CHAPTER **2**

EVALUATION OF FIRST METATARSOPHALANGEAL JOINT RANGE OF MOTION PRE AND POST BUNION SURGERY: Clinical and Radiographic Correlation with Stress Lateral Dorsiflexion Views. Part 2.

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INTRODUCTION

Hallux abducto valgus (HAV) has been shown to have diminished first metatarsophalangeal joint (MPJ) total range of motion (ROM), deviated center of rotation, and abnormal metatarso-sesamoid center of rotation, compared to normal controls in cadavers (1). These dynamics were attributed to the prominent medial eminence and periarticular capsuloligamentous scarring with articular degenerative changes (1), which also are a result of the pathomechanical forces. Although in this study we are also addressing hallux limitus pathology, Shereff et al similarly attributed limited dorsiflexion in hallux rigidus patients primarily due to the dorsal mechanical block (exostosis). According to Taranto, the hallux abductus angle (HAA), first intermetatarsal angle (IMA), and lateral stress dorsiflexion views were the only variables found to be significantly different between hallux valgus and hallux limitus and thus predictors of these processes (2). Surgically altering the first MPJ has a significant impact on its dynamics. Therefore, parameters for measuring its accuracy preoperatively, perioperatively, and postoperatively are worth investigating. The stress lateral dorsiflexion radiographic view is a great tool to aid in measuring that accuracy (Figure 1).

In our first retrospective study, preliminary data suggested that first MPJ ROM is maintained and increases postoperatively within 1 year, though not statistically significant. Results from our prospective study revealed a significant decrease at 1 year, in clinical dorsiflexion compared to preoperative, though there was a small sample size measured at 1 year postoperative. Division of data by diagnosis and procedure showed significant decreased clinical and radiographic dorsiflexion postoperatively in hallux valgus type surgeries (Austin and closing base wedge) patients but significant increase in hallux limitus-type surgeries (Keller and Green-Waterman) patients. A positive correlation was also found between clinical and radiographic measurements preoperatively, 6 weeks postoperatively, and 1 year postoperatively, indicating a stress lateral radiographic view had some value in quantifying dorsiflexion. Those results will be further elaborated on with this long-term follow-up study, again evaluating clinical and radiographic first MPJ ROM postoperatively for bunion surgery, and attempting to correlate the two. We will also be evaluating patient satisfaction by means of the Bristol Foot Score (BFS).

Figure 1. Lateral stress dorsiflexion view.

Figure 2. Clinical non-weightbearing dorsiflexion.

Figure 3A. Measurement of first ray range of motion.

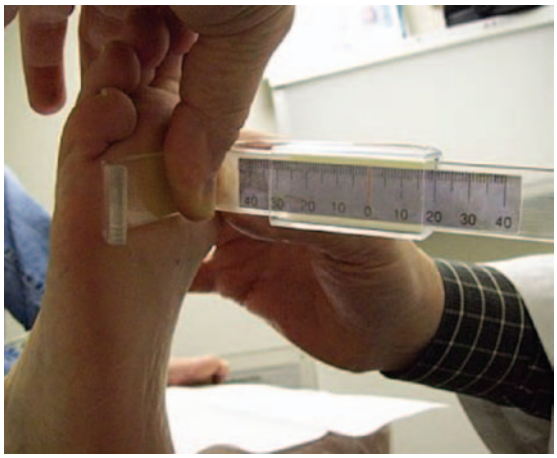


Figure 3B. Measurement of first ray range of motion.

Knowing which types of bunion surgeries will significantly impact normal first MPJ ROM/mechanics, and therefore affect gait is an integral part of surgical planning and management. With a longer-term follow-up on these patients, our previous results can be further supported or challenged to give greater insight to the impact of these surgeries on first MPJ ROM. It may support a consistent and more appropriate way to measure first MPJ ROM. Our hypothesis is that 4 to 5 years post-bunion surgery, first MPJ dorsiflexion range of motion will be decreased, both clinically and radiographically.

METHODS

All 58 patients from our last study were contacted via mail to participate in this long-term continuation study. Of those 58 patients, 12 patients (17 feet) who underwent bunion surgery by Drs. Donald R. Green and Richard M. Green at the San Diego Podiatry Group between November 2007 and December 2008 were included in the study. The age range was 29-74 years, and there were 9 women and 3 men. Similar to the previous two studies, excluded patients were those who had been diagnosed with first MTPJ nonosteoarthritic conditions, dysplasias, or infection involving the first MTP joint or first metatarsal bone. Also excluded were those with ulceration of the foot or ankle, significant trauma causing fracture to the first metatarsal bone or first MTP joint (preoperatively) breakage or backing out of fixation (postoperatively), or patients who were nonambulatory (i.e., wheel-chair bound).

Clinical measurement data preoperatively, intra-operatively, 6 weeks, 3 months, 6 months and 1 year postoperatively, were used again in this study. These were combined with the new clinical and radiographic measurement data taken at greater than 1-year post surgery. The measurements included non-weightbearing (NWB) passive first MPJ ROM (resting, dorsiflexion and plantarflexion) with subtalar joint neutral position. A goniometer was used and a force placed on or beneath the base of the proximal phalanx of the hallux. The measured angle was between the lateral longitudinal axis of the hallucal proximal phalanx and first metatarsal bone (Figure 2).

Position and ROM of the first ray was also assessed by once again placing the subtalar joint in neutral and then measuring the amount of dorsiflexion and plantarflexion of the first metatarsal head relative to the second metatarsal head with the thumb and index finger of each hand, using a Whitney biomechanical device (Figure 3). Positioning of the second toes was also evaluated relative to the hallux as

to lack of contact, abutting, underlying or overriding the first. Lachman's test (proximal phalanx translocates dorsally by 2 mm or more relative to the second metatarsal head at the second MTP joint) (3) was also measured. Other parameters assessed included: first metatarsocuneiform prominence, deformities of the lesser toes, and hallux plantar purchase power ability to pull a piece of paper out from beneath the patient's hallux. Intraoperative procedural data and clinical measurement data used from the last study including procedure type and primarily passive dorsiflexion and plantarflexion ROM of the first MPJ were compared.

Radiographs taken for this study were all either 4 or 5 years post surgery. Radiographic measurement data was used for preoperative and postoperative (6 weeks, 3 months, 6 months, 1 year) and combined with current study values. Views evaluated include: dorsoplantar, medial oblique, lateral foot views as well as lateral stress dorsiflexion view (Figure 4). All radiographs were reviewed for first metatarsal length, shape of first metatarsal head and base, first and second MPJ congruity, and signs of first MPJ degeneration. Angles measured were metatarsus primus adductus, hallux abductus, metatarsus primus declination, hallux interphalangeus, metatarsus adductus, true intermetatarsal angle, Engle's angle, forefoot adductus, talocalcaneal talonavicular coverage angle, and cuboid abduction angle. The tibial sesamoid position was also measured, all as previously described in the literature. The medial oblique view was used to assist in evaluation of digital dorsiflexion.

The lateral view was assessed for first metatarsal declination angle, talo-first metatarsal angle or Meary's angle, Seiberg Index (4), calcaneal inclination angle, Kirby's sign, and dorsal first MPJ lipping/spurring. The stress lateral dorsiflexion view was used to measure first MPJ dorsiflexion in stance with the patient being instructed to bring their foot up and over the hallux "as much as possible." This angle was found by comparing the long axis bisection of the hallucal proximal phalanx with the bisection of the first metatarsal bone.

As in our previous study, the BFS questionnaire was given to each participant to assess overall subjective foot health, and assess overall patient satisfaction. The results were compared to the previous study results. This study was IRB approved (#12-5891) and consent was obtained.

RESULTS

SPSS software was used for all statistical analysis. The paired sample t-test, Pearson R correlation coefficient for determining association between variables, 1-way ANOVA, and 2-way ANOVA were all used to analyze the data. *P* values less than or equal to 0.05, or (5%), were considered

Figure 4. Lateral stress dorsiflexion view.

significant. During our previous study, 1-year data had too few cases to be included in the majority of the analysis and those measurements were therefore combined in this study's data points. All patients included in this study are either 4 or 5 years post surgery, but for the purposes of this study will be labeled as greater than 1-year post surgery. Out of 12 patients and 17 feet, 17 feet had clinical and 14 feet had radiographic measurements obtained at this postoperative visit. Of the 58 patients contacted, 22 of them returned the BFS survey (38%).

The data were divided based on type of surgery (i.e., HAV or hallux limitus). Results of HAV surgeries (Austin or CBWO) revealed a decrease in clinical dorsiflexion at greater than 1 year postoperative when compared to preoperative values on average (Figure 5). A total of 8 feet decreased clinically, with a range of 1-35 degrees. The outlier in this group was 1 foot that lost 35 degrees, and without that patient the range became 1-25 degrees. The average clinical decrease was 10 degrees with the outlier, and 7 degrees without it. All but 1 patient in the HAV group returned to within 8 degrees of clinical dorsiflexion when compared to their preoperative amount of dorsiflexion. Radiographically, the HAV group also tended to have a decrease in amount of dorsiflexion at the first MPJ. A total of 7 of the feet in this group decreased with a range of 0-26 degrees, and 2 feet actually increased the amount of dorsiflexion 5 degrees. There was 1 foot that had no gain and no loss, while 1 foot was missing preoperative data. The average radiographic decrease in dorsiflexion, however, was 15 degrees. Additionally, all but 1 foot in the HAV group returned to within 20 degrees of radiographic dorsiflexion when compared to their preoperative amount (Figure 6).

Hallux limitus type surgeries (Green-Waterman or Keller) showed trend of increase in clinical dorsiflexion at greater than one year postoperatively when compared to

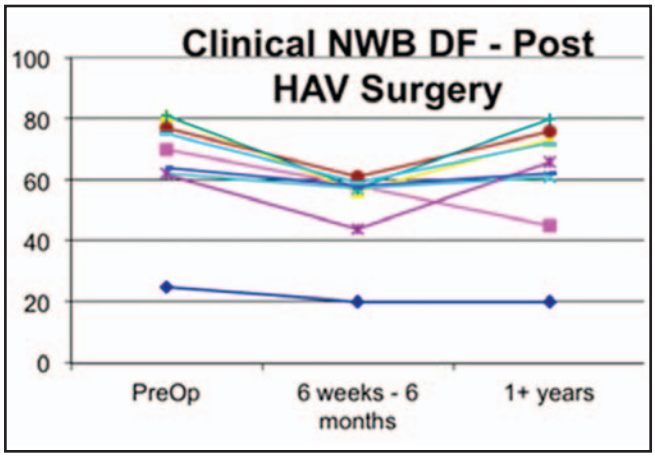
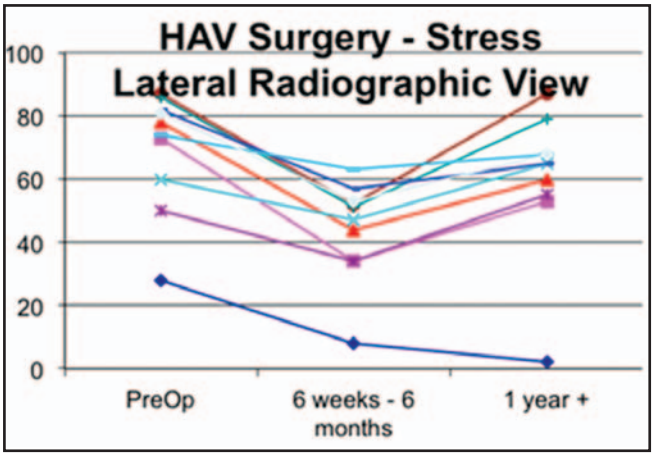


Figure 5.



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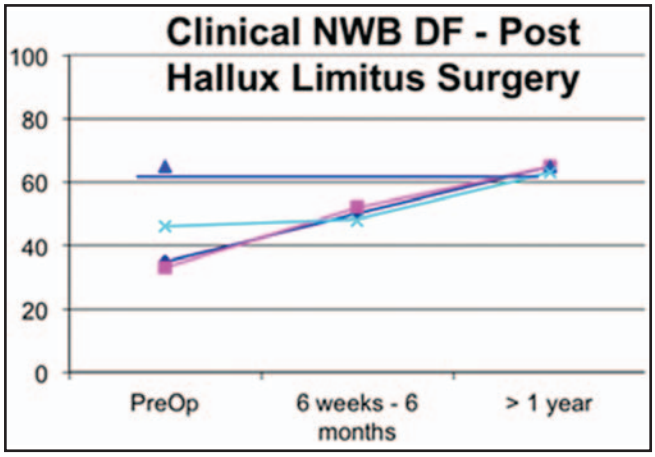

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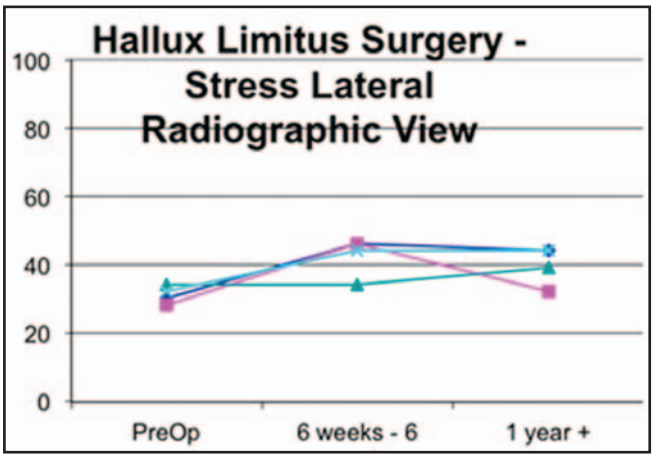

Figure 8.

preoperative measurements (Figure 7). Clinically, 5 feet increased with a range of 17-32 degrees, and one foot had no change in amount of dorsiflexion. This gives an average of 22 degrees of clinical increase in first MPJ dorsiflexion. Radiographically, 4 feet gained between 4-14 degrees of dorsiflexion while, 2 feet had no preoperative data. The average radiographic increase of first MPJ dorsiflexion was 10 degrees, and did tend to decrease (Figure 8).

A high and strong correlation (Pearson's r = 0.766) was also found between postoperative first MPJ clinical NWB passive dorsiflexion and greater than 1 year postoperative radiographic stress lateral views (Figure 9). The most common diagnosis was HAV. The most common procedure performed was the Austin (more than half), and enough to perform analysis on the closing base wedge, Keller, and Green-Waterman procedures (Table 1).

Using the 2-way ANOVA, patients had a statistically significant lower (improved) score on the BFS, at greater than 1 year post surgery, when compared to preoperative scores, with a *P* value less than or equal to 0.02 or (2%). When separating the patients by type of surgery, there was a statistically significant decrease in the BFS in the HAV group at the greater than 1 year follow-up compared to preoperative. The average HAV satisfaction score improved from 25/73 to 9/73. This decrease was also shown in the hallux limitus group and was approaching statistical significance, but due to small sample size in this group, it was unable to be achieved. However, the average hallux limitus satisfaction score improved from 24/73 to 11/73.

Clinical hallux purchase power was also investigated. In the HAV group, 8 out of 11 feet maintained the same amount of purchase power as they had preoperatively. One foot decreased from "'not moveable" to "resistant," 1 foot decreased from "not movable" to "easily movable," and 2 patient had no preoperative data. In the hallux limitus group, 5 out of 6 feet maintained the same amount of purchase power as they had preoperatively, and 1 of the 6 feet had no preoperative data.

Seiberg's index was also evaluated. In the group of feet that received an Austin bunionectomy, 6 out of 9 feet elevated ~1 mm; 2 feet decreased 2 mm; and 1 foot increased 2 mm. In the closing base wedge/McBride

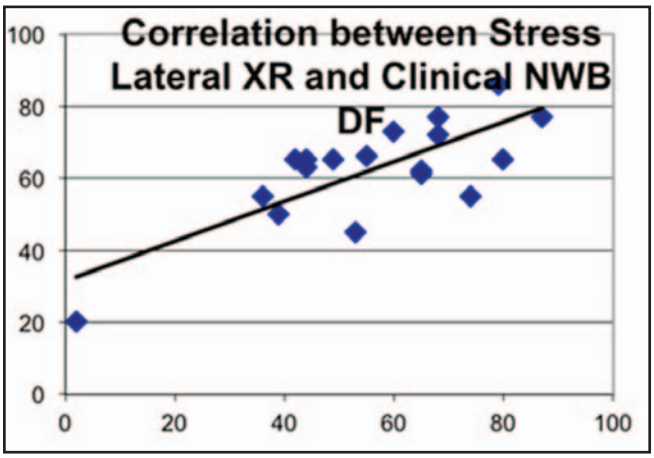

Figure 9.

group, 2 out of 2 feet elevated 1 mm. In the Green-Waterman bunionectomy group, 3 feet out of 4 had no change, while 1 foot decreased 1 mm. In the Keller group 1 foot increased 1 mm, and 1 foot decreased 2 mm.

Results of the metatarsal protrusion distance revealed a 1-2 mm shortening of the first metatarsal after Austin or Green-Waterman bunionectomies. The Keller naturally had no effect on the protrusion distance; while the closing base wedge osteotomy showed a relative lengthening of the first metatarsal (1-2 mm) compared to the second, when the metatarsal moved more laterally.

DISCUSSION

We accept our hypothesis that clinical and radiographic dorsiflexion at the first MPJ decreases 4-5 years post-operatively compared to preoperatively for Austin and closing base wedge osteotomy/McBride bunionectomies. The average decrease was 11 degrees when clinical and radiographic measures were combined. As discussed previously, the clinical average was 7 degrees, compared to the radiographic average of 15 degrees. For hallux limitus type surgeries (Green-Waterman and Keller), the combined clinical and radiographic average was increased 16 degrees. Again, the clinical average of increase was 22 degrees, while the radiographic increase was 10 degrees. When comparing clinical versus radiographic measurements, all data were combined and a correlation was found. A high and strong positive correlation was found between preoperative values versus 4-5 years postoperative values and the clinical, and radiographic measurements, giving some value to obtaining a stress lateral radiograph. This is a good, time efficient way to quantify the amount of dorsiflexion available preoperative and to be able to compare the range postoperative.

Table 1
PROCEDURES PERFORMED, NUMBER OF FEET.

Austin	9 (52.9%)
Modfied McBride + closing base wedge osteotomy	2 (11.8%)
Modified Green Waterman	4 (23.5%)
Keller	2 (11.8%)

Patient's scores improved significantly postoperative for the BFS, indicating that a reduction in pain and improvement of function was attained surgically. On average HAV patients lowered their BFS from 25/73 to 9/73; while hallux limitus patients lowered their scores from 24/73 to 11/73.

When examining clinical hallux purchase power, results were good. For the HAV group of patients, 8 out of 11 feet maintained the same amount of purchase power as they had preoperatively. In the hallux limitus group, 5 out of 6 feet maintained their preoperative level of purchase power. Only 1 foot in the HAV group lost a significant amount of purchase power, and that patient underwent an Austin bunionectomy. The Austin and closing base wedge showed significant reduction in HAA and IM angle 4-5 years postoperatively; indicating that correction of the deformity is maintained long term. As expected, the Keller and Green-Waterman had no decrease in IM angle and no significant change in HAA.

When evaluating the first metatarsal position in the sagittal plane, there was really no significant change. It seems there was a trend for HAV type surgeries to obtain some elevation (approximately 1 mm), and for hallux limitus surgeries to maintain the same preoperative position. As there are no current guidelines or recommendations backed by literature, about where to place the first metatarsal head in the sagittal plane, these values may be significant or not. The significance of the elevation would also need to be combined with the dynamic function of the foot as well for proper correlation. Results of the metatarsal protrusion distance were consistent with the literature. The Austin and Green-Waterman tended to shorten the first metatarsal ~1-2 mm, while the closing base wedge osteotomy tended to show a relative lengthening of ~1-2 mm. The Keller had no bearing on the protrusion distance.

A high and strong correlation was found between postoperative first MPJ clinical NWB passive dorsiflexion and greater than 1-year postoperative radiographic stress lateral views. This finding gives significant value to

obtaining a stress lateral dorsiflexion radiograph when performing first ray surgeries. Obtaining a quantifiable amount of dorsiflexion at the pre, intra, and postoperative periods gives a great deal of information to the doctor, as well as some predictable information to share with the patient prior to surgery. It would be beneficial in future research to ascertain which of these two measurements correlates best with the amount of dorsiflexion needed for normal function in gait.

Limitations include a low number of patients, and less variety in procedure, (which may also be a strength). Also the small number of procedure types may also be viewed as a weakness, however we believe these 4 procedures (Austin, closing base wedge, Keller, Green-Waterman) are some of the most common ones still being done today.

CONCLUSION

When combining all the data, we accept our hypothesis that bunion surgery decreases dorsiflexion motion at the first MTP joint 4 to 5 years postoperatively, both clinically and radiographically. When the data was split by procedures, a trend of decrease in the HAV (Austin and closing base wedge) group, with an 11-degree average (clinical and radiographic) supports our hypothesis. The hallux limitus (Green-Waterman and Keller) group showed an average of 16-degrees of increased dorsiflexion (clinical and radiographic). A high and strong positive correlation was found between clinical and radiographic measurements preoperatively and 4 to 5 years postoperatively, showing that a stress lateral radiographic view has some value in quantifying the amount of first MPJ dorsiflexion.

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