

# Patient-reported Outcomes of Calcaneonavicular Coalitions Treated With Surgical Excision and Fat Graft Interposition: A Two-Center Experience

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## ABSTRACT

**Background:** The purpose of the present study was to evaluate clinical/radiographic outcomes, and complications for calcaneonavicular coalition (CNC) excision and fat graft interposition in patients under the age of 18. **Materials and Methods:** A retrospective review of all pediatric patients surgically treated with symptomatic CNC at two institutions was performed. Demographic data and postoperative complications were recorded. Functional results were evaluated with AOFAS Ankle-hindfoot Scale and Visual Analog Scale (VAS). Radiographic assessment of coalition recurrence was performed on the most recent oblique radiograph (resected gap remaining <50%). **Results:** Between January 2008 and January 2018, 52 patients (65 feet) with CNC were surgically treated. Forty patients (48 feet) met the inclusion criteria and were available for evaluation. The average age at surgery was 11.9 years old (range 9-17 years old). The average follow-up was 43 months. The average AOFAS score improved from 58.9±8 points preoperative to 92.9±7.8 points postoperatively (p<0.001). Preoperative pain scores averaged 6.9 ± 2.5 points. At the last follow-up, the VAS score was 0.49 ± 1.1 points (p<0.001). Most patients (87.5%) were painless at the last follow-up and five patients (6 feet) had occasional pain with strenuous activities. Five complications were recorded: wound dehiscence (N=3) and superficial infection (N=2). Two feet (4.2%) had coalition regrowth on the postoperative radiographs without requiring further surgery. **Conclusion:** Calcaneonavicular coalition excision with fat graft interposition can improve function and relieve pain with a low rate of complications in the pediatric-adolescent population.

**Keywords:** Foot, adolescent, calcaneonavicular, coalition resection.

**Level of Evidence:** IV

## Resultados funcionales del tratamiento de coaliciones calcáneo-escafoideas con resección e interposición de grasa autóloga: Experiencia de dos centros

## RESUMEN

**Objetivo:** Evaluar los resultados clínico-radiográficos y las complicaciones en pacientes <18 años con coaliciones calcáneo-escafoideas (CCE) sintomáticas tratados con resección e interposición de grasa autóloga de la región glútea. **Materiales y Métodos:** Se analizó retrospectivamente a los pacientes con CCE sintomáticas operados con dicha técnica, en dos instituciones, y un seguimiento mínimo de 2 años. Se analizaron los datos demográficos y las complicaciones posoperatorias. Los resultados funcionales fueron evaluados con la escala AOFAS y la EAV. Se determinó la presencia de recidiva en la radiografía oblicua más reciente (defecto remanente <50%). **Resultados:** Entre enero de 2008 y enero de 2018, se operó a 52 pacientes (65 pies) con CCE. Cuarenta (48 pies) cumplían con los criterios de inclusión. La edad promedio al operarse era de 11.9 años. El seguimiento promedio fue de 43 meses. El puntaje AOFAS promedio mejoró significativamente de 58,9 ± 8,2 preoperatorio a 92,9 ± 7,8 después (p < 0,001). El puntaje promedio preoperatorio de la EAV era de 6,9 ± 2,5 y de 0,49 ± 1,1 (p < 0,001) en el último seguimiento. El 87,5% no tenía síntomas en el último control y 5 pacientes (6 pies) sufrían molestias ocasionales con la actividad física intensa. Hubo 5 complicaciones posoperatorias: dehiscencia de la herida e infección superficial. Dos pies (4,2%) presentaron recidiva radiográfica de la coalición aunque ningún paciente requirió revisión. **Conclusión:** La resección de CCE y la interposición de grasa autóloga permiten aliviar el dolor y mejorar la función con una baja tasa de complicaciones en la población pediátrico-adolescente.

**Palabras clave:** Pie; adolescentes; coalición calcáneo-escafoidea; resección.

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## INTRODUCTION

Calcaneonavicular coalitions (CNC) are congenital anomalies in which there is a fibrous, cartilaginous, or osseous connection between the calcaneus and the navicular.<sup>1</sup> This condition is believed to be due to an alteration in differentiation and segmentation, resulting in a failure in the normal formation of this joint.<sup>2</sup> The estimated incidence varies from 1% to 13%, which makes it one of the most common foot and ankle pathologies in children.<sup>3,4</sup> The abnormal connection between the navicular and the calcaneus can cause significant morbidity. The typical patient with symptomatic CNC is an adolescent with persistent pain, limited range of motion, and repeated sprains or fractures of the ankle or foot.<sup>5</sup>

Persistent symptoms, despite nonsurgical measures, may lead to the need for surgical treatment. CNCs are usually treated by resection and soft tissue interposition to prevent recurrences. Jayakumar and Cowell<sup>6</sup> were the first to publish the use of the extensor digitorum brevis muscle for the interposition. Other authors have alternatively proposed the use of autologous fat from the gluteal fold or abdominal region, bone wax or fibrin glue.<sup>7-9</sup> It remains controversial which interposition material can provide the best functional outcome and the lowest recurrence rate.

Since 2008, the authors of this study have used a technique that involves a very careful resection and a free fat graft taken from the gluteal region as interposing tissue. This study aims to evaluate the clinical-radiographic outcomes and complications in patients <18 years with symptomatic CNC treated with this procedure and a minimum follow-up of two years.

## MATERIALS AND METHODS

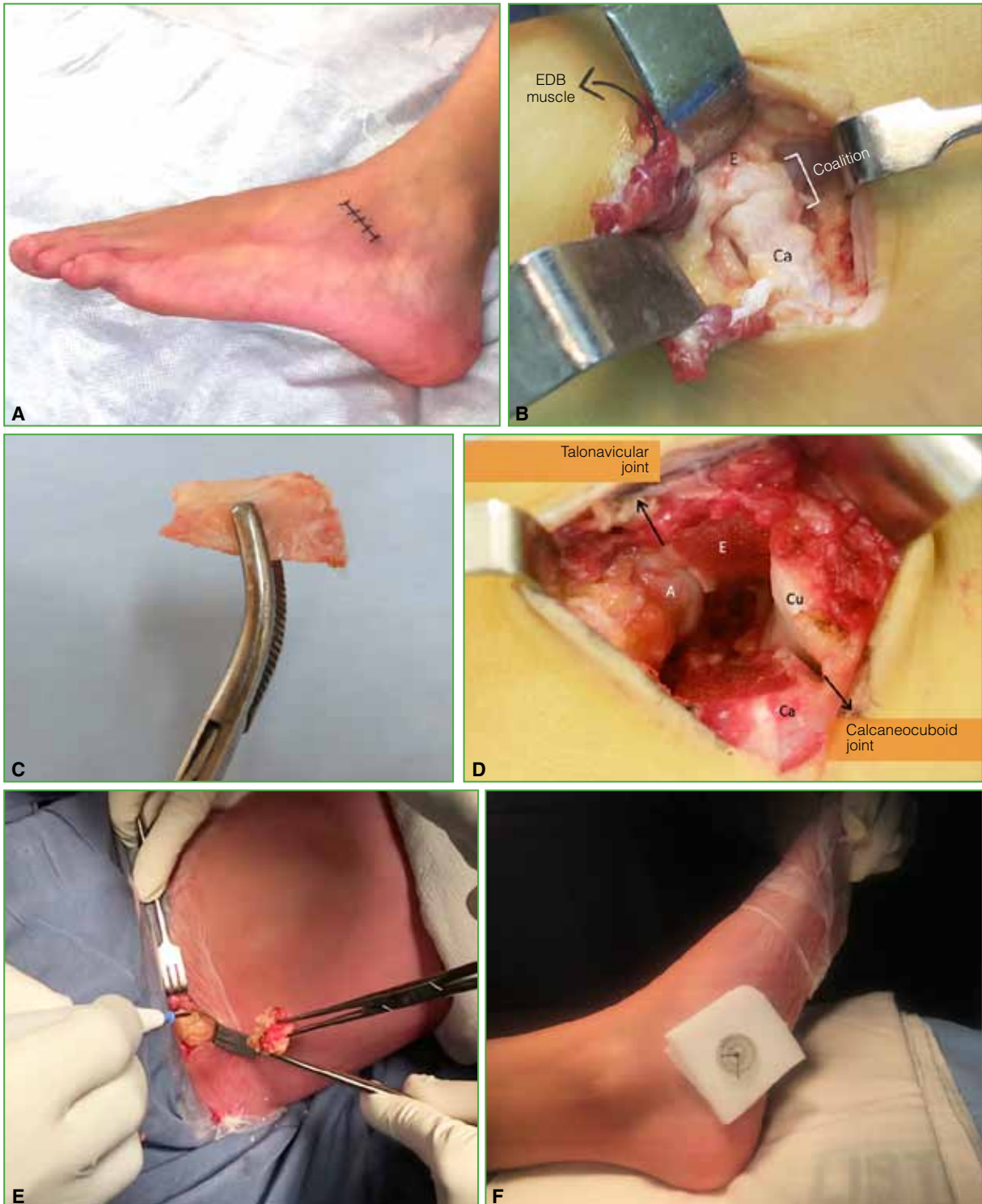
This study was approved by the ethics committee of both participating institutions. All patients with a diagnosis of CNC treated with the same surgical technique over a period of 10 years (from January 2008 to January 2018) were retrospectively analyzed. All surgeries were carried out in two reference centers and were in charge of four surgeons specializing in Children's Orthopedics. Those patients with associated bars, severe deformity requiring realignment in the same surgical time, revision surgeries and a follow-up <24 months were excluded from the analysis.

### Surgical technique

After general anesthesia and antibiotic prophylaxis during anesthetic induction, a hemostatic cuff is placed on the thigh and antiseptic measures are taken. The patient is placed in the dorsal decubitus position with an enhancement in the lateral gluteal region. A 3-4 cm oblique lateral approach is performed, centered on the coalition. The aponeurosis of the extensor digitorum brevis muscle is incised. It is carefully disinserted from its proximal origin with an electro-surgical knife and marked with Vicryl 0. The coalition is identified clinically and the resection margins are identified by fluoroscopy. As a guide, the calcaneocuboid joint is used for the proximal limit and the joint between the cuboid and the lateral wedge for the distal limit. The resection is performed with 10 mm chisels to initiate the cut and then 5 mm in the plantar area of the bar to avoid injuring the cuboid or the head of the talus.<sup>5</sup> If a portion of the bar remains in the plantar area, Kerrison-type forceps can be used. The periosteum in the plantar region of the coalition is completely resected. Complete resection of the fusion is confirmed clinically and radiographically (Figures 1 and 2). Next, we proceed to take the fat graft from the gluteal region. In nine



**Figure 1.** Resection margins.



**Figure 2.** A. Approach. B. Intraoperative image. C. Coalition. D. Image of the defect after completing the resection. E. Fat harvesting from the posterointernal gluteal fold. F. Button fixation of the fat graft. A = talus, Ca = calcaneus, E = navicular, Cu = cuboid.

cases, it was taken from the most posterior region of the gluteus. As two patients presented dehiscence, it was decided to modify the incision to a posteromedial position. To do this, the ipsilateral hip is flexed and abducted. The fat is prepared with Vicryl 0 sutures, introduced into the defect and button-fixed on the sole of the foot (*pull-out*). The extensor digitorum brevis muscle is repositioned with separate Vicryl 1 stitches, attaching it to the extensor retinaculum. Subcutaneous cellular tissue is then closed with Vicryl 2.0 and the skin with Monocryl 4.0. A sterile bandage and a plaster splint are placed below the knee without standing for two weeks. After this period, the splint and plantar button are removed. Progressive standing and physical therapy are indicated to improve range of motion and strength and to retrain gait. A progressive return to sports activities is usually allowed after three months.

### Patient evaluation

The information analyzed included demographic data (age, sex, side), type of bar,<sup>10</sup> symptoms that led to the consultation, previous treatment and postoperative complications (infection, wound dehiscence, recurrence, etc.). CNCs were classified according to Upasani<sup>10</sup> into four types: frustrated, fibrous, cartilaginous, and bone. Before surgery, anteroposterior, lateral, and oblique radiographs of the foot were taken, and a computed tomography (CT) scan was performed to rule out associated coalitions and assess foot alignment.

Functional results were evaluated with the *Ankle-Hindfoot Scale* of the AOFAS (*American Orthopedics Foot and Ankle Society*)<sup>11</sup> and the visual analog scale (VAS)<sup>12,13</sup> through a telephone survey. The *Ankle-Hindfoot Scale* analyzes subjective and objective parameters, with values from 0 to 100 points, considering optimal results directly proportional to the number of points. The VAS is a one-dimensional measurement tool for calculating pain intensity, in which the response corresponds to a level of agreement by defining a position on a continuous line between two points (from 0 to 10). It was defined as radiographic recurrence of the bar when the intraoperative resection margin decreased to less than 50% on the last oblique radiograph.<sup>7</sup> A patient was considered to have a symptomatic recurrence if they presented the aforementioned characteristics, but with pain that limited their usual activities.

### Statistical analysis

Descriptive statistics (average and standard deviation) were used for the description of quantitative variables, and absolute frequencies were used for qualitative variables. The preoperative and postoperative differences of the AOFAS functional scale were evaluated with the paired Student's t-test. The alpha value was set at 0.05. All statistical analyses were performed with the SPSS v.19.0 program (IBM Corp., Armonk, NY, USA).

## FINDINGS

Between January 2008 and January 2018, 52 patients (65 feet) with CNC underwent surgery. Forty (48 feet) met the inclusion criteria and could be identified for evaluation. The average age at the time of surgery was 11.9 years (range 9-17). The demographic characteristics of the patients and the results according to the *Ankle-Hindfoot Scale* and the VAS are described in the [Table](#).

**Table.** Demographic data and functional outcomes

Patients (feet)	40 (48)
Age	11.9 years (range 9-17)
Upasani Classification (10) #	I: 12.5% (n = 6), II: 50% (n = 24), III: 20.8% (n = 10), IV: 16.7% (n = 8)
Average follow-up (months)	43 (range 24 - 132)
AOFAS- <i>Ankle-Hindfoot Scale</i> (preoperative-postoperative)	58.9 ± 8.2 - 92.9 ± 7.8 (p <0.001) *
Visual analog scale	0.49 ± 1.1 (range 0-4)
Radiographic recurrence	4.2% (2/48)
Clinical recurrence	0% (0/48)

\* Student's paired t-test.

# Upasani Classification: I (forme fruste), II (fibrous), III (cartilaginous), IV (osseous).

87.5% of the patients were completely asymptomatic at the last follow-up. Six feet (5 patients) had occasional discomfort that did not interfere with activities of daily living. Two feet (4.2%) had a radiographic recurrence of the coalition (**Figure 3**). One of these patients presented pain, for which he was treated with rehabilitation and the symptoms improved. Neither patient required revision surgery.

There were five postoperative complications (10.4%). Three patients suffered wound dehiscence: two in the area where the interposition material (fat) was taken and one on the lateral aspect of the foot. One of them, located in the gluteus, was treated with debridement and secondary closure. The other two dehiscences were treated with curings. Two superficial infections were reported and cured with oral antibiotics (first-generation cephalosporin).



**Figure 3.** Radiographic recurrence image.

## DISCUSSION

Surgical resection of symptomatic CNCs represents the gold standard for treatment.<sup>14,15</sup> Among the options, one of the most popular is resection through a dorsal approach and interposition of the extensor digitorum brevis muscle.<sup>6</sup> Good to excellent results have been reported with this technique, between 69% and 88%,<sup>6,16-19</sup> with reossification rates that vary from 0% to 38%, according to the definitions used by the authors.<sup>16-19</sup> A cadaver study refutes the use of the extensor digitorum brevis as an interposition material.<sup>7</sup> Due to anatomical restrictions, the extensor digitorum brevis muscle would not be of sufficient length and volume, leaving more than a third of the defect unfilled on the plantar aspect of the resection. Another disadvantage is that osteoprogenitor cells reside in muscle<sup>20</sup> and as such may not be the best option when the goal of surgery is to minimize the risk of recurrence. On the other hand, the use of the extensor digitorum brevis generally results in a large and cosmetically unattractive cleft in the tarsal sinus.

For this reason, some authors<sup>5,7</sup> recommend using autologous fat from the gluteal fold or abdomen. Free autologous fat has been used as an interposition material in the resection of physeal arrests, posttraumatic synostoses, CNCs and talocalcaneal coalitions.<sup>7,8,21-23</sup> Tachdjian<sup>24</sup> was the first to describe its application in CNC. Although there are very few series that describe the outcomes of this technique,<sup>7,8</sup> the reossification rate would appear to be lower. Mubarak *et al.*<sup>7</sup> evaluated 55 patients (78 feet) treated with resection and fat graft interposition. The result was excellent in 48 patients (87%), fair in four (8%), and poor in three (5%). Although 10 feet presented radiographic reossification, only three of them (5%) caused symptoms. Masquijo *et al.*<sup>8</sup> compared the functional



outcomes and the reossification rate in 56 feet treated with resection and interposition with bone wax (n = 18), autologous fat (n = 23) and extensor digitorum brevis muscle (n = 15). Patients treated with fat graft interposition had better functional outcomes and a significantly lower reossification rate (p = 0.004). Although the few patients treated with bone wax obtained results comparable to those with autologous fat, wax is a synthetic material that can produce foreign body reactions and wound dehiscence; therefore, it should be used with caution.<sup>25</sup>

The results of the series evaluated in this study are a confirmation of those already reported. The low recurrence rate (4.2%) after a minimum follow-up of two years allows us to affirm that the autologous fat graft taken from the gluteal area is an excellent interposition material, since it covers the defect in its entirety and has a better consistency than locally obtained fat, thus avoiding the reossification of the bar. Another advantage of using fat and repositioning the extensor digitorum brevis muscle to its original insertion is that it avoids the formation of an umbilication (in the resection area) and a bony prominence (anterior portion of the calcaneus) that often bothers patients when wearing footwear. In our series, there were three wound dehiscences. Two were located in the graft harvesting area. In the first nine patients in the series, the graft was taken from the posterior gluteal fold. After the aforementioned complication, we decided to modify the graft harvesting area using the posterointernal crease of the gluteus, because it is an area with less skin tension, better healing, and is more aesthetic. Since we introduced this modification, we have not observed complications like the one described. The remaining dehiscence occurred in the foot wound. The disadvantage of the lateral approach to the foot is that it presents little subcutaneous cellular tissue, so the closure must be very careful to avoid such a complication.

Our study has some limitations related to the methodological design and retrospective data collection. The AO-FAS scale has not been validated in the pediatric population, although it has been used in other similar studies.<sup>8,23</sup> Despite these limitations, we consider that the results with a minimum follow-up of two years are encouraging, since most of the patients had no symptoms and were able to return to their activities without difficulties.

## CONCLUSION

The resection of symptomatic CNCs with the interposition of a free fat graft taken from the gluteal region allows to improve function and relieve pain with a low rate of complications.

Conflict of interests: The authors declare they do not have any conflict of interests.

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