CHAPTER 9

HALLUX VALGUS SURGERY AND THE SESAMOID APPARATUS

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To date, numerous procedures have been described and advocated for the surgical correction of the hallux abducto valgus (HAV) deformity. These have included both soft tissue and osseous procedures alone or in combination. Most surgeons agree that an HAV deformity is the result of dynamic and/or structural abnormalities. The retrograde force applied to the first metatarsal as a result of lateral deviation of the hallux usually results in an increase in the intermetatarsal angle. Splaying between the first and second metatarsals may, however, be a structural abnormality, and not the result of retrograde pressure from a deviated hallux.

Some authors have suggested that an HAV deformity of a dynamic nature can successfully be corrected by the use of muscle-tendon balancing procedures alone, precluding the need for any type of osteotomy. In other cases, where there is an increase in the intermetatarsal angle secondary to a structural abnormality, an osteotomy or arthrodesing procedure will be necessary to achieve the desired correction.

In addition, it has been suggested that restoration of muscle-tendon balance around the first metatarsophalangeal joint (MPJ) through soft tissue procedures alone or in combination with a proximal or distal osteotomy will effectively change the position of the sesamoid apparatus with respect to the first metatarsal head. Some authors have suggested that the derotation and mobilization of the sesamoid apparatus is an integral part of the surgical procedure. Transfer of the adductor tendon to assist in the relocation or derotation of the sesamoid apparatus beneath the metatarsal head has been advocated by some authors.

The sesamoid apparatus appears to be a key structure in the development and propagation of an HAV deformity. Its restoration to a more normal anatomic position should be an important consideration when correcting most HAV deformities. Preoperatively measuring the tibial sesamoid position is routine practice by most podiatric physicians. Various grading methods have been described to report the tibial sesamoid position. The bisector of the first metatarsal has served as the primary reference point for determination of this position. The impact of its change following surgery is infrequently mentioned, and has been rarely discussed in the literature.

The authors of this study wished to determine how the relationship between the sesamoid apparatus and the first metatarsal actually changes as a result of surgery. Does the sesamoid apparatus itself actually move? Is it solely the first metatarsal segment which moves as a result of HAV surgery, or is it a combination of both? Understanding what actually occurs may help surgeons better understand the deformity and select the most appropriate procedure or procedures for correction of this common deformity.

HYPOTHESIS

The anatomic position of the sesamoid apparatus does not change as a result of HAV surgery, as it is firmly imbedded in the surrounding soft tissues. Any change in the position of the sesamoid apparatus is a direct result of a change in position of the first metatarsal which occurs as a result of the surgical procedure or procedures performed. The sesamoid apparatus itself does NOT move.

MATERIALS AND METHODS

This retrospective evaluation involved a radiographic study of two patient groups. Group 1 consisted of 27 patients with 30 symptomatic HAV deformities which were corrected surgically by muscle tendon balancing procedures (Modified

McBride/True McBride Procedures), distal metaphyseal osteotomy (Austin or modified Austin-type procedures), diaphyseal shaft osteotomy (Scarf or Z-type procedures) or proximal metaphyseal osteotomy (closing base wedge osteotomy). Radiographic evidence of an HAV deformity (IMA > 8 degrees; HAA > 16 degrees) consistent with the clinical observations was also necessary. Patients who underwent surgical correction by resection arthroplasty, implant arthroplasty or an arthrodesis type procedure were not included. Weight-bearing radiographs at least two months postoperatively were also necessary.

Group 2 consisted of 30 feet in 26 patients with no clinical or radiographic evidence of a bunion deformity. All patients had achieved skeletal maturity and demonstrated ossification of the bones within the foot.

The following radiographic parameters were reviewed on angle and base of gait weight bearing radiographs:

1. Tibial Sesamoid Position (TSP)
2. Tibial Sesamoid - 2nd Metatarsal Distance (TSMD)
3. Intermetatarsal Angle (IMA)
4. Hallux Abductus Angle (HAA)

All measurement were determined by a single investigator to minimize investigational error and provide consistency with technique. All measurements were determined using the following techniques.

Tibial Sesamoid Position (TSP): The position of the tibial sesamoid was determined utilizing the bisector of the first metatarsal and the previously published seven position scale (Table 1).

Tibial Sesamoid - Second Metatarsal Distance (TSMD): A radiographic measurement, not previously described, was designed to further evaluate changes in position of the sesamoid apparatus before and after HAV surgery. The distance in millimeters (mm) from the medial border of the tibial sesamoid to the bisector of the second metatarsal was determined.

Intermetatarsal Angle (IMA): The intermetatarsal angle was determined by the angular relationship formed between the bisectors of the first and second metatarsal bones. The bisector of the first metatarsal on the preoperative radiographs of Group 1 patients and Group 2 patients was determined by identifying the midpoint of the diaphyseal - metaphyseal junction proximally and distally and forming a line connecting the two points.

The bisector of the first metatarsal on the postoperative radiographs of Group 1 patients were determined as follows: the line connecting the midpoint of the proximal metaphyseal-diaphyseal junction and the center of the effective articular surface distally. This is a method currently employed by podiatric physicians following surgical correction of an HAV deformity.

Hallux Abductus Angle (HAA): The hallux abductus angle was determined in all groups by the angular relationship formed between the bisector of the first metatarsal and the bisector of the proximal phalanx of the hallux (Figs. 1-3).

RESULTS

There were a total of 53 patients representing 60 feet. Group 1 (Surgical Group) was composed of 27 patients representing 30 feet with clinical and radiographic evidence of an HAV deformity. Group 2 (Control Group - No HAV Deformity) consisted of 26 patients and 30 feet with no clinical or

Table 1

SEVEN POSITION SCALE

Position 1: Entire sesamoid is medial to the first metatarsal bisector.
Position 2: The lateral aspect of the sesamoid is tangential to the metatarsal bisector.
Position 3: The lateral 1/3 of the sesamoid overlaps the bisector.
Position 4: The sesamoid is centered over the bisector.
Position 5: The medial 1/3 of the sesamoid overlaps the bisector.
Position 6: The medial aspect of the sesamoid is tangential to the bisector.
Position 7: The entire sesamoid is lateral to the bisector.

radiographic evidence of an HAV deformity. Patients ranged in age from 13 to 61 years with an average age of 40 years. The average follow-up was 6.35 months, with a minimum follow-up of 2 months. All radiographs were taken in weight-bearing angle and base of gait (Table 2).

In Group 1, the average preoperative TSP was 5.30 (range: 2 to 7) while the postoperative TSP averaged 2.83 (range: 1 to 5). In Group 2 the TSP averaged 2.40 (range: 2 to 4). In Group 1 the average preoperative TSMD was 30.57 mm (range: 21 to 37 mm) and the average postoperative TSMD was 30.47 mm (range: 26 to 39 mm). The overall difference in the TSMD was 0.10 mm. Group 2 had an average TSMD of 32.23 mm, (range: 29 to 38 mm).

In Group 1 the preoperative IMA averaged 12.73 degrees (range: 6 to 18 degrees). The post-operative IMA averaged 3.73 degrees (range: 0 to 10 degrees). In Group 2 the IMA average was 6.53 degrees (range: 4 to 8 degrees).

In Group 1 the average preoperative HAA was 22.93 degrees (range: 6 to 48 degrees). The average postoperative HAA was 6.91 (range: 0 to 20 degrees). In Group 2 the average HAA was 8.17 degrees (range: 3 to 16 degrees).

DISCUSSION

The importance of the change in the position of the first metatarsal head with respect to the sesamoid apparatus has long been appreciated by surgeons correcting the HAV deformity. Others have not felt the relationship to be an important one. The failure to improve upon this relationship and restore a more normal position has been considered a major contributing factor to complications following HAV surgery, especially those resulting in recurrence of deformity. Likewise, a malposition of the sesamoid apparatus, where the tibial sesamoid is displaced medial to the first metatarsal head, is associated with the complication of hallux adductus or hallux varus deformity. While such words as "relocation" and "derotation" are used to describe the goals of

Table 2

DATA SUMMARY

Group I
27 Patients
30 HAV Deformities
3 Bilateral

Group II
26 Patients
30 Feet
4 Bilateral

PARAMETER*	PREOP	POSTOP	NORMAL
TSP range	2-7	1-5	1-4
TSP average	5.30	2.83	2.30
TSMD range	21-37	26-39	29-38
TSMD average	30.47	30.57	32.23
TSMD range	3 to +5		n/a
TSMD average	0.37		n/a
HAA range	14-46	0-20	3-16
HAA average	26.4	9.70	8.17
IMA range	6-18	0-10	4-10
IMA average	12.73	3.73	6.53

*HAA and IMA measured in degrees. TSMD measured in millimeters. TSP measured using the traditional 7 position scale.

muscle-tendon rebalancing procedures around the first MPJ, they are somewhat misleading. Some surgeons clearly believe that any change in the relationship between the first metatarsal head and the sesamoid apparatus is a direct result of displacement of the first metatarsal. Others are more skeptical.

To date, the authors have not been able to identify any literature which has studied this intimate relationship. This pilot study was intended to determine whether there was any significant displacement of the sesamoid apparatus itself, or whether the change in the relationship is more the result of change in the position of the first metatarsal bone itself. The latter implies that the sesamoid apparatus is a relatively fixed structure imbedded within the soft tissue of the plantar aspect of the foot. In order to determine and study the relationship, a new measurement was employed (TSMD). By utilizing the second metatarsal as the principal reference point, the authors set out to determine whether the sesamoid apparatus moves (increases or decreases its distance from the second metatarsal) or whether the improved alignment of the sesamoid apparatus with respect to the first metatarsal head is a direct result of movement of the metatarsal bone itself. The results of this study suggest that the change in position is a direct result of lateral transposition of the metatarsal head itself, regardless of the procedure performed. The resulting decrease in the IMA appears to be the primary factor responsible for the improved alignment.

At the time of the writing of this article, additional data is being collected and analyzed from two additional centers. This will provide data from three separate institutions (The Foot and Ankle Institute of the Pennsylvania College of Podiatric Medicine, Philadelphia, Pennsylvania; Northlake Regional Medical Center, Tucker, Georgia; and Mt. Sinai Medical Center, Cleveland, Ohio). A more detailed statistical analysis can then be performed providing further validity of the results.

Is there clinical significance to the results of this study? Can certain inferences be drawn from the results? How can one utilize this data to better assist in the selection and execution of surgical procedures with the hopes of improving upon the surgical outcomes, and thereby avoid the potential for the postoperative complications related to malalignment such as a recurrent HAV deformity or iatrogenic hallux varus?

If the sesamoid apparatus is firmly fixed within the soft tissue structures of the plantar aspect of the foot, any improvement in the relationship between the metatarsal head and the sesamoid apparatus is primarily the result of movement of the first metatarsal. This movement can be the direct result of soft tissue procedures alone, osseous procedures alone, or a combination of both. There is no single parameter that can adequately predict the efficacy of any given procedure for any given individual. Clearly, radiographic findings should not be the sole determinant for selecting a surgical procedure; rather they should be correlated with clinical findings (refer to Figs. 1-3).

It is generally assumed that an HAV deformity is the result of muscle tendon imbalance around the first MPJ, structural abnormalities or a combination of both. A deformity which is the result of muscle-tendon imbalance implies an HAV deformity of a "dynamic" etiology. Thus, as the abduction of the hallux increases, there is an increase in the retrograde force placed against the first metatarsal head which results in increased splaying between the first and second metatarsals. McBride pioneered this concept, and his ideology remains popular today. His surgical approach continues to be a mainstay component of the surgical correction of an HAV deformity.

Release of the adductor tendon (including the lateral head of the flexor hallucis brevis muscle and/or lateral capsular tissues) alone or in combination with transfer of the adductor tendon or removal of the fibular sesamoid will *not* result in a reduction of the IMA if the deformity is rigid in nature. Inadequate mobility of the first metatarsocuneiform or naviculocuneiform articulation would leave a persistent splaying between the first and second metatarsals, regardless of the extent of lateral soft tissue release around the MPJ. In such cases, while the clinical alignment of the hallux may be improved, persistent splaying between the first and second metatarsals will be seen radiographically. A recurrence of deformity is likely with the wearing of normal shoes as the hallux is forced to assume a more normal position in relation to the second digit. If, on the other hand, good mobility and flexibility are present, a significant decrease of the IMA can be expected postoperatively as a result of removal of the retrograde force of the great toe against the first metatarsal head (Figs. 4, 5A, 5B).

Figure 1A. Preoperative dorsoplantar radiograph of a patient who underwent surgical correction of a symptomatic HAV deformity by a distal metaphyseal osteotomy. The reference lines are shown.

Figure 1B. Postoperative dorsoplantar radiograph.

Figure 2A. Preoperative dorsoplantar radiograph of a patient who underwent surgical correction of a symptomatic HAV deformity by proximal metaphyseal osteotomy. The reference lines are shown.

Figure 2B. Postoperative dorsoplantar radiograph.

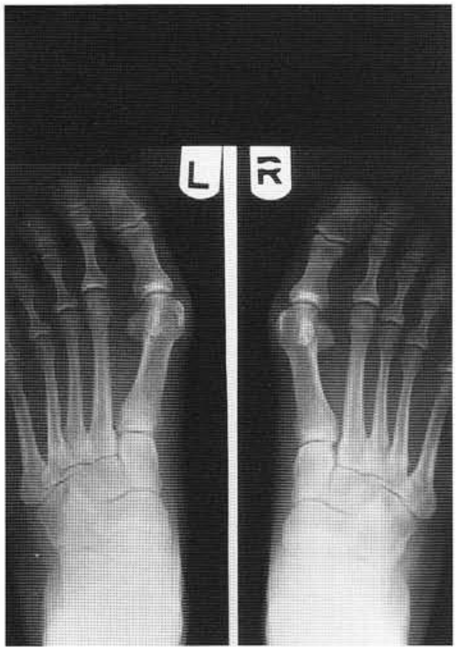

Figure 3A. Preoperative dorsoplantar radiograph of a patient who underwent surgical correction of a symptomatic HAV deformity by McBride bunionectomy (fibular sesamoidectomy) and muscle tendon rebalancing only. No osteotomy was required

Figure 3B. Postoperative view. The patient in now greater than one year postoperative with no evidence of recurrence. Notice the excellent alignment and position of the tibial sesamoid with respect to the first metatarsal head. The deformity was clinically very flexible and accounts for the excellent restoration of alignment of the entire first ray segment.

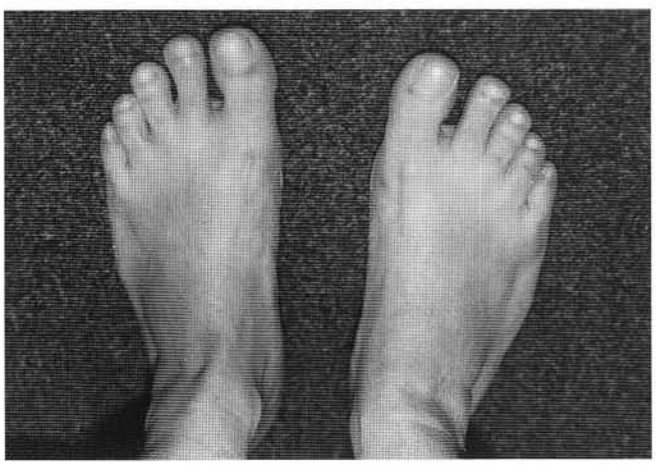

Figure 3C. Postoperative clinical view.

Figure 4. Preoperative dorsoplantar view of a patient with a recurrent HAV deformity in spite of having had a distal metaphyseal osteotomy and an osteotomy of the proximal phalanx. Correction of the deformity requires a proximal base wedge osteotomy due to the lack of flexibility (rigid deformity) in order to reduce the intermetatarsal angel and restore a more normal relationship between the sesamoid apparatus and the first metatarsal head. Notice the severe displacement of the sesamoids.

Figure 5A. Preoperative dorsoplantar radiograph of a patient who underwent correction of a symptomatic HAV deformity by a McBride-Austin bunionectomy including the excision of the fibular sesamoid to restore normal muscle tendon function around the first MPJ.

Figure 5B. Postoperative dorsoplantar view. Notice the excellent reduction of the deformity, especially the intermetatarsal angle and sesamoid position, as well as the HAA correction. Minimal displacement of the capital fragment was necessary to achieve correction of this deformity due to the flexibility present preoperatively. Dorsiflexion of the first MPJ preoperatively was in excess of 100 degrees with a very mobile first ray in both the sagittal and transverse planes. This deformity was considered to be a combination of dynamic and structural etiology.

In cases where the deformity is more rigid in nature, reduction and improvement in the relationship between the sesamoids and first metatarsal head will necessarily require some type of osseous procedure to reduce the first and second metatarsal splaying. The selection of an osseous procedure usually depends upon both the clinical and radiographic findings. In some cases, a distal metaphyseal osteotomy is satisfactory, while in other cases a more proximal procedure will be required.

Flexibility of the first ray should be assessed clinically as well as intraoperatively. In patients with a flexible deformity, it is not uncommon to have an increased range of motion at the first MPJ. A range of motion of 60 to 120 degrees of dorsiflexion in such individuals would not be uncommon. In addition, clinical assessment of the first metatarsal by movement of the segment in the sagittal and transverse planes will provide further insight into the flexibility or rigidity of the deformity. These findings, along with the radiographic interpretation are helpful in determining which procedure will be most beneficial.

Soft tissue procedures which involve transfer of the adductor tendon over the metatarsal head into the capsular tissues or directly into the metatarsal itself, primarily serve to assist in the reduction of splaying between the metatarsals. They do not directly result in movement or mobilization of the sesamoid apparatus itself. Their influence is indirect in nature. Any "derotation" or "relocation" of the sesamoids beneath the metatarsal head reflects solely the movement of the metatarsal segment itself.

This pilot study seems to support the theory that the sesamoid apparatus does not change as a result of HAV surgery. The authors expect that the results will be even more convincing as a larger data pool is accumulated from a multi-center investigational approach, and will publish the results of the multi-center analysis. It is hoped that this information will provide surgeons with further insight into the complexity of the HAV deformity.

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