ORIGINAL ARTICLE

Results of hallux valgus treatment in adolescents using the modified Bösch technique

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ABSTRACT

Introduction: *hallux valgus* is an unsightly and painful deformity that causes disorders in the use of footwear and long-term walking disability due to calluses, ulcerations and foot deformities. In Cuba, the population goes to consultations since adolescence to request its correction. Due to its multicausal character, there are few preventive options that can be carried out. Its treatment should be directed to achieve, by surgical methods, the resolution of the problems of the deformity.
Objective: to determine the results of *hallux valgus* treatment in adolescents using the modified Bösch technique.
Methods: a prospective longitudinal study was conducted with 23 patients diagnosed with *hallux valgus* considered as mild and moderate according to the Coughlin-Mann classification and surgically corrected by the modified Bösch technique at the "Eduardo Agramonte Piña" Pediatric Hospital between January 2018 and January 2022.
Results: the most frequently observed group was between 11 and 15 years old, female. Moderate *hallux valgus* predominated, which presented bilaterally in most cases. Before the intervention, most of the patients presented moderate pain, limitation of recreational activities and important alignment defects. Six months later they presented good alignment, mild limitation of activities and absence of pain.
Conclusions: correction of *hallux valgus* in adolescents using the modified Bösch technique is effective in correcting this deformity satisfactorily.
Key words: *hallux valgus*; osteotomy; modified Bösch technique; adolescent

RESUMEN

Introducción: el *hallux valgus* es una deformidad antiestética y dolorosa que produce trastornos para el uso del calzado e incapacidad para la marcha a largo plazo por callosidades, ulceraciones y deformidades del pie. En Cuba la población acude a consultas desde la adolescencia para solicitar su corrección. Debido a su carácter

multicausal son pocas las opciones preventivas que pueden ser realizadas. Su tratamiento debe ser encaminado a lograr, por métodos quirúrgicos, la resolución de los problemas propios de la deformidad.
Objetivo: determinar los resultados del tratamiento del *hallux valgus* en adolescentes mediante la técnica de Bösch modificada.
Métodos: se realizó un estudio longitudinal prospectivo con 23 pacientes diagnosticados de *hallux valgus* considerados como leves y moderados según la clasificación de Coughlin-Mann y corregidos de forma quirúrgica mediante la técnica de Bösch modificada en el Hospital Pediátrico "Eduardo Agramonte Piña" entre enero de 2018 y enero de 2022.
Resultados: el grupo observado con mayor frecuencia fue el comprendido entre 11 y 15 años, del sexo femenino. Predominó el *hallux valgus* moderado, que se presentó de forma bilateral en la mayoría de los casos. Antes de la intervención la mayoría de los pacientes presentaban dolor moderado, limitación de las actividades recreativas e importantes defectos de la alineación. Seis meses después presentaron buena alineación, limitación leve de las actividades y ausencia de dolor.
Conclusiones: la corrección del *hallux valgus* en adolecentes mediante la técnica de Bösch modificada es eficaz para corregir esta deformidad de forma satisfactoria.
Palabras clave: hallux valgus; osteotomía; técnica de Bösch modificada; adolescente

INTRODUCTION

The initial description of *hallux valgus* is attributed to Laforest (1782), surgeon to King Louis XVI; however, Schnepp cites earlier descriptions by Legran (1731) in his work "La toilette des pieds" and by Rouselot (1769) in "L'art de soigner les pieds", but it was in 1981 that Carl Hueter, a German orthopedic surgeon, first assigned to this deformity the term *hallux valgus* (HV).[1]
HV is one of the most common chronic forefoot problems affecting the bony and soft tissues that comprise and surround the first metatarsophalangeal (MTF) joint and is characterized by dislocation or subluxation of the joint, *valgus* of the first toe, *varus* of the first metatarsal (MT) and disruption of the remaining toes.[2,3,4] As the deformity progresses the soft tissues on the lateral side contract and those on the medial side relax, the head of the first metatarsal shifts medial to the proximal phalanx and the proximal phalanx shifts to the lateral side, thereby exposing the fibular sesamoid. If the head deviates medially it moves away from the sesamoids and the crista, which normally stabilizes them, dislocates. The deformity progresses and the stabilizers become deforming forces.[5,6]
The most accepted definition with respect to radiological parameters is first toe valgus (angle formed between the longitudinal axis of the first metatarsal and the longitudinal axis of the proximal phalanx of the first toe) greater than 15° (hallux valgus angle -HVA-) >15° and intermetatarsal angle, formed between the longitudinal axis of the first and second MT, (IMA) greater than 9°.[7]
Taking into account these angles mentioned, it can be classified, according to Coughlin-Mann, into: mild (AVH less than 20 degrees and IMA angle less than 11 degrees, dislocated sesamoids less than 50%), moderate (AVH between 20 and 40 degrees, IMA of 11 to 15 degrees, dislocated sesamoids from 50 to 75%) and severe or acute (AVH greater than 40 degrees, IMA of 16 degrees or more, dislocated sesamoids from 75 to 100%).[8]

This disease currently affects 28.4% of the population over 30 years of age. Its prevalence varies among different populations, in non-shoe wearing populations the prevalence is around two percent.In adult shoe wearing populations a prevalence in women of up to 44 percent has been reported.[6] In children and in adolescents it is a common condition affecting up to 36% of this population. It presents considerations including the presence of epiphyses and the difficulty in deciding the timing of surgical intervention with respect to bone growth. These cases usually present for evaluation between the ages of 11 and 14 years.[9]

The etiology of *hallux valgus* has been debated for years, it is known to be associated with genetic component and the use of tight shoes and high heels and its relationship with other mechanical alterations of the foot: retraction of the Achilles tendon, severe flatfoot, neuromuscular diseases (cerebral palsy), transient ischemic accidents, rupture of the posterior tibial tendon and rheumatoid arthritis, among others.[10]

In the early stages it is possible to treat most patients with non-surgical methods such as appropriate footwear modifications, exercise and certain changes in activity. Surgical intervention is rarely indicated for purely cosmetic reasons, except in adolescents with significant and progressive deformity. In this age group, even mild symptoms often worsen, especially when there is a family history of *hallux valgus*.[11]

The first reports on surgical correction of HV date back to the beginning of the 19th century; different surgical techniques were available and are still in use today, as shown in various reference treatises on foot surgery.[12] There are currently more than 200 surgical techniques described. In recent years there has been a large increase in publications and new procedures have emerged that claim to be less invasive and more effective.[13] Minimally invasive surgical techniques have become increasingly popular because they can achieve corrections through small incisions, with minimal damage to surrounding soft tissues, rapid recovery and less scarring. Due to the advancement of arthroscopy, lateral first metatarsal release and medial capsule plication procedures can be performed, which have the advantage of direct visualization of sesamoid reduction and avoidance of *hallux* hypercorrection; however, arthroscopic surgery is more complex, takes longer and the risk of injury to the dorsomedial collateral nerve is higher. Studies have shown that certain distal first metatarsal osteotomies, performed open or percutaneously, can correct intermetatarsal angles up to 20 degrees, achieve correction of the distal articular facet angle and decrease metatarsophalangeal stiffness; however, it is a demanding procedure that involves a long learning curve and is a challenge for the surgeon. The first generation percutaneous *hallux valgus* correction technique, which had no fixation, was described by Isham. The second generation was the technique described by Bosch and published in 1990: it consists of a subcapital osteotomy perpendicular to the diaphysis of the first metatarsal with the objective of achieving a cephalic lateral displacement of 75% or more of the total diameter of the diaphysis of the metatarsal so that the medial cortex of the distal osteotomized fragment is in contact with the lateral cortex of the proximal fragment.[14,15,16]

Since there are few studies that address the results of HV correction in the pediatric population of Camagüey Province, the present research was carried

out to determine the results of *hallux valgus* treatment in adolescents using the modified Bösch technique at the Orthopedic Service of the "Eduardo Agramonte Piña" Pediatric Hospital.
Any adolescent between 12 and 18 years of age with an unsightly HV considered progressive by the patient and with a family history of this disease is a candidate for surgical correction using this technique.

METHODS

Design and population

A prospective longitudinal study was conducted with 23 patients diagnosed with *hallux valgus* considered as mild and moderate according to the Coughlin-Mann classification and surgically corrected by means of the modified Bösch technique at the "Eduardo Agramonte Piña" Pediatric Hospital of Camagüey City, in the province of the same name, between January 2018 and January 2022.
The universe was composed of 23 patients with diagnosis of HV attended in the mentioned health care and teaching institution during the aforementioned period of time. The sample represented the totality of the patients.
Inclusion criteria:

- Patients older than 11 years and younger than or equal to 19 years with a diagnosis of *hallux valgus*.
- Patients whose legal guardians agreed to their participation in the study by signing the informed consent form.

Exclusion criteria:

- Patients in whom it was not possible to obtain the necessary data for the investigation or its follow-up.
- Patients who presented severe vascular disorders.

Study variables

- Age groups: from 11 to 15 years old and from 16 to 19 years old.
- Sex: male and female
- Affected foot: right, left or bilateral
- *Hallux valgus* classification: Coughlin-Mann severity classification
- Clinical-functional assessment: according to the American Orthopaedic Foot and Ankle Society (AOFAS) scale
- Complications
- Advantages of the technique

Procedures/data collection and management

The data from the review of the medical records and the direct interview with the patients were collected in a data collection form created for the purposes of the research.
The data obtained were collected in tables. The AOFAS scale and HVA values, as well as the presence of complications, the duration of the procedure and the possibility of combination with other techniques to correct coexisting deformities were taken into account for their evaluation. All these data were compared before the procedure and at six months after the intervention.

The deformity was corrected using the modified Bösch technique in adolescents with HV considered mild and moderate according to the Coughlin-Mann scale. The procedure was performed as described below: after intravenous general anesthesia, the patient was placed in supine decubitus on the surgical table, after blood drainage an ischemia cuff was placed at thigh level, sepsis and antisepsis measures were performed in the area and the surgical fields were placed, which were positioned in such a way as to allow flexion of the knee to obtain anteroposterior images with the image intensifier. An incision of approximately two centimeters is made, longitudinal to the axis of the first metatarsal, proximal to the first metatarsophalangeal joint, on its dorsomedial region; the deep fascia is sectioned following the skin incision; Farabeau separators are used to separate the edges of the surgical wound caudally and cephalad; the periosteum is sectioned longitudinally; two perforations are made, with a 2.5 millimeter drill, at the level of the neck of the first metatarsal; osteotomy is performed with a ten millimeter straight osteotome, perpendicular to the longitudinal axis, and the lines of the previous perforations are followed; a 3.2 millimeter Steinmann wire is introduced through the incision extraperiosteally and the medial edge of the head of the first metatarsal and the proximal and distal phalanges are followed to exit at the tip of the finger; It is advanced until its proximal end is located at the level of the osteotomy performed; a grooved area is used to laterally displace the metatarsal head and correct the deformity, which is confirmed by visualization through the image intensifier; Steinmann wire is introduced into the distal portion of the osteotomy along the intramedullary canal to the base of the metatarsal, its exposed distal end should be bent 90 degrees to prevent proximal migration; it is washed with plenty of physiological saline solution and the wound is sutured, which together with the bent distal end, is covered with sterile dressing and bandage, followed by immobilization type plaster boot.

At two weeks a window is opened in the cast to remove the stitches and radiographic control is performed. At four weeks the Steinmann wire is removed and finally the immobilization is removed at six weeks.

The evaluation was performed six months after surgery. Radiological measurements of AVH and AMI before and after surgery were taken into account, as well as the application of the AOFAS functional scale (1994), which consists of eight specific sections that allow an approach to the level of patient satisfaction. The score is calculated on the basis of data derived from an interview and a physical examination. This 100-item scale contains data related to pain, activity level, deformity and movement.[17,18]

Ethical considerations

The information obtained was used only for research purposes and complied with the application of the ethical principles stipulated in the Declaration of Helsinki, of autonomy, beneficence, non-maleficence and justice.

RESULTS

Table 1 shows that before surgery 22 patients (95.7%) had an AVH between 21 and 40°; however, six months later, during radiological reevaluation, 100% of patients were found to have an AVH less than 15 degrees.

Table 1. Distribution of patients according to HVA value

HV angle	Preoperative		Postoperative 6 months	
	No.	%	No.	%
< 15°	0	0.0	23	100
16° - 20°	1	4.3	0	0.0
21° - 40°	22	95.7	0	0.0
Total	**23**	**100**	**23**	**100**

Table 2 shows that the parameters after surgery had higher values: pain with an average value of 40 points, function of 9.8 and alignment of 15.
In relation to the complications of the patients with *hallux valgus* only one (4.4%) presented superficial necrosis of the wound.

Table 2. Evaluation of patients with *hallux valgus* according to the AOFAS scale

Scale items	Average value		
	Maximum	Before surgery	After surgery
Pain	40.0	23.6	40.0
Function	10.0	7.4	9.8
Alignment	15.0	2.1	15.0

The surgical procedure was performed in 16 patients (69.5%) in less than 10 minutes (Table 3). It was possible to perform this technique and flatfoot correction in the same surgical time in four (17.5%) patients.

Table3. Distribution of patients according to the duration of the surgical procedure

Duration time (minutes)	No.	%
< 10	16	69.5
10 - 20	3	13.0
20 - 30	4	17.5

All patients who underwent surgery using this technique required less than 24 hours of hospitalization.

DISCUSSION

HV is a very complex disease, both in its etiopathogenesis and in its therapeutic approach. Metatarsal osteotomy performed by minimally invasive surgery has surpassed the objectives of surgical treatment and has obtained, with less damage to the soft tissues, clinical-radiographic results similar to those of conventional open techniques; they are currently considered aggressive techniques and, therefore, whenever possible, more conservative surgery is advised.[19,20]
The HVA measures the angle between the axis of the first metatarsal and that of the first phalanx of the finger. Its normal value is zero to 15°. In most of the studies reviewed, surgical correction is only performed in patients with AVH above 21°; however, it should be taken into account that this work was performed in adolescents in whom pain and unsightly deformity that causes progressive deterioration are surgical indications, therefore, despite being

considered mild, it could require surgical correction in the future due to the appearance of symptoms and signs that could affect their quality of life.[21]
Studies on functional outcomes report that the mean score of the AOFAS scale increased from 59.19 to 98.72 points 12 months after surgical correction using the Bosch technique;[15,14] results similar to those found in this investigation and which coincide with those described in the literature in a series of 1,653 interventions in which this technique was used.[13,14] Comparative studies suggest that the degree of satisfaction of patients who have undergone percutaneous correction techniques is similar to that of open surgical techniques.[22]
As in any other surgical procedure, complications can always be present. Knowledge of your patient, clinical examination of the deformity, a rigorous study of the diagnostic images and a well performed and indicated surgical procedure will avoid their frequency.
Among the most frequent complications are recurrence of the deformity (some authors state that juvenile patients recur more frequently than adults), *hallux varus*, problems in the consolidation of osteotomies, transfer metatarsalgia, vascular necrosis of the head of the first metatarsal and infection.[6]
In this series there was only superficial wound necrosis as a complication. In the series reviewed, referring to the Bösch technique, satisfactory results are shown, with a low rate of complications and recurrences. In one study, when evaluating the results as a whole, it is stated that they are good because the number of complications is relatively small.[15]
Regarding surgical time, some authors perform the Bösch surgery in ten minutes. The discomfort caused by the Steinmann pin in the postoperative period should not be a limitation in this surgical technique nor a reason to add a definitive osteosynthesis because, after its removal, the correction of the osteotomy is not modified.[23]
The foot functions as a structural, anatomical and functional unit, so it is difficult to select patients whose only reason for consultation is pain and HV deformity, and it is also common to find patients who come for consultation with other associated foot deformities. In the sample studied, 17.3% of the patients had associated flat feet. A higher and similar proportion is reported by Sánchez Pulgar (86.2%) and Piqué Vidal (79.4%): these authors report, in addition to flatfoot, other associated deformities: metatarsus abductus and rearfoot deformities; they also recognize the Egyptian foot as an associated deformity. Because this technique is a relatively simple procedure that can be performed in a short time, it was possible to correct the HV and flatfoot deformity in the same surgical time in all the cases in which it was presented.[23,24]
Currently, when the orthopedic surgeon decides to perform surgical treatment for HV correction, he can choose between classic open surgery and minimally invasive surgery. In the present investigation, the treatment of this condition was approached by means of minimally invasive technique. Unlike traditional interventions, this is an outpatient procedure. In the present study, 100% of the patients were discharged early before 24 hours, which coincides with those of most of the authors who performed similar procedures on an outpatient basis. Although in almost all the literature consulted this procedure was performed under regional anesthesia, in the present study it was decided to

perform it under general anesthesia due to the psychological and emotional characteristics of this age group.[24]
This technique has certain advantages such as reduced surgical time, faster healing, reduced risk of deep vein thrombosis and, mainly, avoidance of the complications derived from osteotomies performed by open surgery: delayed consolidation, malpositioned consolidation, pseudoarthrosis, avascular necrosis of the head of the first MT, shortening of the first radius and intolerance to osteosynthesis material.

CONCLUSIONS

HV correction in adolescents using the modified Bösch technique is a useful and effective method that corrects the deformity and prevents possible complications caused by inadequate foot support in this age group. It is a technique that does not have major technical complications and can be performed with the basic instruments found in the operating room.
The predominant AVH was between 21° and 40°. Superficial necrosis of the wound was the complication presented. After surgery, all the parameters of the AOFAS scale increased their value with a surgical time that in most cases did not exceed ten minutes. It was possible to correct another podalic deformity in the same surgical time.
All the cases were performed on an outpatient basis. The advantages of the surgical technique used were the correction of the deformity and pain relief, the scarce presence of complications, the reduction of surgical time, the smaller size of the wound, a hospital stay of less than 24 hours and the possible combination with other surgical interventions.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

AUTHORS' CONTRIBUTION

JMVR: conceptualization, research, writing the original draft, writing (revising and editing).
AMM: conceptualization, data curation, research, writing (reviewing and editing).
MMP: writing the original draft, writing (review and editing).
ELM: methodology, writing (review and editing).
LFF: validation, writing (review and editing).