CHAPTER **35**

TIGHTROPE BUNIONECTOMY PROCEDURE AND ITS COMPLICATIONS

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INTRODUCTION

Hallux abducto valgus, or a bunion deformity as it is commonly known, has a prevalence of 19.25 persons per 1,000, or 51 million people in the US. Many female patients complain about the deformity; however, it is unknown whether that is due to a propensity for female patients to seek treatment or symptomatic secondary to tight female shoegear.

There are different conservative methods for management of the hallux abducto valgus deformity. Most authors agree that biomechanics of the foot plays a major role in acquiring this deformity. Management of the deformity starts by stabilizing the foot to prevent the deformity from progressing. However, if there is persistent pain in spite of conservative treatment, then surgical procedures are indicated.

Over the years, many different types of surgical procedures had been devised. Distal metatarsal head osteotomies are the most popular in correction of the deformity due to the inherent stability of the metatarsal head. Austin et al described the technique of a horizontal V osteotomy in 1962. Throughout the years, the technique has been modified to include elongation of the arms of the osteotomy and to include various types of fixation. Austin also describes immediate weight bearing postoperatively, but today most surgeons would place patients in guarded weight bearing status with a postoperative shoe.

All osteotomies that reduce the intermetatarsal angle causes the patient inconvenience in some way during the postoperative course. This can range from guarded weight bearing in a postoperative shoe 3-4 weeks, to a nonweight-bearing course in a short leg cast for 4-6 weeks. New and novel procedures have been described to reduce the amount of surgical trauma and the postoperative course.

What if there was a technique to reduce the intermetatarsal angle without performing an osteotomy through the distal metatarsal metaphyseal bone? This will decrease the postoperative period and eliminate inherent risks that are associated with an osteotomy. The Arthrex Mini-Tightrope System, based on the Tightrope System for Ankle Synthesmosis repair, was designed for correction of the hallux abducto valgus deformity without performing an osteotomy. This retrospective study compares the efficacy of the Arthrex Mini-Tightrope System with a distal osteotomy for correction of the hallux abducto valgus deformity.

PATHOMECHANICS

Most authors agree that "excessive compliance" (lack of stiffness, hypermobility), of the first ray can lead to a hallux abducto deformity. The lack of stiffness can stem from excessive pronation through the stance phase of gait. Excessive pronation can be caused by compensated forefoot and hindfoot frontal plane deformity, pes valgus deformity, metatarsus adductus, and rotational deformities of the lower extremity.

Instability of the first ray during stance phase of gait can lead to excessive motion at the metatarsalphalangeal joint. This can cause more motion in the frontal and transverse planes, pushing the metatarsal head medial. As the proximal phalanx moves more lateral, the stabilizing forces of the adductus hallucis and flexor hallucis brevis tendons become deforming forces. The mechanical pull is now lateral to the long axis of the metatarsal. As the deformity progresses, the lateral capsule contracts and tightens while the medial capsule weakens. The lateral deforming force and weakened medial capsule causes the metatarsal head to move medial. The abductor hallucis can no longer stabilize the hallux. As the medial eminence becomes increased over time, it causes compression of the medial dorsal cutaneous nerve. Neuritic symptoms are exacerbated when the foot is enclosed in a tight fitting shoe.

Other etiologies of hallux abductovalgus deformity are inherited congenital/familial deformities and neuromuscular diseases that cause a neuromuscular imbalance. There is a familial tendency for bunion deformity as a foot type that often leads to bunion deformities.

STUDY DESIGN

The patient base was from a Southern California HMO population. All patients had a hallux abductovalgus deformity. The inclusion criteria was that the patients had a hallux abductovalgus deformity, and the exclusion criteria were any patients that had a neuromuscular disease or had juvenile hallux abductovalgus deformity.

There were 18 patients with a total of 21 feet between June 2007 and June 2008 who had the TightRope procedure performed for hallux abductovalgus deformity. The patients were regularly followed in the outpatient clinic until they were ready for discharge. A chart review of 40 patients with 44 feet who had an Austin-Chevon osteotomy were also examined as a comparison with the Tightrope procedure.

Radiographic evaluation was performed for all patients in this study. The radiographic evaluation consisted of preoperative and postoperative evaluations of the metatarsal adductus, first intermetatarsal, hallux abductus angles, metatarsal protrusion distance and the sesamoid position on the AP view. The radiographic evaluation on the lateral view consisted of the Seiberg's Index. The midfoot and rearfoot were generally assessed to determine the foot position of neutral, pronated, or supinated.

PROCEDURE

The patient was placed in a supine position on the operative table. A dorsal-medial linear incision approximately 6 cm in length was made over the first metatarsophalangeal joint. A linear dorsal capsulotomy was performed. The periosteum was reflected off the medial neck and midshaft of the metatarsal. If necessary, the prominent medial eminence was resected. The lateral release was performed in a standard fashion. With the periosteum removed from the medial aspect of the first metatarsal, a 2.0 mm drill was used to make a hole at the midshaft level in the transverse plane.

A second incision was made in the dorsolateral aspect of the second metatarsal. The perisosteum was then reflected at the midshaft of the lateral metatarsal using a periosteal elevator. A 2.0 mm drill hole was then made at the midshaft level in a straight transverse fashion perpendicular to the weight-bearing surface. The #2 Fiberwire was then inserted on the medial side of the first metatarsal and extended to the lateral side of the second metatarsal, where the button was placed. Once the intermetatarsal angle was reduced, the Fiberwire was hand tightened to hold the correction. Closure was then performed in layers.

The patient was then placed in a postoperative shoe for a period of 4 weeks. The patient can be weight bearing as tolerated. Instructions were given to the patient for no strenuous activity, but the patient can return to work.

RESULTS

There were 58 patients with 65 feet who had a Tightrope bunionectomy or a distal Austin-Chevon bunionectomy. The average age was 52.3 years. The average followup was 5.4 months. On the preoperative AP radiographic evaluation, the average metatarsal adductus angle was 17.123, the intermetatarsal angle was 12.2, the hallux abducto angle was 28.47, average sesamoid position was 5.27, and the metatarsal protrusion distance was -0.26 millimeters. The Seiber's angle was 0.019 on the lateral view. Postoperatively, the metatarsal adductus angle was 17.062, the intermetatarsal angle was 7.662, hallux abducto angle was 13.385, the sesamoid position of 3.354, and the metatarsal protrusion distance of -0.0446. Seiber's angle was 0.062. All of the angles showed statistical significance except for metatarsal adductus (Table 1).

Of the 58 total patients, 18 patients (21 feet) had the Tightrope Bunionectomy procedure. Preoperatively the metatarsal adductus angle was 18.33, the intermetatsal angle was 13.0, the hallux abducto angle was 33.24, the average sesamoid position was 5.67, and the metatarsal protrusion distance was -1.24 millimeters. On the lateral view, Seiber's angle was 0. Postoperatively, the metatarsal adductus angle was 18.10, the intermetatarsal angle was 7.24, the hallux abducto angle was 14.05, the sesamoid position was 3.28

Table 1

TOTAL PATIENTS IN STUDY

TOTAL PATIENTS	PRE-OPERATIVE	POST-OPERATIVE	*P*
Metatarsal adductus	17.12308	17.06	0.076034
Intermetatarsal angle	12.2	7.66	**<0.01**
Hallux abducto angle	28.48	13.38	**<0.01**
Sesamoid position	5.27	3.35	**<0.01**
Metatarsal protrusion (mm)	-0.26	-0.44	**<0.01**
Seiber's index	0.68	0.21	**<0.01**

Table 2

PATIENTS WITH THE CHEVRON PROCEDURE

CHEVRON	PRE-OPERATIVE	POST-OPERATIVE	*P*
Metatarsal adductus	16.54	16.56	0.06
Intermetatarsal angle	11.81	7.86	**<0.01**
Hallux abducto angle	26.20	13.06	**<0.01**
Sesamoid position	5.09	3.38	**<0.01**
Metatarsal protrusion (mm)	0.20	-0.22	**<0.01**
Seiber's index	0.23	0.06	**<0.01**

Table 3

PATIENTS WITH THE TIGHTROPE PROCEDURE

TIGHTROPE	PRE-OPERATIVE	POST-OPERATIVE	*P*
Metatarsal adductus	18.33	18.05	0.29
Intermetatarsal angle	13.00	7.23	**<0.01**
Hallux abducto angle	33.23	14.04	**<0.01**
Sesamoid position	5.66	3.28	**<0.01**
Metatarsal protrusion (mm)	-1.23	-0.90	**<0.01**
Seiber's index	0	0	**<0.01**

with a metatarsal protrusion distance of -0.91 millimeters. Seiber's Index was 0.05. All of the angles show statistical significance except for metatarsal adductus and Seiber's Index. Complications were seen in 6 patients after the procedure; 4 of the 6 patients had a transverse fractured second metatarsal in the vicinity of the tightrope. All 4 patients had the hardware removed and an ORIF of the second metatarsal. Of the 4 patients, 1 patient had bilateral feet performed at the same time and 1 patient had a Tailor's Tightrope bunionectomy. One patient reported pain at the metatarsal-cuneiform joint and at the site of the hardware, and subsequently had her hardware removed. One patient tripped and fractured the fourth and fifth metatarsals. All complications were treated accordingly (Table 3).

The remaining 40 patients with 44 feet had an Austin-chevron procedure. Preoperatively, the metatarsal adductus angle was 16.55, the intermetatarsal angle was 11.82, the hallux abducto angle was 26.21, the sesamoid position was 5.09, and the metatarsal protrusion distance was 0.205 millimeters. Seiber's Index was 0.029. Postoperatively, the metatarsal adductus angle was 16.55, the intermetatarsal angle was 7.86, the hallux abducto angle was 13.07, sesamoid position was 3.39, and the metatarsal protrusion distance was -0.23 millimeters. Seiber's Index was 0.07. Again, all the angles showed statistical significance except for metatarsal adductus (Table 2).

Comparisons were made between the chevron procedure subgroup and the tightrope procedure subgroup. Preoperatively, it was found that the Tightrope patients had a statistically significant increase in metatarsal adductus angle, increased intermetatarsal angle, increased hallux abducto angle, a shorter metatarsal protrusion, and decreased Seiber's Index. Postoperatively, the metatarsal protrusion distance was the only value that was statistically significant (Table 4).

Finally, the Tightrope subgroup was further divided into patients that did not have a complication and patients that had a complication. Preoperatively, the metatarsal adductus angle showed a statistical significance increase in patients that had complications. Postoperatively, the intermetatarsal angle and the sesamoid position showed statistical significance (Table 5).

DISCUSSION

The results show that in this patients in both groups show reduction in the intermetarsal angle, the hallux abducto angle, the sesamoid position, metatarsal protrusion, and Seiber's Index postoperatively. This is to be expected. Between the Austin-chevron and the Tightrope procedure subgroups, the postoperative results showed no statistical significant difference, which shows that the Tightrope procedure works as well as the Austin-chevron procedure.

There are many surgical procedures to correct the hallux abducto valgus deformity. Over the years, many new and innovative procedures have been developed, from Revedin's osteotomy to the more popular Austin-chevron

Table 4

CHEVRON PROCEDURE VERSUS TIGHTROPE PROCEDURE

CHEVRON VS. TIGHTROPE	PREOPERATIVE Chevron	PREOPERATIVE Tightrope	*P*	POSTOPERATIVE Chevron	POSTOPERATIVE Tightrope	*P*
Age	57.39	49.61	**0.05**			
Body mass index	28.70	28.03	0.36			
Metatarsal adductus	16.54	18.33	**0.05**	16.56	18.09	0.08
Intermetatarsal angle	11.82	13.00	**0.05**	7.86	7.23	0.13
Hallux abducto angle	26.20	33.23	**<0.01**	13.06	14.04	0.31
Sesamoid position	5.09	5.66	**0.03**	3.38	3.28	0.38
Metatarsal protrusion (mm)	0.20	-1.23	**<0.01**	-0.22	-0.90	0.01
Seiber's index	0.22	0	**<0.01**	0.06	0	0.09

Table 5

NO COMPLICATIONS VERSUS COMPLICATIONS IN TIGHTROPE PROCEDURE SUBGROUP

NO FRACTURE VS. FRACTURE	PREOPERATIVE No Fracture	PREOPERATIVE Fracture	*P*	POSTOPERATIVE No Fracture	POSTOPERATIVE Fracture	*P*
Age	48.53	56.16	0.19			
Body mass index	27.11	30.53	0.14			
Metatarsal adductus	19.53	15.33	**<0.01**	19.4	14.83	**<0.01**
Intermetatarsal angle	12.46	14.33	0.19	6.6	8.83	**0.01**
Hallux abducto angle	34.80	29.33	0.14	12.8	17.16	0.14
Sesamoid position	5.60	5.83	0.35	2.93	4.16	**0.01**
Metatarsal protrusion (mm)	-1.26	-1.16	0.44	-0.73	-1.33	0.26
Seiber's index	0	0	N/A	0	0	N/A

osteotomy. Austin describes the osteotomy as a transverse 60 degree V-shaped osteotomy at the metaphysical bone to allow the metatarsal head to shift laterally. This causes a relative decrease in the intermetatarsal angle and allows the head to glide over the sesamoids. With a lateral release, the tension on the proximal phalanx of the hallux is decreased, allowing the base of the proximal phalanx to articulate with the head of the metatarsal.

The principles of correction of a low to moderate hallux abducto valgus deformity have remained the same. The goal is to decrease the deformity by placing the metatarsal head over the sesamoids and allowing the proximal phalanx to articulate with the metatarsal head. Since most distal head procedures involve performing an osteotomy and a lateral displacement of the metatarsal head, there is always an inherent risk of nonunion, delayed union, malunion, avascular necrosis, and protruding and painful hardware (if used). The mini-tightrope procedure was devised to avoid

an osteotomy of the metatarsal head. Removal of the medial eminence using a sagittal saw does not including the same inherent risks as a distal head osteotomy.

Originally, the Arthrex Tightrope system was used as an alternative to a synthesmotic screw for an ankle synthesmotic injury. Since the synthesmosis has a slight motion, the Tightrope system allows for that motion due to its flexible nature. It has been shown that it is strong enough to hold the correction and has the added benefit of not having to remove the construct. The same advantages for the ankle were thought to hold true for the hallux abducto valgus deformity. If there was a way to correct the intermetatarsal angle without performing an osteotomy, then it would negate the inherent risks of a head procedure. The Tightrope system seems to be an appropriate procedure, in that no osteotomy was performed at the metatarsal head in order to place the head over the sesamoids.

In this retrospective study, there were 18 patients (total of 21 feet) that had the Tightrope procedure for correction of a hallux abducto valgus deformity along with 40 patients (44 feet) that had an Austin-chevron bunionectomy. There were no postoperative complications with the Austin-hevron bunionectomy. Within the tightrope group, 3 patients had the procedure on bilateral feet. Twelve patients did well after the procedure with no complications; however, they did state that there was increased swelling in the first interspace. They stated that they were satisfied with the procedure and they were able to perform tasks of daily living with no pain. On subsequent follow up radiographs, there were no changes in the intermetatarsal angle from the first postoperative visit to the last. The Tightrope system held the correction in place. However, there were 6 patients that had complications, including 4 patients that had a fracture of the second metatarsal at the level of the Tightrope. Those patients required a second procedure, in which ORIF of the second metatarsal was performed and the Tightrope was removed. This represents a 33% complication rate.

Preoperatively, the patients in the Tightrope procedure subgroup had an increased amount of deformity than the patients in the chevron procedure subgroup. Postoperatively, the 2 subgroups were statistically insignificant. This shows that even though the deformity is greater preoperatively, the Tightrope procedure corrected the deformity as well as the chevron procedure.

It was felt that the high rate of stress fracture of the second metatarsal was due to the 2.0 mm transverse drill hole through the diaphyseal bone. This weakens the bone significantly enough that the bone cannot withstand the traumatic events of weight bearing. None of the patients in the study was observed to be osteopenic; however, bone density span was not performed preoperatively due to unforeseen complications. Another potential reason for the second metatarsal fractures is that the first ray has an independent range of motion with its own axis that is different from the central metatarsals. By anchoring the first metatarsal to the second metatarsal with significant tension across the fiberwire to correct the deformity, it places more stress on the second metatarsal. The fiberwire is also a hard abrasive suturing material that, over time and with motion, can cause a cutting action against the cortex of the second metatarsal, which will weaken it further. It was felt that a combination of the size of the drill hole and the tension on the fiberwire caused increased stress on the second metatarsal, that in some patients it was unable to withstand.

There were some weaknesses to this study. There were only 18 patients that had the Tightrope procedure. A larger population base is needed to adequately assess the complication rate. A longer follow up is also needed in order to assess whether the procedure can hold the correction over time. A 5 year follow up will also determine if there is any wear on the fiberwire.

CONCLUSION

The Tightrope procedure for correction of the hallux abducto valgus deformity is a very powerful procedure. It reduces the intermetatarsal angle and with a lateral release, reduces the hallux abductus angle without performing an osteotomy at the distal metatarsal head. It avoids the complications associated with the distal head osteotomy; however, it introduces new complications. Although a small population in this study contributed to its high complication rate, it is high enough to warrant a more extensive evaluation of the Tightrope procedure. The Tightrope system has its inherent complications that need to be resolved before it can become a viable procedure for correction of the hallux abducto valgus deformity. Until the procedure can be refined, we have suspended the use of the Tightrope procedure for elective surgery due to high rates of complications.

Figure 1. Preoperative radiograph.

Figure 2. Postoperative (1 month) view.

Figure 3. Preoperative radiograph.

Figure 4. Postoperative (3 weeks) view.

Figure 5. Postoperative ORIF of the second metatarsal and hardware removal with Austin bunionectomy.

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