ORIGINAL ARTICLE

Percutaneous hallux valgus surgery in children: Short-term outcomes of 33 cases

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KEYWORDS
Hallux valgus; Children; Adolescent; Minimally invasive foot surgery; Skeletally immature

Summary
Background: Many surgical procedures for hallux valgus correction have been reported, including percutaneous techniques. In children, the risk of recurrent hallux valgus after any type of surgical correction seems to deserve attention. To our knowledge, no studies have investigated the outcomes of percutaneous hallux valgus surgery in children. Here, we report a study on this topic.

Materials and methods: We retrospectively reviewed 33 percutaneous surgical procedures to correct idiopathic hallux valgus in 18 children younger than 16 years of age. Radiographs obtained pre-operatively and at last follow-up were used to determine the hallux valgus angle (HVA), intermetatarsal angle (IMA), and distal metatarsal articular angle (DMAA). Clinical outcomes were assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) score and a satisfaction score.

Results: Mean follow-up was 30 months. At surgery, mean age was 12.5 years and the growth plates were open in 20/33 (61%) cases. Mean HVA correction was 8.6° (from 28.06° to 19.45°, P < 0.01) and mean DMAA correction was 7° (from 15.97° to 8.97°, P < 0.01). At last follow-up, 20 (61%) feet had HVA values greater than 16°, but in half these cases the patients reported being satisfied with the procedure, leaving 30% of feet with symptomatic under-correction. Mean post-operative AOFAS score was 80.7. Patients were satisfied or very satisfied for 24/33 (73%) feet.

Discussion: We found a high-rate of radiographic under-correction. Studies of factors associated with recurrent hallux valgus would be expected to result in technical improvements and therefore in better outcomes.

Conclusion: Our evaluation of short-term outcomes after percutaneous hallux valgus surgery without internal fixation showed both a high-rate of under-correction and a high-rate of patient satisfaction. Medium-term studies are needed to determine whether these results are sustained over time. The available data suggest a number of technical improvements. At present, we plan to continue to offer this procedure to children and their families.

Level of evidence: Level IV, retrospective study.

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Introduction

Hallux valgus (HV) is a common deformity of the first ray of the foot [1] in which the hallux is deviated towards the midline. The main consequences are pain over the medial exostosis formed by the prominent head of the first metatarsal and widening of the forefront with difficulty finding shoes that fit. Apart from wearing appropriate footwear, surgery is the main treatment for HV.

In adults, dozens of surgical techniques have been reported [2]. In recent years, minimally invasive and percutaneous methods have produced promising results [3,4]. The use of these methods in children may raise concern regarding the risk of recurrence [5–15]. The percutaneous Reverdin-Isham osteotomy [16] probably deserves evaluation in this population at risk for recurrent HV and re-operation.

To the best of our knowledge, no published studies of percutaneous HV correction in children are available. We therefore conducted a retrospective evaluation of the short-term clinical and radiographic outcomes of 33 percutaneous HV correction procedures in patients younger than 16 years of age.

Material and methods

From December 2006 to October 2010, 33 percutaneous HV procedures were performed in 18 patients, all of whom were females. Mean age at surgery was 12.5 years (range, 8.1–15.7 years). Of the 15 patients with bilateral HV, 14 had surgery on both feet on the same day. All three cases of unilateral HV were on the left side.

In all 33 cases, there was congruent HV with no evidence of osteoarthritis. Inclusion criteria were age younger than 16 years and an HV angle (HVA) equal to or greater than 16° (with no restriction on the maximum value). Exclusion criteria were post-traumatic deformity and secondary HV (due for instance to cerebral palsy, connective tissue disorders, or rheumatic diseases).

Patients were selected for surgery based on the presence of pain, difficulties with footwear, and cosmetic considerations.

Clinical outcomes were assessed at least 12 months after the procedure based on the American Orthopaedic Foot and Ankle Society (AOFAS) score [17], patient satisfaction (rated as very satisfied, satisfied, somewhat dissatisfied, or dissatisfied), and procedure-related pain (rated as mild, moderate, or severe).

The pre-operative radiographic work-up included an antero-posterior weight-bearing view for determination of the HVA, intermetatarsal angle (IMA), and distal metatarsal articular angle (DMAA). The following values were considered abnormal [16]: HVA greater than 15°, IMA greater than 10°, and DMAA greater than 8°.

An antero-posterior weight-bearing radiograph of the foot was obtained at last follow-up. HVA, IMA, and DMAA were measured. Under-correction was defined as HVA greater than 16°. At surgery, the growth plates were open in 20/33 (61%) cases.

We defined symptomatic under-correction as HVA greater than 16° with a patient satisfaction rating of somewhat dissatisfied or dissatisfied.

Statistical tests were performed to compare the pre- and post-operative radiographic data. Values of P ≤ 0.05 were considered significant. Statistical tests were done using XLSTAT® (Addinsoft, Paris, France).

Operative technique

General anaesthesia was used alone for eight procedures and general anaesthesia plus local and regional anaesthesia for 23 procedures. Spinal anaesthesia was used in a patient with bilateral HV.

Surgery was performed without a tourniquet to allow the moderate bleeding to cool the tissues heated by the power instruments. Maximum rotational speed of the motor was 10 000 rpm. The patient was supine with the pelvis at the lower edge of the operating table, the contralateral limb on a gynaecological leg holder, and the limb to be treated on a knee bar. The foot to be treated was placed on the image amplifier housing previously covered with sterile drapes.

We used the technique described by De Prado et al. [16] and combining a Reverdin-Isham distal metatarsal osteotomy, bunionectomy (resection of the medial prominence of the head of the first metatarsal), release of the first metatarsal-phalangeal joint, and osteotomy of the first proximal phalanx. Bunionectomy was not performed routinely, as the head of the first metatarsal is not always prominent in children. The distal wedge osteotomy performed through a medial approach aimed to correct the orientation of the distal joint surface of the first metatarsal (DMAA). Bunionectomy was performed via the same approach. The metatarsal-phalangeal joint was released via a lateral approach using a Beaver® blade to divide the lateral sesamoid-phalangeal and sesamoid-metatarsal ligaments, thus releasing the two hallux sesamoid bones. Finally, a wedge osteotomy was performed in the proximal metaphysis of the first proximal phalanx via a medial approach. When the IMA was greater than 18°, an additional step was lateral wedge osteotomy of the base of the first metatarsal via a dorsal approach (Fig. 1).

A bandage maintaining the first ray in over-correction was fashioned (Fig. 2) and kept for 6 weeks, with two changes, on days 7 and 21. The parents removed the last bandage after 6 weeks and replaced it with a toe spacer in the first web space, which was worn for 6 months. Immediate weight-bearing was allowed. Rehabilitation therapy was not used.

Results

Of 25 included patients, 18 (33 operated feet) were re-evaluated at least 12 months after HV surgery. Mean follow-up was 31.5 months (range, 14.1–58.2 months). Bunionectomy was performed in only ten (30%) cases and osteotomy of the base of the first metatarsal was not required in any of the cases. The pre-operative and post-operative IMA values were between 10° and 18° in all 33 cases.

The procedure was performed on an outpatient basis in 42% of cases. In the other cases, the patients stayed in the hospital overnight.

Table 1 reports the pre-operative and post-operative values of the HVA, IMA, and DMAA. Significant differences...
Figure 1  Radiographs in a patient who was 8 years old at surgery. A. Before surgery. B. In the immediate post-operative period. C. 18 months after the procedure.

<table>
<thead>
<tr>
<th>Table 1  Radiographic results in 33 paediatric cases of idiopathic hallux valgus.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-operative angle (°)</td>
</tr>
<tr>
<td>mean ± SD (range)</td>
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<td>--------------------------</td>
</tr>
<tr>
<td><strong>HVA</strong></td>
</tr>
<tr>
<td>28.06 ± 6.30 (18 to 42)</td>
</tr>
<tr>
<td><strong>IMA</strong></td>
</tr>
<tr>
<td>13.61 ± 2.59 (10 to 18)</td>
</tr>
<tr>
<td><strong>DMAA</strong></td>
</tr>
<tr>
<td>15.97 ± 5.74 (0 to 28)</td>
</tr>
</tbody>
</table>

HVA: hallux valgus angle; IMA: intermetatarsal angle; DMAA: distal metatarsal articular angle.
between the pre-operative and post-operative values were found for the HVA and DMAA.

Under-correction was associated with higher pre-operative IMA values, higher post-operative DMAA values, and less DMAA correction, compared to restoration of normal alignment (Table 2). Fisher’s exact test analysis of the contingency table of post-operative HVA values versus pre-operative and post-operative DMAA values showed a significant association between post-operative HVA and post-operative DMAA ($P < 0.001$, Table 3). In two cases, good radiographic results were obtained despite pre-operative DMAA values between $0^\circ$ and $8^\circ$.

Clinical outcomes are reported in Table 4. Mean post-operative AOFAS score was 80.7. For 24/33 (74%) procedures, the patients reported being satisfied or very satisfied with the surgical outcome. For 12/33 (36%) procedures, the patients rated pain intensity as mild.

The post-operative HVA value was greater than $16^\circ$ in 20/33 (61%) cases. For ten of these 20 cases, the patients reported being satisfied or very satisfied with the procedure. Of the ten remaining cases, three were treated using a scarf osteotomy and three others were scheduled for re-operation at the request of the patients, yielding a total of 6/33 cases (18%). The post-operative HVA value was greater than $20^\circ$ in 12/33 (36%) cases.

The post-operative course was uneventful in 21/33 (64%) cases. The most common complications were post-operative pain ($n = 9$), a greater than 2-week delay in weight-bearing ($n = 7$), and focal hypoesthesia ($n = 4$, with resolution in three cases).

Discussion

After a mean follow-up of 31.5 months, 20/33 (61%) feet showed under-correction, including ten for which the patients were satisfied with the result. Thus, radiographic recurrence was not consistently associated with poor clinical outcomes. Risk factors for under-correction were a high pre-operative IMA value and insufficient DMAA correction.

Limitations of our study include the retrospective design, small number of patients, and short follow-up duration. Despite the risk of recall bias, questionnaires were necessary in our study to collect data missing from the medical records (e.g., pain was not evaluated routinely). The radiographs taken during the post-operative period were non-weight-bearing and/or taken with the over-correcting bandage. Consequently, we were unable to determine whether the cases of under-correction at last follow-up were ascribable to initial under-correction or to a recurrence of the deformity. Low inter-observer reproducibility has been reported for some angles, most notably the DMAA [18–20]. In our study, to minimise measurement error, all angles were measured by the same person, who was not among the surgeons.

The optimal management of HV in paediatric patients is not agreed on. Some surgeons feel that corrective procedures should be delayed until adulthood, with conservative measures such as orthotic therapy in the interval [21,22]. Reported recurrence rates after surgery vary widely and the absence of stringent radiological criteria is an obstacle to comparisons. The Mitchell osteotomy of the first metatarsal neck has been associated with recurrence rates of 20% to 30% [5,7,8], as well as with metatarsalgia ascribed to the shortening of the first metatarsal [9]. The scarf osteotomy (double chevron with a long longitudinal cut) has been used in children with outcomes that also tended to deteriorate over time [10]. In a study of 19 scarf osteotomies, ten (53%) feet had post-operative HVA values of $16^\circ$ or greater, a proportion similar to that found in our study [6]. In paediatric patients, the McBride procedure (adductor hallucis transfer) was followed by radiographic recurrence rates.
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Table 2  Comparison of the groups with restored alignment (HVA < 16°) and under-correction (HVA > 16°) at last follow-up.

<table>
<thead>
<tr>
<th></th>
<th>HVA &lt; 16°</th>
<th>HVA &gt; 16°</th>
<th>P value Mann-Whitney</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n = 13)</td>
<td>(n = 20)</td>
<td></td>
</tr>
<tr>
<td>Pre-operative IMA mean ± SD (range)</td>
<td>12.23 ± 2.17° (10° to 16°)</td>
<td>14.61 ± 2.45° (10° to 18°)</td>
<td>0.01</td>
</tr>
<tr>
<td>Post-operative IMA mean ± SD (range)</td>
<td>12.08 ± 2.69° (8° to 18°)</td>
<td>13.22 ± 2.67° (9° to 18°)</td>
<td>0.19</td>
</tr>
<tr>
<td>IMA correction mean ± SD (range)</td>
<td>0.15 ± 2.34° (−4° to 4°)</td>
<td>1.39 ± 2.38° (−2° to 6°)</td>
<td>0.27</td>
</tr>
<tr>
<td>Pre-operative DMAA mean ± SD (range)</td>
<td>13.93 ± 7.02° (0° to 28°)</td>
<td>17.44 ± 4.22° (8° to 23°)</td>
<td>0.067</td>
</tr>
<tr>
<td>Post-operative DMAA mean ± SD (range)</td>
<td>2.46 ± 4.56° (−4° to 10°)</td>
<td>13.67 ± 6.88° (4° to 28°)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>DMAA correction mean ± SD (range)</td>
<td>11.46 ± 8.02° (0° to 28°)</td>
<td>3.78 ± 7.23° (−12° to 18°)</td>
<td>0.014</td>
</tr>
</tbody>
</table>

HVA: hallux valgus angle; IMA: intermetatarsal angle; DMAA: distal metatarsal articular angle.

ranging from 41% to 75% [11—13]. With chevron osteotomy in adolescents, the rate of poor results was 16% [14]. Lateral hemiepiphyseodesis of the base of the first metatarsal improved the IMA without significantly improving the HVA [15].

Salmeron et al. [6] distinguished two patterns of paediatric HV, with metatarsus varus (IMA > 10°) and without metatarsus varus (IMA < 10°). High IMA values (> 10°) indicated greater severity of the deformity and predicted a higher risk of recurrence [13,23]. Our data support these findings.

The reasons for HV recurrence are unclear but probably involve incomplete understanding of the primary mechanisms responsible for the deformity. Although the intrinsic and extrinsic pathogenic factors have been identified and the successive phases of perpetuation and worsening described [2,24], the initiating cause of the deformity remains poorly understood. According to one viewpoint, the primary abnormality is varus malalignment of the first metatarsal, known as metatarsus primus varus. Another possibility is primary HVA modification leading the hallux to push against the second ray, creating a lever effect that displaces the head of the first metatarsal medially, inducing a secondary increase in the IMA [5]. The term ”metatarsus varus” is diversely defined as the angle between the axis of the medial cuneiform bone and the axis of the first metatarsal [25] or as the angle between the first and second metatarsals (i.e., the IMA) [5,6,26].

Table 3  Contingency tables of post-operative HVA values versus pre-operative and post-operative DMAA values. Statistically significant differences are in bold type (P ≤ 0.05 by Fisher’s exact test).

<table>
<thead>
<tr>
<th></th>
<th>Post-operative HVA</th>
<th>Total (%)</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>HVA ≤ 16° (n = 13)</td>
<td>HVA &gt; 16° (n = 20)</td>
<td></td>
</tr>
<tr>
<td>Pre-operative DMAA</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>&lt; 0°</td>
<td>2 (6)</td>
<td>0 (0)</td>
<td>2 (6)</td>
</tr>
<tr>
<td>0° to 8°</td>
<td>11 (33)</td>
<td>20 (61)</td>
<td>31 (94)</td>
</tr>
<tr>
<td>&gt; 8°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-operative DMAA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 0°</td>
<td>3 (9)</td>
<td>0 (0)</td>
<td>3 (9)</td>
</tr>
<tr>
<td>0° to 8°</td>
<td>9 (27)</td>
<td>6 (18)</td>
<td>15 (45)</td>
</tr>
<tr>
<td>&gt; 8°</td>
<td>1 (3)</td>
<td>14 (42)</td>
<td>15 (45)</td>
</tr>
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</table>

Table 4  Clinical outcomes of the 33 procedures.

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Mean AOFAS score</td>
<td></td>
</tr>
<tr>
<td>Global (/100)</td>
<td>80.7</td>
</tr>
<tr>
<td>Pain (/40)</td>
<td>35.2</td>
</tr>
<tr>
<td>Satisfaction, n (%)</td>
<td></td>
</tr>
<tr>
<td>Very satisfied</td>
<td>6 (18)</td>
</tr>
<tr>
<td>Satisfied</td>
<td>18 (55)</td>
</tr>
<tr>
<td>Somewhat dissatisfied</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Dissatisfied</td>
<td>9 (27)</td>
</tr>
<tr>
<td>Pain, n (%)</td>
<td></td>
</tr>
<tr>
<td>Mild</td>
<td>12 (36)</td>
</tr>
<tr>
<td>Moderate</td>
<td>17 (52)</td>
</tr>
<tr>
<td>Severe</td>
<td>4 (12)</td>
</tr>
</tbody>
</table>
AOFAS: American Orthopaedic Foot and Ankle Society.

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The AOFAS score [17] provides a functional assessment. Although to the best of our knowledge, this score has not been validated in paediatric patients, it was used in a study of the scarf osteotomy in adolescents, in which post-operative AOFAS score values were similar to those found in our population [10]. Willemen et al. obtained 84% of good and very good clinical outcomes after the Mitchell osteotomy [5] and Salmeron et al., 52% of good outcomes after the scarf osteotomy [6]. However, the absence of stringent clinical evaluation criteria is a major obstacle to comparisons of functional outcomes.

In adults, the three main percutaneous techniques described for HV surgery are subcapital osteotomy of the first proximal phalanx [27], chevron osteotomy [28], and Reverdin-Isham osteotomy [16,29].

In the two studies of percutaneous therapy similar to that used in our study [30,31], the radiographs showed about 50% correction of the HVA and DMAA. Both studies found significant clinical improvements with mean post-operative AOFAS scores of 93/100 and 87.5/100, respectively, and high rates of satisfied/very satisfied patients of 87% and 89%, respectively, at the minimum follow-up of 12 months (median follow-up, 13 and 24 months, respectively).

Loss of first metatarsal-phalangeal joint motion has been described as a complication of percutaneous HV surgery [29,32]. Bauer et al. [30] suggested that intra-articular debris produced during extensive bunionectomy combined with the intra-articular osteotomy may cause the loss of motion. They reported a 17% decrease in mean motion range (from 90° to 75°) of the first metatarsal-phalangeal joint, which they considered comparable to that seen after other percutaneous or open procedures. Although we did not obtain accurate measurements of metatarsal-phalangeal motion range, marked stiffness of this joint was not recorded in any of our patients. Furthermore, bunionectomy is not always required in children and was not performed routinely in our population.

It has been suggested that percutaneous surgery may no longer have a role in the treatment of HV in adults. Instead, chevron osteotomy with internal fixation has been described as the preferred technique. One suggested advantage of this treatment is improved angle correction associated with correction of the IMA.

Several hypotheses deserve consideration with the goal of improving our surgical results. One possible course of action would consist in switching to chevron osteotomy, which would probably require internal fixation. Alternatively, the Reverdin-Isham procedure could be adapted to the specific features of juvenile HV in order to decrease the recurrence rate. First, as the HVA can be corrected by only 50%, this procedure may be best reserved for deformities with HVA values less or equal to 32°. Second, the cut-off described by De Prado [16] as indicating a need for IMA correction may need to be lowered. IMA correction is probably in order when the IMA value is greater than 10°. Either percutaneous osteotomy of the base of the first metatarsal or lateral hemiepiphyseodesis of the base of the first metatarsal may produce about 2° of angle correction in patients whose growth is expected to continue for at least 2 years [15].

Conclusion

Our short-term evaluation of percutaneous HV surgery without internal fixation showed a high-rate of under-correction that co-existed with a high-rate of patient satisfaction. Obtaining medium-term data will add valuable information to our study. Our results suggest a number of technical alterations aimed at improving the outcomes of percutaneous HV surgery. At present, we plan to continue to offer this procedure to our patients and their families.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References

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