT OF PATIENTS WITH BLOUNT'S DISEASE: SYSTEMATIC REVIEW

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ABSTRACT

Introduction: Blount's disease is a disorder of posteromedial proximal tibial physis that causes progressive varus deformity, procurvatum and internal tibial rotation. The homonymous condition, described by Blount in 1937, when left untreated, can lead to progressive discrepancies in limb length, changes in gait and premature osteoarthritis. The management of Blount's disease in adolescents and young adults is complex and associated with a high risk of morbidity. The gradual correction of this deformity with the use of the hexapod external fixator can minimize soft tissue damage and allow subsequent adjustment in the degree of correction. The Hexapod system was developed as an extension of existing fixation systems. Hexapod represents a kinematic mechanism, which generates three-dimensional movements (translations and rotations) varying the length of 6 distractors. Hexapod is a well-known robotics construction for the spatial positioning of a platform. A software calculates the adjustment needs of the 6 distractors. Studies have shown that reduction or correction maneuvers with the use of Hexapod are effective in the treatment of different types of orthopedic deformities, among them, Blount's disease. This study aims to analyze the effectiveness of using the Hexapod fixator in the treatment of patients with Blount's disease. Knowing that one of the main problems for the analysis of the demonstration of efficiency of conservative treatments in Blount's disease is the lack of standardization of orthopedic devices, this study focuses on the use of the Hexapod fixative, considering what the authors have found using it. them in the treatment. It is noteworthy that this study proposes a challenge, since both the Brazilian and international published literature is scarce in relation to the subject, which may limit the results of this research. From this, it can be said that this is a study of social, professional and academic relevance.

Methods: A systematic literature review was conducted based on the guidelines of the PRISMA recommendation. The data collection process was performed in the CAPES, SciELO, Lilacs and PubMed databases from the descriptors selected for this research in December 2019. After selecting the articles, they were reviewed to collect data from this research, which It was based on the checklist proposed by the PRISMA method composed of 27 items and the flowchart composed of four steps that bring the information flow with the different phases of a systematic review. The selected articles were reviewed according to the research instruments collecting relevant information so that they could be analyzed considering their results and their contribution to this study. Thus, in the data collection process the objectives of this research were considered at all times. The selected articles were analyzed considering the following variables: Year of publication; language of publication; type of research; data approach; age of the patients; treatment time; and focus of results (technique efficiency, risks or complications). **Conclusion:** The results showed that only one selected article was written in Portuguese, all the others (6) were written in English, which confirms the scarcity of studies on the subject and points out the need for a greater number of approaches. The reliability of the selected articles is emphasized, considering that all presented a low risk of bias. The average age of patients who participated in the different surveys was 14 years, with a range from 19 months to 64 years. The shortest treatment time observed was 120 days, with 7 years as the maximum time reported by the authors. The authors identified the method as efficient, with low risks and with the main complications encountered, infection and recurrence of the problem. It was possible to conclude that the use of Hexapod external fixator has been shown to be effective in the treatment of patients with Blount's disease, both in children and in older patients, however, its results are seen more quickly when treatment is started early, reducing treatment time, risks and complications.

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INTRODUCTION

In 1937, Blount described a disease in children that affected the proximal third of the leg, characterized by the formation of a "beak" at the level of the proximal and medial metaphysis of the tibia, leading to a varus and procurvate deformity, associated with internal torsion of the leg. In addition to the classic name "Blount's tibia varus", two other terms are used in the literature to describe this disease: "tibia varus" and "tibia deforming osteochondrosis Of unknown etiology, it mainly affects children aged two to five years old. It is a developmental disease that can be described as an abnormality of the endochondral ossification of the medial part of the proximal tibial physis(1,2). Diagnosed from clinical examination and imaging exams, its early treatment is considered essential, as its inadequate management can lead to the development of medial tibial epiphysiodesis at 6 to 8 years of age (1,2,3), associated with abnormal gait, reduced tolerance to exertion and secondary osteoarthritis. Despite being more common in pediatric patients, Blount's disease can also be found in adolescents and adults, being classified as late, with the treatment being considered more complex due to the more frequent risks of morbidities (2). In pediatric patients, in whom the disease is in its early stages, conservative treatment with the use of an orthosis is indicated, and surgical treatment is recommended in cases where the initial treatment fails. However, authors such as Heflin, Ford and Stevens (4), Erkus, Turgut and Kalenderer (1), Delniots et al. (5) and Montenegro et al. (6) point out that its use is still controversial, as few studies were dedicated to analyzing the results of orthotics, thus limiting their use and reliability as a form of treatment. In the study by Montenegro et al. (6) factors such as: 1) lack of standardization of orthopedic devices; 2) difficulty in regulating the treatment regimen; 3) absence of control groups; and, finally, 4) the differentiation between Blount's disease and physiological genu varum. Pesenti, Lobst and Launay (7) and Montenegro et al. (6) point to efficiency in the use of orthoses, especially for patients under three years of age and who present unilateral stage I or II Langenskiöld disease. In more severe cases, surgery is needed to realign the mechanical axis of the lower limb. The main surgical options include internal fixation and acute correction, growth modulation, and gradual correction with an external fixator. Acute correction is associated with the risk of complications such as compartment syndrome, nerve damage and limb length discrepancy. External fixators allow subsequent modifications in the degree of correction and lengthening of the shortened tibia, especially in unilateral Blount's disease. With the new generation of external hexapod fixators, rotational deformity can also be corrected. The Hexapod system was developed as an extension of existing fixator systems. The Hexapod represents a kinematic mechanism, which generates three-dimensional movements (translations and rotations) varying the length of 6 distractors. The Hexapod is a well-known robotics construct for the spatial positioning of a platform. A software calculates the adjustment needs of the 6 distractors. Studies have shown that reduction or correction maneuvers using Hexapod are effective in the treatment of different types of orthopedic deformities. Knowing that one of the main problems for analyzing the demonstration of efficiency of surgical treatments in Blount's disease is the lack of standardization of orthopedic devices, this study focuses on the use of the Hexapod fixator, considering that the authors have found success in using it. It is highlighted that this study is a challenge, since both the Brazilian and international published literature is scarce on the subject. From this, it is possible to say that this is a study of social, professional and academic relevance.

Goal: To carry out a review of the functional results obtained in patients with Tibia Vara de Blount submitted to surgical treatment with Hexapod Fixator; Identification of the mean age of patients with Tibia Vara de Blount submitted to treatment with an external Hexapod Fixator; Evaluate the main technical parameters used to evaluate the effectiveness of the correction of Blount's deformity; Treatment time; main complications;

METHODS

A systematic literature review was carried out using the PUBMED, SCIELO and MEDLINE databases, with the keywords Blount disease, external fixator and external fixation. The search was carried out by 2 independent researchers, with disagreements on inclusion or not being decided by a third reader. It is noteworthy that in this research a systematic literature review was carried out based on the guidelines of the PRISMA recommendation (Main Items for Reporting Systematic Reviews and Meta-analyses) validated in Brazil by Galvão, Pansani and Harradi (9), which highlight the review literature as extremely important in health care. The selected articles were analyzed considering the following variables: Year of publication; language of publication; type of search; data approach; age of the patient(s); treatment time; and focus on results (technique efficiency, risks or complications). It should be noted that the articles were analyzed considering the risk of bias so that it was possible to verify the quality of the selected publications.

Eligibility and Selection Criteria: The studies found were submitted to the following inclusion criteria:

- Studies related to the proposed theme, published in the last 15 years (2004-2019)
- Articles in languages: English, Spanish and Portuguese;
- Research carried out on humans;
- Articles available in full version.

The exclusion criteria were:

- Repeated studies in databases
- Low reliability or simple case reporting
- Outside the framework of the inclusion criteria

RESULTS

According to the search strategy, 27 studies with the aforementioned descriptors were found, which were again evaluated according to their design and relevance according to the type of study filters and inclusion criteria. There was a very strong correlation between the searches of the two researchers ($k=0.802$). Then, 13 articles were selected by the abstract and, after a complete reading, 5 articles were selected (Table 1). As general characteristics, a total of 96 patients were included in this review. The average age of patients who participated in the different surveys was 14 years. The shortest time of treatment verified was 120 days, verifying about 5 years as the maximum time reported by the authors. As can be seen in table 1, In all articles, the authors' experience with hexapodal fixators in the correction of Blount's tibia varus was described in positive terms. In almost all patients it was possible to achieve correction with good superficial results. The main technical parameters used to assess the effectiveness of the correction were based on the diagram by Paley et al (Figure 1), the most used being MAD (72.9%), MPTA (66.6%) and JLCA (42, 7%). The main complications reported were infection of the pins path (39.5%), predominantly superficial, requiring surgical re-approach in a minority of cases, and deformity recurrence (13.5%). bone callus refractures and fibular nerve injuries, in addition to recurrence of deformities (Figure 2). All these last adverse effects occurred in a small number of patients and were not associated with permanent disability. In the studies that directly compared the hexapodal fixators with the classic Ilizarov fixator, there was no statistically significant difference in the final correction rate or in the number of complications, however, correction speed, loss of lean mass or weight gain were not compared. in patients.

DISCUSSION

From the systematic review carried out in this research, it was possible to verify the scarcity of studies aimed at the use of Hexapod in the treatment of patients with Blount's tibia varus, being imperative

Table 1. Characterization of articles by title, author, year of publication, work objectives, complications and clinical outcome

Title/Author (year)	Study Design and Number of Patients	goal	complications	Clinical Outcome
The role of taylor spatial frame in the treatment of Blount disease. Tsibidakis et al. (2018)	Prospective Study 16 patients	Report treatment results in children with Blount's disease using Taylor's spatial framework (TSF).	Pin infection was present in 6 tibias, while software changes were required in 5 patients. Recurrence was observed in 3 patients (trigeminals).	Postoperative improvement of all measures was observed. The MPTA increased from an average of 71.8° (58° - 79°) to 92.5° (90° - 95°), the Drennan decreased from 16.6° (14° - 18°) to 3.6° (0° - 6°), the FT angle changed from 15.4° (10° - 25°) of varus to 5.9° (2° - 10°) of valgus and the LLD decreased by 208 mm (150 -320) to 69 mm (0-120). The mean follow-up was 45.6 months
Gradual correction of proximal tibia deformity for Blount disease in adolescent and young adults Saw et al. (2019)	retrospective cohort 22 Patients	It investigates the surgical outcome and complication rate of the gradual correction of neglected Blount's disease through single-level extra-articular corticotomy	Two patients developed pathological fractures over distracted bones, one developed late union and the other excessive correction	The mean MAD improved from 95 ± 51.4 mm to 9.0 ± 37.7 mm (medial to the midpoint of the knee), the mean AFT improved from 31 ± 15° varus to 2 ± 14° valgus and the mean FCTSA improved from 53 ± 14° to 86 ± 14°. The average duration of application of the fixative was 9.4 months.
The challenges of a comprehensive surgical approach to Blount's disease Edwards, H ughes e Monsell (2017)	Prospective study. 7 patients	Assessment of technique needed to simultaneously address all components of early-onset Blount's disease.	Pin site infection occurred in four patients One patient developed recurrent infections and required a prolonged course of oral antibiotics. One patient developed temporary paresthesia over the anterior aspect of the proximal tibia. One patient developed complete left peroneal nerve palsy, with complete recovery after 15 months. Premature consolidation of the fibular osteotomy was observed in one patient. Two patients (three limbs) developed recurrence of the original deformity. Patient 6 required bilateral tibial and peroneal epiphysiodesis two years after the initial surgery. There was a recurrence of varus deformity in the left knee nine months after epiphysiodesis	The mean follow-up period was 4.6 years (2.2 to 9.0). The mean age at surgery was 9.5 years (6.6 to 10.6) and the mean weight at the time of surgery was 45.5 kg (36 to 64). The average time in the external fixator was 5.6 months (3.5 to 10.4) After the acute elevation of the hemi-plateau, mean preoperative MPA of 43.41° (24.00° to 56.80°; mean normal limb: 23.46°) was corrected to a mean of 20.71° (4.18° at 37.20°) in the most recent revision. The mean preoperative MAD of affected limbs was 4.85 cm (0.47 cm to 7.95 cm; mean normal limb: 0.5 mm) corrected to 1.88 cm (0.00 cm to 4.55 cm) in the latest revision. The mean preoperative MPTA of the affected limbs was 43.58° (29.90° to 76.95°; mean normal limb: 77.08°) corrected to 75.46° (67.50° to 81.90°) in the latest revision. The mean preoperative LDFA of the five affected limbs was 78.66° (75.75° to 84.50°; mean normal limb: 80.17°) corrected to 82.01° (78.50° to 90, 15°) in the latest revision
Gradual Deformity Correction in Blount Disease. Mayer et al (2019)	Retrospective cohort. 41 patients	Ilizarov versus TSF	Twenty patients had pin path infections. 2 had osteomyelitis. 3 required readjustment of the pins due to skin irritation. 2 had peroneal nerve palsies, 21 patients did not follow guidelines, and one developed premature consolidation. 7 limbs required secondary surgery for recurrent deformity (2 revision tibial osteotomies with external fixation, 5 required lateral proximal tibial hemi-epiphysiodesis due to premature closure of the medial physiodesis. 1 patient required medial hemi-epiphysiodesis due to valgus deformity due to lack of adherence to the plane therapeutic	The mean age at treatment was 9.6 years, with a mean follow-up time of 34 months. Mean preoperative MPTA, MAD, and JLCA improved significantly at frame removal as well as at final follow-up, with no significant changes in correction between frame removal time and final follow-up. There was no difference in MPTA and MAD in patients treated with an Ilizarov frame versus a TSF. MPTA, MAD, and JLCA improved significantly regardless of underlying diagnosis (infant vs. adolescent Blount's disease) or history of prior surgical intervention. The most common complication was superficial infection at the pin site.
The use of the Taylor spatial frame in adolescent Blount's disease: is fibular osteotomy necessary? Eidelman et al (2008)	Prospective study. 8 patients	To examine the results of the treatment of patients with adolescent tibia varus treated by tibial osteotomy and Taylor's spatial framework (TSF) without fibular osteotomy.	100% superficial infection and an episode of bleeding that resolved after post replacement	All patients had accurate anatomical correction of the deformities and no problems related to the fibula occurred during or after the correction.

Source: Prepared by the author.

the need for further studies on the subject to better support its use in orthopedic practice, mainly in Brazil, since no study in Portuguese was selected. The researches selected for this study, for the most part, used the Taylor Spatial Frame (TSF), verifying it as the preferred Hexapod among professionals. This is likely due to the fact that it is a commercial system subsidized by Smith and Nephew and that it was the first to use a computer program to make the calculations by the surgeon.

Angle	Normal (deg)	Range (deg)
LDFA	87	85–90
MPTA	87	85–90
LDTA	89	86–92
PPTA	81	77–84
ADTA	80	78–82
MAD (mm)	10	3–17

Figure 1. Diagram for radiological measurements by Paley et al



Figure 2. Main complications of the treatment of the Tibia Rod of

The results presented demonstrate the efficiency of this technique, highlighting the possibility of gradual correction as one of its main advantages. Authors such as Alsancak, Guner and Kinik 12 mentioned that the earlier the treatment with this type of fixative, the better and faster the results, in addition to reducing the risks and complications of the treatment. According to Saw et al. 13 effective results can also be achieved in older patients, however, the risks are greater, highlighting that, in these cases, a longer duration of application of the framework should be considered to reduce the risk of pathological fracture or subsequent bone deformation adjusted. The results of Park et al. 18 They also confirmed the efficiency of the method, both in children and in older patients. In the research carried out by Tsibidakis et al. 14 it was verified that the use of external fixation offers advantages of postoperative adjustment and simultaneous stretching, when indicated. According to the authors, this type of fixation has certain advantages in these patients, allowing for excellent stability and early weight bearing. Compared to other external fixators, the TSF has the advantage of gradually correcting multiplanar deformities such as angulation, translation, rotation and shortening, minimizing these complications. It should be noted that this is a simple, precise and reproducible technique. 14 In the case of correction of residual deformity, it can be performed without surgical means, improving the patient's morbidity rate and unloading the surgeon's workload. 14 Mahmoud 15 also mentioned the efficiency of using Hexapod, claiming to be an effective method to correct the deformity and restore knee stability with early results and with high satisfaction. Thus, it is possible to conclude that the use of Hexapod-type fixative is effective in the treatment of patients with Blount's tibia rod, both in children and in older patients, however, its results are seen more quickly when the treatment is started early, reducing treatment time, risks and complications, which places the responsibility not only on the surgical technique and implant used, but on the early recognition of the pathology by the health professional, as well as a resolute and comprehensive health system.

CONCLUSION

From the literature review carried out in this research, it was possible to verify the scarcity of studies focused on the use of Hexapod in the treatment of patients with Blount's tibia varus, and further studies on

the subject are needed to better support its use in orthopedic practice, especially in Brazil. Based on the studies, it can be concluded that the use of Hexapod is highly effective and has a low associated risk.

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