

MEDIUM TERM OUTCOME OF THE KELLER ARTHROPLASTY

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INTRODUCTION

The proper treatment of hallux limitus and hallux abducto valgus (HAV) is a dilemma for foot and ankle surgeons. A multitude of procedures and techniques have been described, in both orthopedic and podiatric literature, for treatment of hallux limitus and HAV. The inference gathered from the multitude of treatments is that no single procedure is 100% successful. Choosing the proper procedure is based on the information from the patient, radiographs, clinical exams, as well as age of the patient, activity level, prior treatment, and expectations.

Resection of base of the proximal phalanx for treatment of HAV was first described in 1886 by Riedel.¹ Davis-Colley described the same procedure for hallux limitus in 1887.² Keller permanently associated his name with the procedure after publishing his results in 1904 and

1912 (Figure 1).³ In the first half of the 20th century the Keller arthroplasty was a popular technique for the treatment of hallux limitus/rigidus as well as HAV. Over the past 50 years the uses and indications for the Keller procedure have evolved.

Keller believed that his procedure was ideal for extremely active patients with debilitating 1st MTPJ pain.⁴ In fact, Keller felt that his procedure was suitable for active duty soldiers. Indications for a Keller arthroplasty include; revision of failed hallux valgus operation,^{5,6} elderly person with severe deformity,^{5,7,8} elderly with limited activity who also demonstrated degenerative changes to first MTPJ with no associated lesser metatarsalgia,^{9,10} traumatic arthritis,⁶ and severe HAV with a short second or long first metatarsal.⁷ Advantages of the Keller arthroplasty are simplicity of technique, reduction of the deformity, pain relief, increased range of motion,⁷ immediate postoperative ambulation, and no need for fracture healing.

Relative contraindications are short first ray or long second ray, very active or very young patient, lesser metatarsalgia or significant lesser metatarsal callosities. Reported complications of the procedure are; lesser metatarsalgia,^{9,11-13} stress fractures of the lesser metatarsals,^{11,14,15} and functional shortening of the first ray.^{6,9} Other possible complications include loss of hallux purchase^{11,13} flail toe¹¹⁻¹³ hallux extensus,^{9,12} hallux varus,^{8,12} recurrence of the deformity (HAV or hallux limitus),¹² hallux malleus,^{11,16} painful osteophytes, hammertoe of the second digit, and painful arthrosis.¹

Many additions and deletions have been made to the original Keller arthroplasty. Some authors advocate the use of K-wires to stabilize the hallux.^{4,5} Some authors perform a Z-lengthening of the extensor hallucis longus tendon when it is "...exerting a deforming force after the phalangeal resection...."¹⁶⁻¹⁸ Bordelon¹⁷ agreed with Wagner⁶ that it is important to reattach the short flexors to the proximal phalanx. Jordan and Brodsky advocated removal of two thirds of the proximal phalanx.¹⁷ While Schneider and Knahr performed minimal bone resection



Figure 1. Keller recommended resecting the proximal 1/3 of the base of the proximal phalanx and remodeling the head of the first metatarsal.

Table 1

MODIFIED ACFAS 1ST MTPJ SCORING SYSTEM (8)

1. **Before the surgery how much did the pain in your foot limit your daily activities? (maximum 30 points)**
 - No pain with normal activity (30)
 - Slight or occasional pain, no compromise in activity (22)
 - Moderate pain, slight effect on activities (14)
 - Pain with serious limitations of activities (6)
 - Pain with total limitation of activity (0)
2. **How would you rate the appearance of your big toe joint before surgery? (maximum 5 points)**
 - Liked it very much (5)
 - I mostly liked it (4)
 - Not sure (neutral) (3)
 - Mostly didn't like it (2)
 - Disliked very much (0)
3. **Before surgery how frequently did you have pain while wearing shoes? (maximum 15 points)**
 - Able to continuously wear any type of shoe (15)
 - Able to wear any type of shoe most of the time (10)
 - Able to wear only walking, athletic, or casual shoes (5)
 - Able to wear only special order, orthopedic, or custom shoes (0)
4. **Before the surgery did you limp from the pain? (maximum 5 points)**
 - No (5) Yes (0)
5. **How much does the pain in your foot limit your daily activities now? (maximum 30 points)**
 - No pain with normal activity (30)
 - Slight or occasional pain, no compromise in activity (22)
 - Moderate pain, slight effect on activities (14)
 - Pain with serious limitations of activities (6)
 - Pain with total limitation of activity (0)
6. **How would you rate the appearance of your big toe joint now? (maximum 5 points)**
 - Liked it very much (5)
 - I mostly liked it (4)
 - Not sure (neutral) (3)
 - Mostly didn't like it (2)
 - Disliked very much (0)
7. **How frequently do you have pain while wearing shoes now? (maximum 15 points)**
 - Able to continuously wear any type of shoe (15)
 - Able to wear any type of shoe most of the time (10)
 - Able to wear only walking, athletic, or casual shoes (5)
 - Able to wear only special order, orthopedic, or custom shoes (0)
8. **Do you limp from the pain now? (Maximum 5 points)**
 - No (5) Yes (0)
9. **Radiographic analysis (Maximum 18 points)**
 - HA Angle (6)**
 - 31°+ (0) 30-21° (3) 20-0° (6)
 - 1 to -3° (2) >-3° (0)
 - IM Angle (6)**
 - 20°+ (0) 11-19° (3) 0-10° (6) <0° (0)
 - First Metatarsal Declination Angle (6) (center of head /center of base)**
 - 16-24° (6) 25-29° (3) >29° (0)
 - 10-15° (3) <10° (0)
10. **Function (Maximum 32 total)**
 - Hallux Purchase (Paper-Pullout: Easy, Resistant, Not Movable) (10)**
 - Not Moveable (10) Resistant (5) Easy (0)
 - Range of Motion: 1st ray (17)**
 - Dorsiflexion of 1st MPJ
 - >60° (11) 46-59° (8) 66-45° (4) <36° (4)
 - Plantarflexion of 1st MPJ
 - > 0° (4) <0° (0)
 - IP Joint Extension (2)
 - Extend to 0° (2) <0° (0)
11. **Would you have this procedure again?**
 - No Yes
12. **How would you rate your satisfaction with the procedure?**
 - Very satisfied (would highly recommend)
 - Satisfied (would recommend)
 - Dissatisfied (would not recommend)
 - Very dissatisfied (would definitely not recommend)
13. **Would you recommend this procedure to a friend?**
 - No Yes

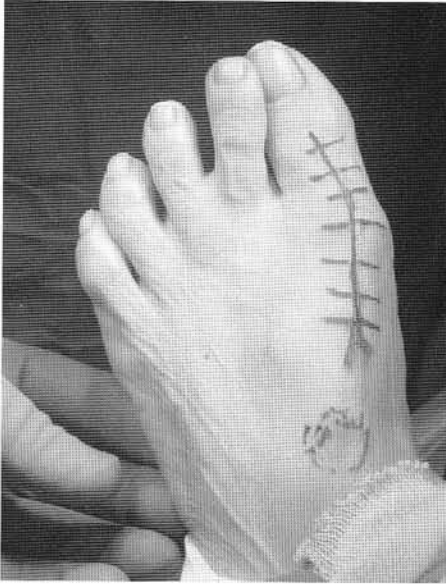


Figure 2. A typical bunion incision is used to expose the first metatarsal phalangeal joint.

with release of extensor hallucis brevis. Capasso et al advocated transfer of the extensor hallucis brevis to the tibial sesamoid.⁷ Capasso also advocated a concave osteotomy of the proximal phalanx to mimic the physiologic shape of the base of the proximal phalanx there by diminishing “stress concentration”.⁷ Donley et al suggested that increased correction could be achieved by combining resection arthroplasty with fibular sesamoidectomy.¹⁹ McGlamry stressed the importance of interposition of the capsule and attachment of the long flexor to the base of the proximal phalanx.²⁰

MATERIALS AND METHODS

Between 1987 and 2004, 58 patients underwent Keller arthroplasty by the senior authors (DRG, RMG). Contact info was available for 37 patients who were more than 6 months postoperative. A questionnaire was sent too all 37 of these patients. There was also an attempt to reach these patients by phone. A total of 12 patients who were available for followup representing 14 feet. The questionnaire included a modified ACFAS universal foot and ankle scoring system: first metatarsophalangeal joint and first ray (Table 1).²¹ There were 11 women and 1 man with an average age at time of surgery of 61 years. Average time of followup was 3 years with a range of 0.9-11 years. Nine patients had the procedure for HAV, 3 for hallux limitus, 1 for failed implant, and 1 for hallux varus.

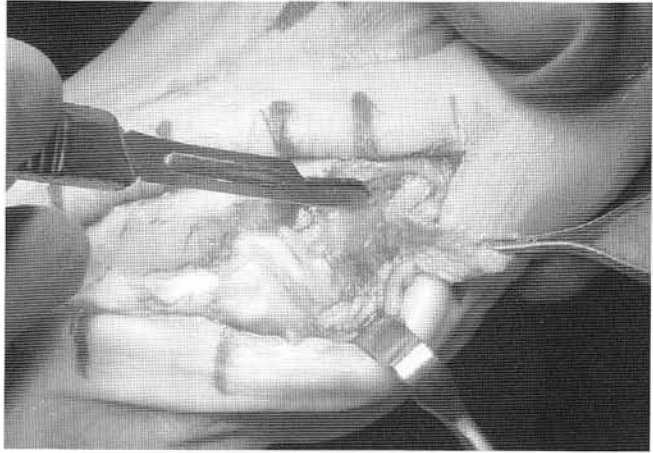


Figure 3. A “U” shaped capsulotomy is made with the base left attached to the proximal phalanx.

SURGICAL TECHNIQUE

The procedure begins with a standard bunion approach with anatomical dissection in layers down to the first metatarsalphalangeal joint capsule (Figure 2). A distal based “U” shaped capsulotomy is made while maintaining the attachment to the midshaft of the proximal phalanx (Figure 3). A lateral release can be performed if necessary. The proximal one-third of the proximal phalanx is resected with power instrumentation (Figure 4). Next the head of the first metatarsal is remodeled and all loose bodies are removed (Figure 5). A drill hole is made in the remaining plantar base of the proximal phalanx (Figure 6). A linear incision is made in the plantar capsule to reveal the long flexor tendon. The long flexor tendon is then isolated and a non-absorbable is woven back and forth through the tendon (Figure 7). The suture is then passed through the previously made hole in the proximal phalanx (Figure 8). Suturing the flexor helps to maintain the alignment of the hallux as well as to retain flexion power. The short flexors distal to the sesamoids can be sutured to the long flexor if there is no significant sesamoid-first metatarsal degeneration. The medial capsular tissue is then flapped over the medullary canal of the proximal phalangeal stump (Figure 9). The remaining medial capsular tissue can be tightened and closed (Figure 10). At this point the extensor tendon can be lengthened if necessary (Figure 11). Soft tissue is then closed in layers.

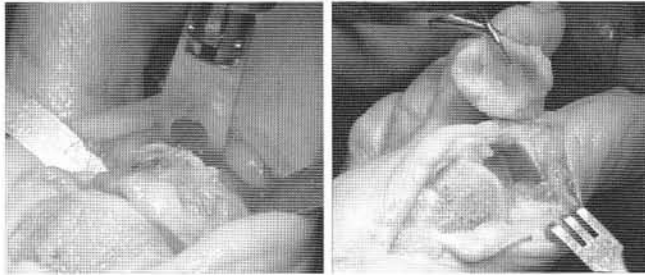


Figure 4A, B. Approximately 1/3 of the base of the proximal phalanx is transected (the osteotomy is usually just distal to the flair of the proximal phalanx).



Figure 5. The head of the first metatarsal is remodeled.

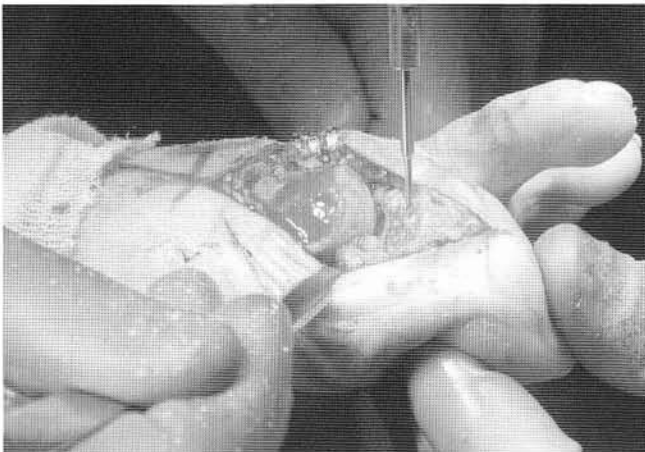


Figure 6. A drill hole is made in the central plantar aspect of the stump of the proximal phalanx.

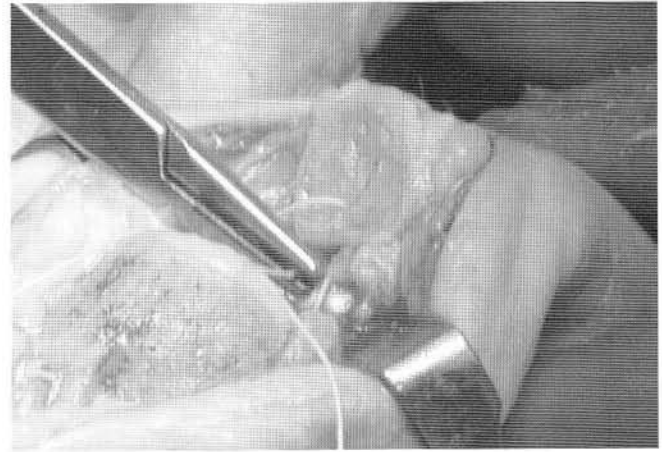


Figure 7. The FHL tendon is isolated and secured with suture.

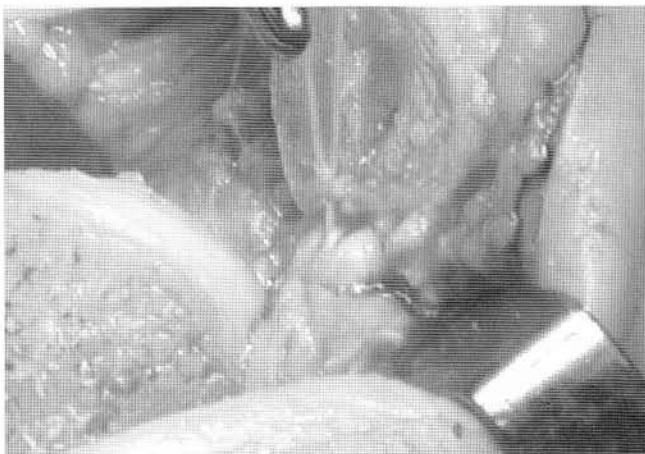


Figure 8. The FHL Tendon is secured to the stump of the proximal phalanx under tension via the drill hole.

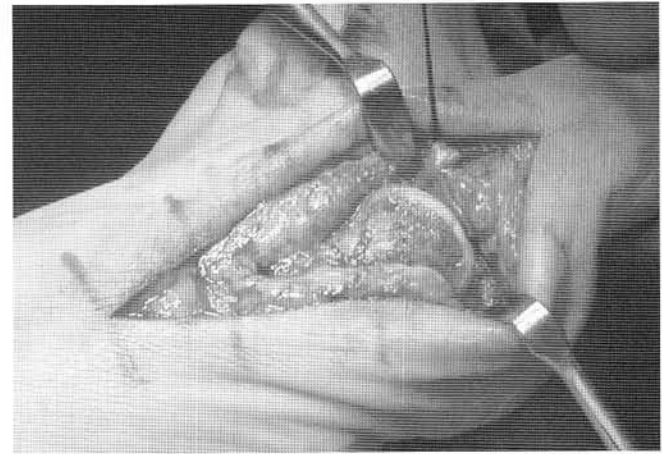


Figure 9. The medial capsular tissue is flapped over the raw bone of the stump of the proximal phalanx and secured to the lateral capsular tissue.

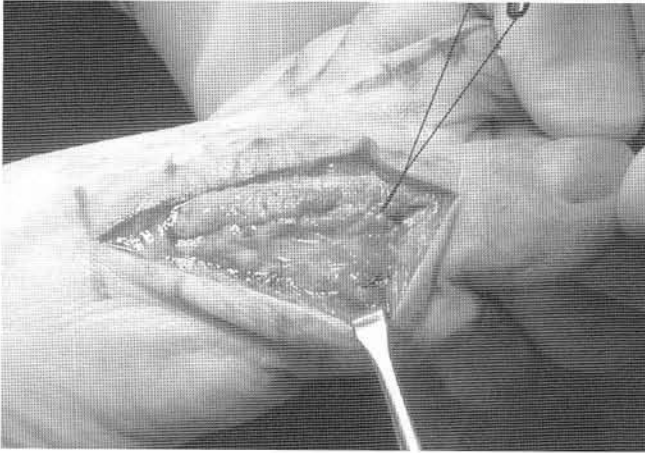


Figure 10. The remaining medial capsular tissue is closed and secured with the hallux in a corrected position.

The flexor tendon was sutured to the base of the proximal phalanx in 13/14 cases. The patient that did not have the flexor sutured was the patient who was having revision of a failed implant. The extensor hallucis longus tendon was lengthened in 8 of 14 cases; 6 did not undergo extensor lengthening.

SUBJECTIVE RESULTS

Patients were asked how they would rate the outcome of their procedure from very satisfied, satisfied, dissatisfied, to very dissatisfied (Table 2). In 8 of the procedures, patients rated their results as very satisfied, 4 were classified as satisfied, 1 was dissatisfied, and 1 was very dissatisfied. Ten patients representing 11 feet would have the procedures done again if given the choice and would recommend the surgery to a friend. 1 patient would not have the procedure done again and would not recommend the surgery to a friend. She was the youngest in our series and was very active in barefoot exercises like yoga. One patient had a successful outcome on one foot but continued to have some pain in the other foot. She would not have the procedure on the one foot but would recommend the surgery to a friend.

Using the ACFAS scoring system²¹ as a guide, patients were asked to rank pain and appearance. Pain is ranked from 30 points for no limitations of activity due to pain to 0 points for complete limitations of activity due to pain. The average preoperative pain score was 10 point while postoperatively it was 24.4. Preoperatively patients mostly did not like the appearance of the big toe joint with an average score of 1.8 out of 5 points. While postoperatively, patients mostly did like the appearance of their big toe joint (3.8/5).

Patients were also asked about level of functionality.

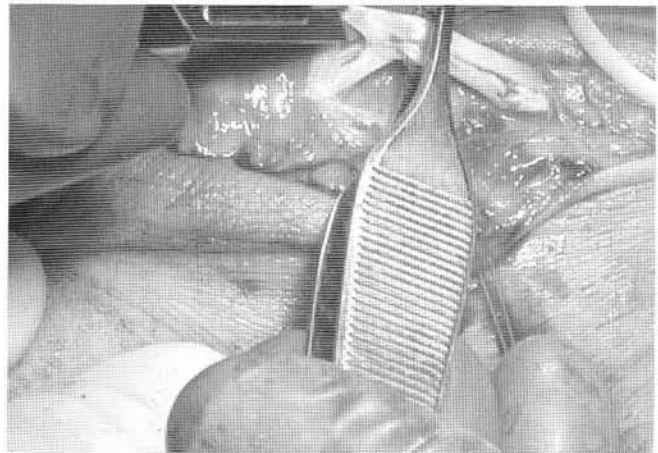


Figure 11. The EHL Tendon is lengthened if needed prior to closure of the wound.

The average preoperative score was a five/15 which is equivalent to only being able to wear athletic or walking shoes. The average postoperative score was 8.2/15 points. This is between being able to wear any shoe most of the time and only able to wear athletic or walking shoe. Preoperatively 8/14 of the feet caused patients to walk with a limp while 6 did not. Postoperatively in 12/14 of the feet the patients were able to walk without a limp; 2 feet continued to cause the patient to walk with a limp.

CLINICAL FINDINGS

All available patients returned for complete lower extremity evaluation. Range of motion of the first metatarsophalangeal joint was performed, using the long axis of the first metatarsal shaft and the long axis of the proximal phalanx in a non-weight bearing position as a reference. (Only postoperative values were available.) The average total dorsiflexion was 62.5° with a range of 20 to 90°. Plantarflexion ranged from 0° to 32° with an average of 13.5°. Both of these scores garnered the maximum allowable points in the ACFAS scoring system of 17 points. Hallux purchase power (paper pullout) was graded as not movable -10 points, resistant -5 points, and easy -0 points. The average score was 7.1 with a range of 0-10.

RADIOGRAPHIC RESULTS

Preoperative and postoperative radiographs were compared in regard to HA angle, IM Angle, First Metatarsal Declination angle. The average preoperative HA angle was 22.8° with a range of -10° to 50°. This gave 3 out of a total of 6 points. The average postoperative HA angle was 12° with a range of -10° to 28°. This gave 6 points out of 6. There was little change in the IM angle. Preoperatively the

Table 1

AVERAGE SCORES							
1st Met Pre-op Declination	20.4° (6)*	Dorsiflexion Post-op	62.4° (11)	Purchase Power Post-op	(7.1)	Limp Pre-op	6 With Limp 8 No Limp (2.9)
1st Met Declination Post-op	19.3° (6)	Plantarflexion Post-op	13.4° (4)	Shoe Gear Pre-op	(5)	Limp Post-op	2 With Limp 12 No Limp (4.3)
IM Pre-op	9.9° (6)	Total ROM Post-op	75.6° (15)	Shoe Gear Post-op	(8.2)	Shoe Gear Pre-op	(5)
IM Post-op	10.7° (6)	Pre-op Appearance	(1.8)	Pain Pre-op	(10)	Shoe Gear Post-op	(10)
HA Pre-op	22.8° (3)	Post-op Appearance	(3.8)	Pain Post-op	(24.4)	Total Avg. Points Pre-op	40.6/73
HA Post-op	11.9° (3)	IPJ Extension Post Op	(2)			Total Avg. Points Post-op	58.3/73
						Total Of All Points Post-op	82.4/100**

* Numbers in parenthesis are the average number from the ACFAS scoring system

** Includes range of motion, purchase power, IPJ extension

IM angle was 10.7° with a range of 3°-22°. The average post op IM angle was 9.9° with a range of 5°-16°. Both of these angles fell within normal range and received 6 out of 6 points. There was also very little change in the preoperative and postoperative first metatarsal declination angle. The average preoperative declination angle was 20.4° with a range of 14°-26°. The average postoperative declination angle was 19.3° with a range of 12°-21°. Both of these scores also fell within the normal limits and scored 6 out of 6 points. The amount of retraction of the sesamoids was also measured. A tangent was drawn to the first metatarsal head and perpendicular to the long axis of the second metatarsal. A parallel line was drawn tangent to the distal aspect of the tibial sesamoid. The average preoperative distance was 12.3 mm while the average postoperative distance was 13.6 mm resulting in an average retraction of 1.3 mm. An average of 29% of the proximal phalanx was resected.

COMPLICATIONS

Metatarsalgia was present in 6 of the 14 cases. One of the patients developed a symptomatic second metatarsal stress fracture. This was the youngest patient that would not have

the surgery again and would not recommend the surgery to a friend. The patient who had the hallux varus repair did not have a complete reduction of the deformity. However, the patient was happy with the results of the procedure and would recommend the procedure to a friend.

DISCUSSION

There are limitations to this research. A retrospective analysis is not as powerful as a prospective analysis. Not all parameters were measured preoperatively. Most of the patient population was older. It was assumed that many of the patients who were not available for followup had died or moved away or into senior care facilities. To obtain long term results the data needs to be at least 5 years out. Our average time of followup was only 3 years.

The one patient who developed a stress fracture of the second metatarsal was also the youngest patient in the group at 49 years old. She was dissatisfied with the procedure and would not recommend it to a friend. This patient participated in non-shod activities such as yoga. The patient also had a 2 mm retraction of the sesamoids which is almost 2 times the average retraction. Better

preoperative and intra-operative analysis of the sesamoids may have revealed a non-arthritis sesamoid apparatus. Had this been noted the short flexor could have been sutured to the proximal phalanx. This would have surely limited the retraction and maintained more of the first metatarsal weight bearing. Another factor to consider is the ability (or inability) to control the patient biomechanically while participating in non-shod activities. This patient was chronologically and biochemically young, maybe too young for this procedure. Preoperative patient education stressing need for orthotics may have also saved this patient some pain and suffering.

One patient who underwent bilateral arthroplasty was very dissatisfied with one foot but was satisfied with the other foot. However this patient would recommend this procedure to a friend. At time of followup the patient reported to have under gone a hip arthroplasty controlateral to the foot that she was very dissatisfied with. She stated that she had been favoring her hip and relying heavily on the contrallateral limb. This may have lead to her discomfort.

Hallux varus, flail toe, and hallux malleous are commonly reported complications. Due to small sample size it is impossible to say why these complications were not see. McGlamry talked about the need to suture the flexor tendon. We feel that this helps to impart stability to the hallux and retain flexor power. Ganley talked about tendon balancing through lengthening of the extensor tendon.²⁰ This also helps to decrease the patients ability to walk away from pain creating early extensor substitution and limits the development of hallux malleous and extensus.

Proper, but not over zealous, resection of the base of the proximal phalanx also limits the formation of a flail toe while increasing range of motion. Lesser metatarsalgia was seen in almost 50% of the cases. There was no mention of the absence or presence of lesser metatarsalgia pre-operatively. It is important to educate the patient that pressure can be transferred to the other metatarsals and this can cause discomfort.

CONCLUSION

Overall the procedure was a success. Only 73 of the total 100 points could be used from the ACFAS scoring system because of the retrospective nature of this study. With that in mind the average preoperative total score was 40.6 / 73 or 55%. The average postoperative score was

58.3 / 73 or 80% over all score. More consideration has to be given to the status of the sesamoid apparatus. If it is non-arthritis, attachment of the short flexor would be beneficial. The need for postoperative biomechanical control needs to be investigated. If lack of first ray loading is the culprit for lesser metatarsalgia and stress fracture perhaps medial column fusions or even first metatarsal phalangeal arthrodesis could be beneficial in a younger more active patient.

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