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TRIPLE ARTHRODESIS IN CEREBRAL PALSY

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ABSTRACT

Objective: To demonstrate the clinical results of triple arthrodesis in Cerebral Palsy patients and determine whether there is any correspondence between the results and the AOFAS scale, and changes in radiographic angles between the pre- and postoperative periods. Methods: Between 1985 and 2005, thirty-four patients (40 feet) were submitted to triple arthrodesis of the foot, with an average follow-up time of ninety-one months. The evaluation consisted of the patient's satisfaction and the presence of pain, plantigrade support, residual deformity, range of movement of the ankle, and the AOFAS. Radiographs were made of the foot and ankle to assess the presence of ankle arthrosis, pseudarthrosis of the joints, and measurements of the following angles: talocalcaneal, talur-first metatarsal and tibiotalar, and talocalcaneal and calcaneal pitch. Results: The results were good in 32.4% of cases, regular in 44.1%, satisfactory in 85.3% and 88.2% had plantigrade support. With the AOFAS scale, the results were good in 33.3% and regular in 24.2%. In the radiographic assessment, the AP talar-first metatarsal angle showed an average improvement of 15º, the LAT calcaneous pitch improved by 7º. The talocalcaneal angles, both AP and LAT, improved in 1º. Conclusions: This study concluded that the triple arthrodesis corrects or improves these deformities; the patient showed a high level of satisfaction, most of them with a plantigrade foot. The AOFAS scale had low correlation with the result. The talur-first metatarsal and calcaneal pitch were the most sensitive in the evaluation of the surgical procedure.

Keywords: Arthrodesis. Cerebral palsy. Foot deformities.

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INTRODUCTION

Equinus deformity (talipes equinovarus) is the most frequent in spastic cerebral palsy (CP), present in all types of topographic distribution, especially in the diparetic kind.[1-5] This is usually accompanied by hindfoot valgus. Varus deformity is more common in hemiplegic patients, and may also be present in diplegics and tetraplegics. It is characterized by imbalance between the spastic inverter (posterior tibial and/or anterior tibial) and evertor (fibular muscles) muscles of the foot. In equinovarus deformity, we find the posterior tibial muscle responsible for hindfoot varus, the anterior tibial muscle for varus and supination of the midfoot, and the triceps muscle compromised by equinism. Varus can be associated with cavus deformity, and may be located in the midtarsal joints (talocalcaneonavicular, calcaneocuboid or cuneonavicular) and is defined by the contracture of the plantar fascia.[2,6-9]

Using x-ray, besides the measurement of the talocalcaneal angles, in the anteroposterior (AP) and profile (P) positions, other angles can be measured and improve the radiographic evaluation of deformities. The talocalcaneal angle (AP) has a normality interval of 15 to 50 degrees.[10] In the talocalcaneal angle (P) it is possible to measure the plantar flexion of the talus: up to 40 degrees is slight, up to 50 degrees moderate and above 50 degrees severe.[11] Another angle used in the lateral view is the calcaneal pitch, which when below 20 degrees indicates plantar flexion of the calcaneus and tarsic instability,[10-12] and when above 30 degrees defines pes cavus, generally associated with hindfoot varus deformity.[11,13] Another measurement used is the talar-first metatarsal angle in the AP position, with normal values that range from -20 to 15 degrees[12] or zero degrees according to Schroeder et al.,[14] that indicates the alignment between forefoot and hindfoot.

In older children, we observed severe fixed deformities with associated instabilities, with pain upon ambulation and deficient gait, making stabilization of the joints necessary. In 1921, Hoke[15] described the subtalar and talonavicular joint fusion procedure, through removal of the talus head and its replacement after withdrawal from the articular cartilage. In 1923, Ryerson[16] published the description of the fusion of another joint using the Hoke technique,[15] the calcaneocuboid joint, calling the surgical technique triple arthrodesis. The objectives of this procedure are to correct deformities, eliminate joint instability, alleviate pain and promote improvement of ambulation, enabling the use of normal shoes or orthoses.

Svartman et al.[17] conducted the review of 109 patients, 117 feet that underwent triple arthrodesis, in the period from 1977 to 1990.

All the authors declare that there is no potential conflict of interest referring to this article.

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Study conducted in the Group of Neuromuscular Diseases, Department of Orthopedics and Traumatology, Faculdade de Ciências Médicas da Santa Casa de São Paulo (FCMSCSP), Irmandade da Santa Casa de Misericórdia de São Paulo (ISCMSP).
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Among these patients, 11 (13 feet) had spastic CP with equinus- cavus-varus and valgus-planus deformities. The surgical technique used was that of Ryerson[16] with internal fixation using steel wires, associated with procedures in the soft parts, and correction of deformities was obtained in 94.8% of the cases (without specification of etiology). All the patients were ambulant in the preoperative period and had difficulty adapting to the shoe or orthosis, but in the postoperative period, 62% began to use normal shoes and 38%, orthoses. There was improvement in all the cases in gait performance. A subsequent evaluation in the same service was carried out by Fucs et al.[18] with the same surgical technique, and found that among the 18 patients (21 feet) with planovalgus and equinus-varus deformities operated between May 1985 and September 1995, 72% of satisfactory results were obtained.

This study aims to assess the long-term results of triple arthrodesis in patients with CP operated between 1985 and 2005 in relation to the physical examination, AOFAS (American Orthopedic Foot and Ankle Society, 1994) scale[19] and radiographic measurement of varus and valgus angles, comparing the pre- and postoperative periods.

CASUISTRY AND METHODS

A retrospective study of 48 patients (56 feet) with spastic CP that underwent triple arthrodesis of the foot with internal fixation with Steimann wires in the period between 1985 and 2005, in a university public hospital. The study was approved by the Institutional Review Board.

Of the 48 patients summoned for revaluation, 14 did not turn up, 12 without justification and two due to death. Of the 34 patients (40 feet) that turned up for evaluation, 47% were female, and six had bilateral involvement, totaling 40 feet. Of these, 10 were planovalgus and 30, equinovarus. Among these 30 patients, 9 had deformity associated with cavus. The right side was involved the most: in 67.5%. The mean follow-up time was seven years and six months (minimum of one year and maximum of 21 years).

The patients were divided into two groups according to the type of deformity in the feet existing prior to surgery: group I, with planovalgus feet and group II, with equinovarus feet. Group I was formed by seven patients (10 feet), two of whom were tetraparetic, four diparetic and one hemiparetic. As regards sex, five were female and two male, and the mean age of the patients at the time of surgery was 16 years and 6 months (minimum of 13 years and 11 months and maximum of 28 years and 8 months). Two patients were operated on the right side, two on the left and three bilaterally. In the preoperative period, three patients were community ambulators, three household ambulators and one non-ambulator. Only two patients complained of moderate pain (located in the foot) in the preoperative period. The mean follow-up time was 10 years and 3 months, ranging from the minimum of 5 years to the maximum of 21 years and 7 months.

Group II was formed by 27 patients (30 feet) and of these 18 were hemiparetic, 7 diparetic and 2 tetraparetic. Of these, 16 were male, and the mean age at the time of surgery was 14 years and 1 month (minimum of 7 years and 2 months and maximum of 30 years and 4 months). Five patients were operated on the left side, 19 on the right and three bilaterally. Before the surgery, 22 patients were community ambulators, 4 household ambulators and 1 non-ambulator. Moreover, in the preoperative period, two patients referred to severe pain, six to moderate pain and two to slight pain. In the preoperative period in both groups, two patients did not make use of orthosis on the feet.

Triple arthrodesis was indicated due to pain, to the severity of the deformity and to joint instability presented by the patients. Before the performance of triple arthrodesis, many patients underwent other surgical procedures for the correction of deformities, as demonstrated by Table 1.

Table 1 – *Surgeries performed before the triple arthrodesis.*

Previous procedures performed	Number
Grice's operation	1
Tenotomy of the adducers	5
Lengthening of the iliopsoas	2
Lengthening of the knee flexors	6
Lengthening of the calcaneal tendon	5
Plantar fasciotomy	2
Femoral rotation osteotomy	4
Hip arthrodesis	1
Posteromedial release of the foot	1
Hemitransfer of the posterior tibial tendon	2
Posterior capsulotomy of the foot	1
Total	30

Radiographic study

Radiographies were taken of foot and ankle in the pre- and postoperative periods, in standing position and in two projections: anteriorposterior (AP) and lateral (L). The talocalcaneal angles were measured in the AP (normal between 15° and 50°)[10] and L (normal between 25° and 50°) positions[10]; talar-first metatarsal angle in AP (normal 0°)[14] and calcaneal pitch angle in L (normal between 20° and 30°).[11]

Clinical angular measurement

The flexion-extension angle was only measured clinically in the postoperative period. Values between 65 and 70 degrees are considered normal.[20]

The surgical technique used was that of Hoke,[15] modified as described by Ryerson:[16] the subtalar, calcaneocuboid and talonavicular joints are exposed through the access route of Ollier. The participants commence the resection of the articular cartilage and remove the bone wedge necessary for correction of the deformity. Fixation is performed with three Steimann wires after the correction. When necessary, a medial access route is used for better approach to the talonavicular joint.

Intervention procedures in soft and bony parts, such as tenotomies, fasciotomies, tendon lengthening, posterior capsulotomy, and osteotomy of the first metatarsal, are performed at the same time as the triple arthrodesis when necessary, as shown in Table 2.

This is followed by plaster immobilization of the sural podalic type; a cruropodalic plaster cast was made when the lengthening of the calcaneal tendon was performed simultaneously, indicated for four weeks and replaced by sural podalic plaster until the consolidation of arthrodesis occurred at around 12 to 16 weeks.

There was only one case (one foot) of arthrodesis review.

Table 2 – *Surgeries associated with triple arthrodesis.*

Procedures performed	number
Lengthening of calcaneal tendon	22
Plantar fasciotomy	13
Lengthening of the flexor hallucis longus	2
Lengthening of the tibialis posterior	4
Lengthening of the flexor digitorum longus	2
Tibio-tarsal and talocancaneal posterior capsulotomy	2
Osteotomy of the first metatarsal	2
Tenotomy of the abductor hallucis	2
Transfer from the posterior tibial tendon to talus	1
Total	50

Results evaluation criteria

The evaluation of results was conducted comparing the subjective and objective aspects. The first were presence of pain and satisfaction with the surgery; and the objective aspects were types of ambulation, correction of the deformity, ankle arthrosis and presence of pseudarthroses.

In keeping with the subjective and objective aspects, the cases were classified as:

Good: foot with arch support, painless, without pseudarthrosis, without ankle arthrosis, with correction of the deformity or minimum residual deformity and with satisfaction of the patient.

Regular: arch support, painless, presence of simple pseudarthrosis, and/or ankle arthrosis, moderate residual deformity and satisfaction or dissatisfaction of the patient.

Poor: foot without arch support, moderate or severe pain, presence of pseudarthrosis of more than one joint, ankle arthrosis, severe residual deformity and dissatisfaction of the patient.

The AOFAS scale was used in the evaluation of results.[19] This score was categorized according to the following criterion: Excellent = 90 to 100 points; Good = 80 to 89; Regular = 70 to 79; Poor = below 69.

Statistical analysis

We presented the qualitative variables in tables containing absolute and relative frequencies. For the quantitative variables, we calculated some summary (descriptive) measurements and built boxplot type graphs.

To analyze the qualitative variables, we utilized:

- Chi-square or Fisher's exact test, to study the association among variables;
- McNemar test, to compare the pre- and postoperative times;
- Kappa index, to study the concordance among evaluations.

The analysis of quantitative variables was performed by means of:

- Wilcoxon test to compare pre- and postoperative times;
- confidence interval for the means.

The level of significance adopted was 5%.

We used the Statistical Package for Social Sciences (SPSS), version 13.0, to conduct the statistical analysis.

RESULTS

At the time of the surgery, the mean age of the patients was 14 years and four months (ranging from 7 to 30 years) and the median was 13 years and 10 months. The patients with planovalgus feet presented mean age of 16 years and six months (ranging from 14 to 28 years) and among those with equinovarus feet, the mean age was 14 years (ranging from 7 to 30 years).

Hemiparetic involvement (55.9%, 19 patients) predominated, with 32.4% of the patients diparetic (11) and 8% tetraparetic (4).

In the postoperative period, 30 patients (88.2%) had arch support and 4 (11.8%), non-arch support. The patients needed different types of support for ambulation at the time of the evaluation. The majority (21, approximately 62%), did not need ortheses. Of those that needed them, the most frequent use was the polypropylene anti-equinus type (AFO) (17.6%). One patient used crutches (2.9%), one used a cane (2.9%), two used walkers (5.9%), and three, wheelchairs (8.8%).

Most patients (73.5%, or 25) did not present postoperative pseudarthrosis. Among the nine that had the complication, seven (20.7% of the total patients) had talonavicular localization, one (2.9%) subtalar and another (2.9%), talonavicular and subtalar.

Of the seven patients considered household ambulators in the preoperative period, two ceased to ambulate after the surgery. However, there was no statistically significant difference in relation to the ambulation behavior, comparing the pre- and postoperative periods (p = 0.157, McNemar test).

It was verified that of the 33 patients that did not have arthrosis in the preoperative period, 9 deteriorated, whereas one developed a slight degree of arthrosis and 8 severe, after the surgery.

As regards pain in the foot and ankle, as shown in Table 3, 22 patients did not complain of pain in the preoperative period.

Table 3 – *Evolution of pain in the foot and in the ankle in the pre- and postoperative periods.*

Pain in the foot			Post				Total
			Absent	Slight	Moderate	Severe	
Pre	Absent	n	19	2	1	0	22
		%	86.4	9.1	4.5	0.0	100.0
	Slight	n	1	1	0	0	2
		%	50.0	50.0	0.0	0.0	100.0
	Moderate	n	1	4	1	2	8
		%	12.5	50.0	12.5	25.0	100.0
	Severe	n	0	0	2	0	2
		%	0.0	0.0	100.0	0.0	100.0
Total		**n**	**21**	**7**	**4**	**2**	**34**
		%	**61.8**	**20.6**	**11.8**	**5.9**	**100.0**

p = 0.363 (McNemar)

Of these, two began to complain of slight pain, and one, of moderate pain, in the postsurgical period. Of the two patients with slight pain in the preoperative period, one improved. Of the eight patients that referred to moderate pain in the preoperative period, one ceased to complain of pain, four evolved with slight pain and two deteriorated to severe pain in the postsurgical period. In relation to the two patients that exhibited severe pain in the preoperative period, they evolved to moderate pain in the postsurgical period. The evolution of pain comparing the pre- and postoperative periods did not show a significant difference ($p = 0.363$, McNemar test). Although eight patients presented improvement in pain, in five cases there was deterioration.

Residual deformity was investigated after the surgery in relation to the type of foot, evaluated in the preoperative period. Of the 10 feet classified as planovalgus in the preoperative period, the majority (9) continued with this deformity. Of the 30 feet classified as equinovarus in the preoperative period, nine (30%) presented pes planus as a residual deformity and four (13%) had no deformity. Of the 34 patients present in the study, the majority (15) presented regular clinical result (44.1%). Eleven (32.4%) had a good result and eight (23.5%), a poor result.

As regards satisfaction, 85.3% of the patients declared they were satisfied with the procedure and 14.7%, dissatisfied.

Angular measurement

The vast majority of feet were classified as non-normal for the flexion-extension angles. In relation to the tibiotalar angle, almost half the feet are classified as normal. (Tables 4 and 5)

Table 4 – *Summary measurements of the anteroposterior angles evaluated in the postoperative period.*

Measurements	Flexion-extension	Tibiotalar
n	39	36
Mean	22.0	6.1
Standard deviation	12.9	5.5
Minimum	2.0	0.0
Median	20.0	5.0
Maximum	50.0	17.0

Table 5 – *Classification of the angles measured in the anteroposterior radiographies evaluated in the postoperative period, according to the parameters of normality.*

Classification	Flexion-extension		Calcaneocuboid		Tibiotalar	
	Frequency	%	Frequency	%	Frequency	%
Non-normal	39	100.0	34	91.9	17	47.2
Normal	0	0.0	3	8.1	19	52.8
Total	**39**	**100.0**	**37**	**100.0**	**36**	**100.0**

The summary measurements of the anteroposterior (AP) and lateral (L) talocalcaneal, talar-first metatarsal (AP) and calcaneal pitch (P) angles in the pre- and postoperative periods are presented in Table 6. Comparing these angles between the surgical times, it is possible to verify that there is no significant difference for the AP and P talocalcaneal angles ($p = 0.592$ and $p = 0.767$, respectively). For the talar-first metatarsal (AP) and calcaneal pitch (P) angles, a decrease is observed in the angular values in the postoperative period ($p = 0.001$ and $p = 0.004$, respectively).

Table 6 – *Summary measurements of the angles obtained in the anteroposterior (AP) and lateral (L) radiographies.*

Measurements	Talocalcaneal (AP)		Talar-first metatarsal (AP)		Talocalcaneal (P)		Calcaneal pitch (P)	
	pre	post	pre	post	pre	post	pre	post
n	32	37	30	37	32	37	32	37
Mean	26.3	24.6	28.0	12.9	22.8	23.1	22.7	16.0
Standard deviation	11.9	6.5	26.3	13.7	11.6	8.1	14.2	8.9
Minimum	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0
Median	25.0	25.0	20.0	10.0	25.0	23.0	23.5	15.0
Maximum	70.0	40.0	92.0	50.0	40.0	42.0	52.0	40.0
P*	0.592		0.001		0.767		0.004	

* Wilcoxon test

The comparison of these angles between pre- and postoperative times showed that there was no significant difference in the evolution of the patients' feet (p values all above 0.05). Although the McNemar test did not detect changes in the evolution ($p = 0.375$), there was an improvement verified in four feet, relating to the talocalcaneal angle (AP). Before surgery they were classified as non-normal and, afterwards were re- classified as normal. In relation to the talar-first metatarsal angle (AP), there was improvement in 7 feet ($p = 0.070$ by the McNemar test). In relation to the talocalcaneal (L) and calcaneal pitch (P) angles, a greater quantity of deteriorations was verified in evolution of the feet (with 18 non-normal against 13 normal feet and 22 non-normal against 9 normal feet; $p = 0.289$ and 0.999, respectively).

Profile of AOFAS in relation to the clinical result and to satisfaction

The mean AOFAS score of the 33 patient was approximately 67.9 (with standard deviation equal to 19), therefore considered "poor". The distribution of categories of the AOFAS scale is exhibited in Table 7, in which it is verified that the majority of these (54.6%) presented "good" or "regular" result.

Table 7 – *Distribution of the AOFAS scale, categorized according to the score.*

AOFAS	n	%	accumulated %
Poor	14	42.4	42.4
Regular	8	24.3	66.7
Good	10	30.3	96.9
Excellent	1	3.0	100.0
Total	33	100.0	

Table 8 contains some summary measurements of the AOFAS scale in relation to the clinical result. It is observed that on average, the AOFAS of the regular and good patients are very close. To verify whether the AOFAS scale distinguishes among the categories of clinical result, the confidence intervals were verified for the mean values. Analyzing these intervals, it is perceived that the AOFAS of the regular and good patients are not different. Now the AOFAS of patients considered poor is lower than the other results.

Table 8 – *Summary measurements of the AOFAS scale, according to the clinical result.*

Measurements	Clinical result		
	Poor	Regular	Good
n	8	15	10
Mean	45.1	71.9	80.3
Standard deviation	15.1	16.7	4.6
CI (95%)	[32.5; 57.7]	[62.6; 81.1]	[77.0; 83.6]
Minimum	14.0	32.0	71.0
Median	46.5	73.0	81.0
Maximum	63.0	97.0	87.0

CI = confidence interval.

Table 9 was constructed with the intention of verifying whether the categorized AOFAS scale can replace the clinical result. In this table, it can be observed that there are 14 patients with a poor rating on the AOFAS scale, but among them there are also 6 (approximately 43%) patients considered regular with a basis on the result. Of the patients with regular AOFAS, half present a good result and similar behavior is observed in the good or excellent AOFAS. The degree of concordance between the two evaluations is low (kappa =0.337).

Table 9 – *Distribution of the categorized AOFAS, according to the clinical result.*

AOFAS		Clinical result			Total
		Poor	Regular	Good	
Poor	n	8	6	0	**14**
	%	57.1	42.9	0.0	**100.0**
Regular	n	0	4	4	**8**
	%	0.0	50.0	50.0	**100.0**
Good or Excellent	n	0	5	6	**11**
	%	0.0	45.5	54.5	**100.0**
Total	n	**8**	**15**	**10**	**33**
	%	**24.2**	**45.5**	**30.3**	**100.0**

Kappa=0.337.

The behavior of AOFAS in relation to the satisfaction of the patients can be seen in Tables 10 and 11. On average, the AOFAS of the dissatisfied patients is lower than that of those that declare themselves satisfied. (Table 10) When we analyze the categorized AOFAS in relation to satisfaction (Table 11), it is perceived that all the patients classified as regular or good (or excellent) were satisfied. Of those with AOFAS considered poor, about 36% appeared dissatisfied (p=0.018).

Table 10 – *Summary measurements of the AOFAS scale according to the satisfaction of the patients.*

Measurements	Satisfaction	
	Satisfied	Dissatisfied
n	28	5
Mean	73.4	37.4
Standard deviation	14.1	13.5
CI (95%)	[67.9; 78.9]	[20.6; 54.2]
Minimum	32.0	14.0
Median	78.0	40.0
Maximum	97.0	48.0

CI = confidence interval.

Table 11 – *Distribution of the categorized AOFAS scale according to the satisfaction of the patients.*

AOFAS		Satisfaction		Total
		satisfied	dissatisfied	
Poor	n	9	5	**14**
	%	64.3	35.7	**100.0**
Regular	n	8	0	**8**
	%	100.0	0.0	**100.0**
Good or Excellent	n	11	0	**11**
	%	100.0	0.0	**100.0**
Total	n	**28**	**5**	**33**
	%	**84.8**	**15.2**	**100.0**

p=0.018 (chi-squared).

Profile of the clinical result and of satisfaction

Table 12 was constructed to verify whether the distribution of patients satisfied with the clinical result is the same as dissatisfied patients. It is observed that the distribution of dissatisfied patients is different from those that declare themselves satisfied (p< 0.001), as the vast majority of satisfied patients presents a regular or good result and, of the dissatisfied patients, all have a poor result.

Table 12 – *Distribution of the clinical result, according to satisfaction.*

Satisfaction		Clinical result			Total
		Poor	Regular	Good	
Satisfied	n	3	15	11	**29**
	%	10.3	51.7	37.9	**100.0**
Dissatisfied	n	5	0	0	**5**
	%	100.0	0.0	0.0	**100.0**
Total	n	**8**	**15**	**11**	**34**
	%	**23.5**	**44.1**	**32.4**	**100**

p<0.001 (chi-squared).

The vast majority of satisfied patients presented arch support (93.1%). Of the dissatisfied patients, three (60%) also presented such support. Yet no significant association was found between arch support and satisfaction (p=0.094).

Among the 29 satisfied patients, 20 (68.9%) presented normal support or support of the AFO type 6, (20.7%). Among the five dissatisfied patients, only one (20%) had normal support and two were wheelchair users (40%), while one used crutches and the last, a walker.

The vast majority of patients exhibited some kind of residual deformity, regardless of the classification relating to the result (only four, 13.8%, did not have a deformity), and in relation to satisfaction or dissatisfaction.

According to Table 13, almost all the patients with good or regular clinical result presented arch support. Of the eight patients with poor result, three (37.5%) did not have such support. The association between arch support and clinical result is statistically significant (p=0.031).

Table 13 – *Distribution of the clinical result according to the arch support*

Arch support		Clinical result			Total
		Poor	Regular	Good	
Yes	n	5	14	11	30
	%	62.5	93.3	100.0	88.2
No	n	3	1	0	4
	%	37.5	6.7	0.0	11.8
Total	**n**	**8**	**15**	**11**	**34**
	%	**100.0**	**100.0**	**100.0**	**100.0**

p=0.031 (Chi-squared)

The vast majority of patients classified as regular or good were normal in relation to the type of support or made use of the anti-equinus type orthosis. Among the patients with a poor result, 75% used some type of orthesis or were wheelchair users, as we can observe in Table 14.

Profile of the angles measured in relation to results

In Table 15, it is observed, through the confidence intervals of the mean values, that in general, the flexion-extension and tibiotalar angles are no different for those with a poor, regular or good result.

Analyzed qualitatively, it is observed, in Table 16, that all the patients are non-normal in relation to flexion-extension. As regards the tibiotalar angle, it is observed that half the patients are non-normal and half, normal. Moreover, it is perceived that the patients are distributed in a similar manner in the three categories of clinical result, thus not presenting association (p=0.675).

To visualize the behavior of the talocalcaneal (AP), talar-first metatarsal (AP), talocalcaneal (P) and calcaneal pitch (P) angles in relation to the result and in the pre- and postoperative periods. (Figures 1 to 4) No statistical tests were conducted due to the small size of the sample in these situations.

Table 14 – *Distribution of the clinical result, according to the type of support.*

Type of support		Clinical result			Tota
		Poor	Regular	Good	
Normal	n	2	10	9	21
	%	25.0	66.7	81.8	61.8
AFO	n	1	3	2	6
	%	12.5	20.0	18.2	17.6
Crutches	n	1	0	0	1
	%	12.5	0.0	0.0	2.9
Cane	n	0	1	0	1
	%	0.0	6.7	0.0	2.9
Walker	n	1	1	0	2
	%	12.5	6.7	0.0	5.9
Wheelchair user	n	3	0	0	3
	%	37.5	0.0	0.0	8.8
Total	**n**	**8**	**15**	**11**	**34**
	%	**100.0**	**100.0**	**100.0**	**100.0**

Table 15 – *Summary measurements of the anteroposterior angles evaluated in the postoperative period, according to the clinical result.*

Measures	Clinical result	Flexion-extension	Tibiotalar
n	Poor	8	8
	Regular	14	14
	Good	8	8
Mean	Poor	12.0	6.6
	Regular	23.5	6.3
	Good	35.3	6.0
Standard deviation	Poor	7.0	6.7
	Regular	12.8	5.3
	Good	10.2	5.1
CI (95%)	Poor	[6.1; 17.9]	[1.0; 12.2]
	Regular	[16.1; 30.9]	[3.2; 9.4]
	Good	[26.7; 43.8]	[1.7; 10.3]
Minimum	Poor	5.0	0.0
	Regular	2.0	0.0
	Good	25.0	0.0
Median	Poor	10.0	6.5
	Regular	22.5	5.0
	Good	31.0	8.0
Maximum	Poor	25.0	15.0
	Regular	45.0	17.0
	Good	50.0	12.0

CI = confidence interval.

Table 16 – *Distribution of the clinical result, according to the categorized flexion-extension, calcaneo-cuboid and tibiotalar angles.*

Clinical result	Flexion-extension	Tibiotalar
	% (Not normal/Total)	% (Not normal/Total)
Good	100.0 (10/10)	62.5 (5/8)
Regular	100.0 (15/15)	42.9 (6/14)
Poor	100.0 (8/8)	50.0 (4/8)
Total	100.0 (33/33)	50.0 (15/30)
p*	-	0.675

*chi-squared test

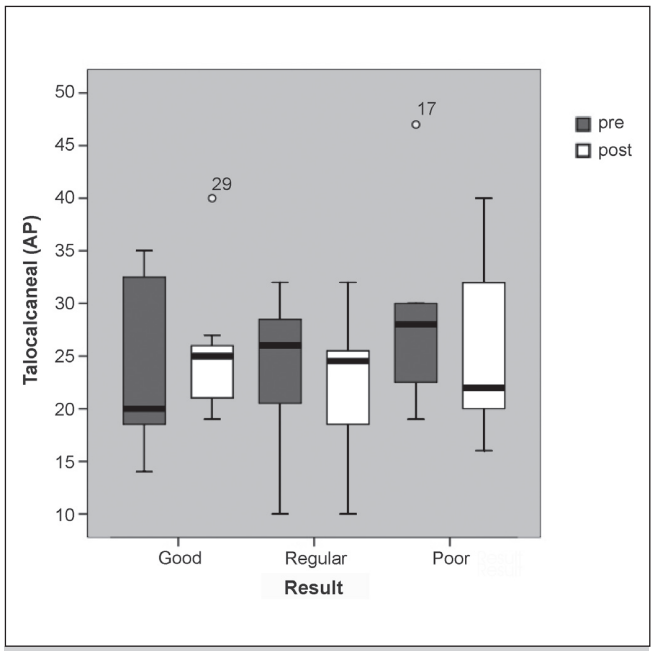

Figure 1 – *Boxplots of the talocalcaneal angle (AP), in the pre-and postoperative periods, according to result.*

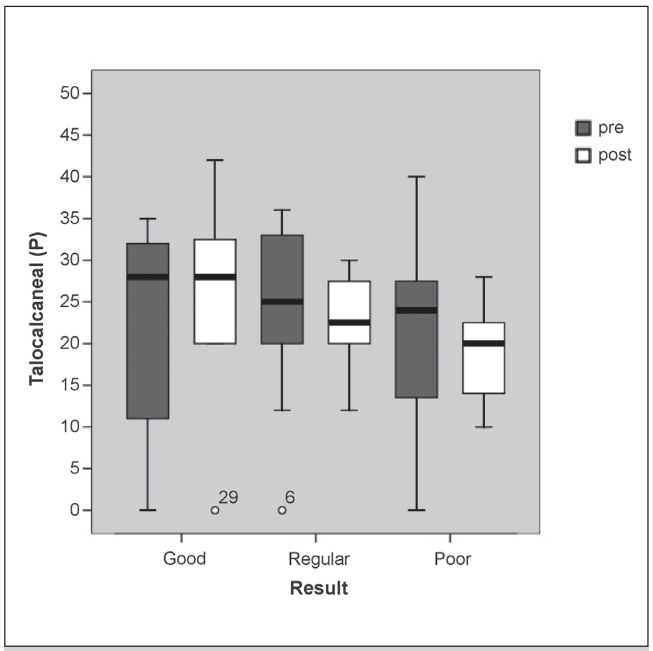

Figure 3 – *Boxplots of the talocalcaneal angle (P), in the pre- and postoperative periods, according to result.*

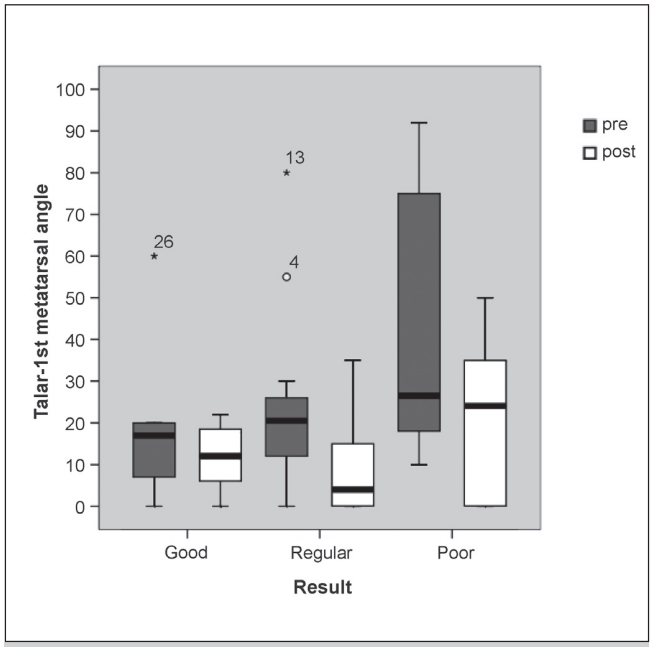

Figure 2 – *Boxplots of the talar-first metatarsal angle, in the pre- and postoperative periods according to result.*

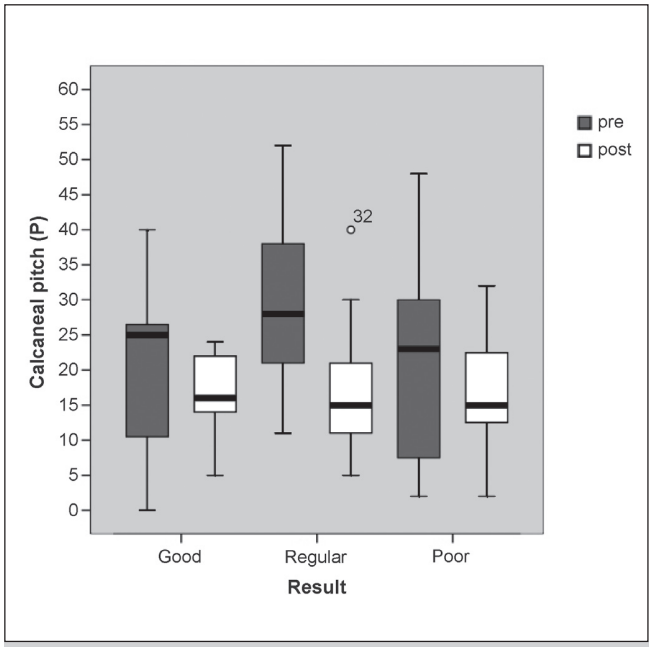

Figure 4 – *Boxplots of the calcaneal pitch angle (P), in the pre- and postoperative periods, according to result.*

Through these graphs, it is observed, for all the angles, that decreases generally occur in variability from the preoperative period to the postoperative period (which is verified by the size of the boxes in the boxplots). This means that the patients became a little more homogeneous after the surgery in relation to these angles. Moreover, it is perceived that, in terms of the median, there are also some oscillations between the pre- and postoperative periods. For example, in Figure 1, we see that the patients with good clinical result present an increase in the talocalcaneal median (AP) in the postsurgical period, while those with a poor clinical result present a more accentuated downslide in the postoperative period than those with a regular result. In relation to the talar-first metatarsal, it is possible to observe a decrease in the median of the postoperative period in all the clinical results, which is more

accentuated for the regular patients. (Figure 2) Figures 3 and 4, relating to the talocalcaneal (P) and calcaneal pitch (P) angles, present a decrease in the median in the postoperative periods, regardless of the clinical result, whereas the downtrend in the first case is subtle and, in the second, more evident.

All these graphs also show similar behavior among clinical results, when compared in the postoperative period only. Except in the talocalcaneal angle (P) that indicates a decrease in the angles with the deterioration of clinical results.

The behavior of the patients' results was studied in relation to these angles in the postoperative period only, and in a quantitative manner. However, going by the confidence intervals, it proved possible to verify that there is no difference among the clinical results, for any angle.

Analyzing these angles classified as normal or non-normal, it is perceived that the behavior of the angles is very similar for all the results. That is, the angles are classified in a similar manner, regardless of the types of result (p values all above 5%).

DISCUSSION

The treatment of foot deformities in CP targets a arch foot, painless and able to make use of orthoses, if necessary. The indication of the severity of the deformity and the presence of pain has been defined, but there are still questions to be answered regarding the patient's age. Controversies also persist in relation to the motor function or performance of the patient. Even through not ambulant, the patient needs to have his or her deformity corrected. In the paralytic patient, deformities of the feet, when not corrected, tend to be structured at the end of growth, and their treatment does not have many surgical options. Triple arthrodesis is best indicated for these stiff feet, in pre-adolescent and adult patients. Once the procedure has been indicated, we should seek the technique that allows the best correction of the deformity in question.[1-3,6,7,14-16,18,20-31] A second step lies in defining the best approach and the best fixation. Variations of triple arthrodesis techniques found in literature have as a common denominator the resection of the articular surface, sufficient bone resection for the correction of the deformity, good coaptation of the open surfaces and stabilization of the correction obtained.[14,21,28]

Triple arthrodesis consists of the fusion of the subtalar, talonavicular and calcaneocuboid joints, and with its indication for corrections of stiff deformity, with or without pain, and of joint instability, which hamper gait or the use of orthesis. In literature, most authors indicate this procedure for patients at an age close to the cessation of growth,[5,21,32-34] yet there are authors that have performed the abovementioned procedure on patients under 12 years of age and obtained satisfactory results.[35] In our study, the mean age of the patients that underwent triple arthrodesis was above 12 years.

The surgical technique most frequently used and mentioned by literature is that of Ryerson[16], described in 1923 with variations in the type of internal fixation, which can be performed with Kirschner wire, Steinnman pin, staple, screws or associations of these materials.[17,18,29,32,36-38] In 1993, Sangeorsan et al.[29] performed triple arthrodesis associating internal fixation with a screw with bone graft and obtained a good result in 77% of the cases. Kissel et al.[36] described the technique of minimum bone resection and internal fixation with screw or staple without graft insertion, and obtained a very good result in 43% of the cases. The aforesaid authors concluded that, although many patients exhibited some pain and limitation of activities, triple arthrodesis is a valuable salvation procedure, capable of restoring function and of improving pain, yet they stressed the importance of the adequate choice of patients to under the abovementioned surgical procedure.

At the time of the postoperative evaluation in this study, 85.3% of the patients declared they were satisfied with the procedures performed, which confirms findings in literature.[3,5,18,39,40] In literature it is verified that the degree of satisfaction of patients is high, between 80 and 95%.[14,17,28] Of the current 40 patients evaluated, 11 were reevaluated, and of these seven patients had equinovarus and three planovalgus deformity, which were in the study by Fucs et al.[18] showing that there was no modification in both results.

However, unlike literature, in our study, the number of patients with planovalgus deformity in the preoperative period was far lower than that of equinovarus patients (33% and 77% respectively). Most authors mention a higher number of planovalgus feet in relation to equinovarus feet.[5,32,34] This is probably owing to the fact that in patients of a tender age (5 to 10 years), with flexible pes planus, surgical treatment is performed with extra-articular arthrodesis in the subtalar joint[20,30] or anterior calcaneal lengthening osteotomy using the Evans technique[6,20,30] or even other surgical techniques. In our study, among the 10 planovalgus feet in the preoperative period, one patient had performed Grice's operation.[20] This explains the fact that the mean age at the time of triple arthrodesis was higher (17 years and two months) in comparison with the patients, who presented equinovarus deformity in the preoperative period (14 years and 1 month).

As regards the influence of the patient's age at the time of surgery on its result, literature is controversial. According to Patterson et al.[28] poor results in patients under eight years of age occur in 47% of cases, and in patients over eight years of age this result is far lower (9%). On the other hand, Kuhns et al.[35] obtained similar results in the two groups of patients with which they worked; one of the groups with children under 11 years of age (mean age 9.8 years) and the other with children over 11 years of age (mean age 13.6 years). Several authors, such as Ireland and Hoffer,[32] Lankosz et al.,[34] and Mulier et al.,[3] obtained good results when performing triple arthrodesis on patients with mean age over 12 years.

As regards behavior between pre- and postoperative periods, it is worth reporting that patients not ambulatory in the preoperative period did not present functional change in the postoperative period, yet two patients that were household ambulators became non-ambulators, in spite of the correction of the deformity in their feet. Ireland and Hoffer[32] enumerate some factors that may explain such a fact. Among these are obesity, lack of stimulus, instability, and performance of other corrective surgeries, on the knee and hip, for instance.

As regards pain, 35% of the patients declared that they felt pain in the foot in the preoperative period and of these, 67% reported improvement of pain after triple arthrodesis, yet 38% of the patients still reported pain in the postoperative period. This data coincides with literature, which reports that 23 to 57% of patients

present pain in the postoperative period.[5,21,37,39,40] In addition, it is necessary to emphasize that, in our study, the mean follow-up time was seven years and six months; Saltzman et al.[40] showed that 45% of the patients that referred to pain in the ankle after a follow-up of 25 years and 55% of the cases appeared with pain after 45 years of follow-up. The deterioration of the result as regards pain in the foot is due to time, since to these authors in 33% to 57% of the cases, the longer the follow-up time in the postoperative period, the greater the incidence and the intensity of pain. In our study, of the eight patients with moderate pain in the preoperative period, five cases started to experience slight pain after the triple arthrodesis. Therefore we verified an improvement in pain intensity with the procedure performed.

There was ankle arthrosis after the triple arthrodesis in 29.4% of the cases, which is within the parameters presented by literature (25 to 43%). Similar to pain, the number of cases of arthrosis in the adjacent joints increases with the follow-up time in the postoperative period.[5,21,29,40] The results obtained in our study reveal that there is no correlation of this ailment with the tibiotalar angle, in the anteroposterior position, of the postoperative period.

As refers to residual deformity, a percentage above that reported in literature (38% to 80%)[5,38,41] was verified in 90% of our patients. As regards the incidence of pseudarthrosis, this was 26.4%, whereas the talonavicular joint was the most extensively impaired (20.6%). These data are not contrary to literature, according to which pseudarthrosis is verified in the study by Ireland and Hoffer,[32] who obtained 22.2% in the patients with etiology in CP. Angus and Cowell[21] and Saltzman et al.[40] obtained 23% and 28% respectively, with different etiologies of deformities of the patients that underwent triple arthrodesis.

In our study, 32.4% of the cases presented a good result, 44.1% regular and 23.5% poor, which is according to literature,[21,39,40] also showing that the longer the follow-up time the smaller the group of patients with results considered good. On the other hand there are authors whose results contradict ours, such as Lanter et al.[41] and Mulier et al.,[3] who obtained, respectively, good results in 75% and 72%, regular in 20% and 24%, and poor in 5% and 4%. This non-concordance with our results may be due to the fact that the deformity that led to the triple arthrodesis of the patients studied by these authors has several etiologies and not just CP, like in our patients. Furthermore, the severity of the deformities must have influenced our results.

In the result obtained in the AOFAS[19] scale score, and the result of the score of the scale according to the clinical result, there was a difference of 18.2% in relation to the poor result, 21.2% in relation to the regular result; the good result with excellent added to good by the AOFAS scale were similar, in the total 33 analyzed cases, as demonstrated in the Kappa test = 0.337, but the degree of concordance between the two evaluations was low, therefore we cannot completely substitute the result by the AOFAS scale, as shown by Table 10, and the percentage difference between the two criteria, probably, as it does not analyze the subjective result as degree of satisfaction, which in the study, 85.3% of the patients declared they were satisfied with the procedure at the time of the evaluation, like the arch support that we obtained in 88.2% of the cases. It cannot be affirmed that the AOFAS scale is an excellent method for evaluation of patients with CP submitted to triple arthrodesis as, in the functional item, with a value of (50 points), the dysfunction is not located in the feet alone, and the patients with neuromuscular diseases present complex impairment of the neuromusculoskeletal system. The scale served as yet another parameter in the attempt to improve and expand the evaluation of patients with CP.

As regards range of flexion-extension motion of the ankle in the postoperative period, the mean was 22 degrees (minimum of 2 degrees and maximum of 50 degrees), which coincides with that obtained by Saltzman et al.[40] and by Tenuta et al.[5] According to Saltzman et al.[40] the dorsiflexion movement of the ankle is the most impaired. This decrease in the range of motion of the adjacent joints, according to Schroeder et al.[14] occurred due to the complexity of the procedure and does not depend on the surgical technique used.

After the triple arthrodesis, our results did not reveal a significant change in the talocalcaneal angle, in the anteriorposterior position, with improvement of 1 degree approximately ($p = 0.592$). As regards the talocalcaneal angle, in the lateral view, there was no change ($p=0.767$), and the study by Sangeorzan et al.[29] reports an improvement in the postoperative period of up to 11 degrees, which differs from our result; the authors went as far as to exclude the talocalcaneal angle in AP from their evaluation due to the difficulty in measuring the angles.

On the other hand, the improvement of 18 degrees verified by Sangeorzan et al.[29] in the talar-first metatarsal angle, in the anteriorposterior position, is similar to that observed in our study, of 16 degrees, statistically significant ($p = 0.001$). And the calcaneal pitch angle, in lateral view, on average showed a decrease of 6.5 degrees, which was also significant ($p = 0.004$). Together with the calcaneal pitch angle, in profile, and the talar-first metatarsal angle, in the anteroposterior position, they were the most sensitive to the surgical procedure, as demonstrated by Graphs 2 and 4, respectively.

As regards the internal fixation of triple arthrodesis, it was verified that it did not influence the result. Seitz and Carpenter,[38] Svartman et al.,[17] Haritidis et al.[39] and Fucs et al.[18] used fixation with steel pins, and the first obtained 79% of satisfactory results, the second 88% of deformity correction, the third 20% of good results, and, finally, the last 72% of satisfactory results. On the other hand, different authors such as Monson and Gibson[37] and Ireland and Hoffer[32] fixed the procedure with staples and obtained 91% of good function. Sangeorzan et al.[29] and Lanter et al.[41] also obtained good results (mean of 75% of satisfaction and excellence) in using a screw as an internal fixation method.

CONCLUSIONS

There was significant improvement in the measurements of the talar-first metatarsal bone angle in the anteriorposterior position, and the calcaneal pitch angle, in profile with the performance of triple arthrodesis. The talar-first metatarsal and calcaneal pitch angles were the most sensitive to evaluate the effect of the surgical procedure. The procedure resulted in arch support for 88.2% of the patients, whereas 62% attended the evaluation without orthoses and using comfortable shoes. The patients with equinovarus deformity had better results than those with planovalgus feet in the clinical evaluation. The vast majority (85.3%) was satisfied with the procedure performed.

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