Original article

Short term results of osteotomy-sparing technique in management of moderate hallux valgus using TightRope system

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ABSTRACT

Background: Currently, correction of the first intermetatarsal angle associated with hallux valgus is done using two main categories of surgeries either a distal or a proximal first metatarsal osteotomy. The osteotomy-sparing technique using TightRope® device was developed to manage hallux valgus avoiding osteotomy complications. Our hypothesis was that osteotomy sparing technique using TightRope® implant would be suitable for moderate hallux valgus in young adult patients with strong larger bones giving good results with minimal complications.

Methods: 26 male patients (30 feet) with age range 18–35 years (average 27.04 ± 4.6) with moderate hallux valgus deformity were managed with osteotomy-sparing method. All patients were assessed clinically using the visual analogue scale (VAS) and American Orthopedic Foot and ankle score (AOFAS) and radiological using hallux valgus angle (HVA), first inter metatarsal angle (IMA) and sesamoids position. P value < 0.05 was statistically significant.

Results: The mean follow up time was 19.5 ± 4.1 (12–27) months. The mean IMA, HVA and AOFAS score improved from $14.2 \pm 2.8^\circ$, $33.4 \pm 7.6^\circ$ and 42.6 ± 6.3 points preoperatively to $8.2 \pm 2.3^\circ$, $13.6 \pm 5.4^\circ$ and 85.8 ± 6.8 points postoperatively, respectively. All were statistically significant. Superficial infection occurred in one case and overcorrection in another with no other complications.

Conclusion: Osteotomy-sparing technique using TightRope device is effective in the management of moderate hallux valgus provided that proper patient selection, adequate surgical technique, and proper postoperative protocol are followed.

1. Introduction

Hallux valgus (lateral deviation of the great toe) is not a single disorder but it is a complex deformity consists of medial angulation of the first metatarsal and lateral deviation of the hallux, with element of rotation (usually pronation) in addition to bunion formation on the medial aspect of the first metatarsal head.¹

Females are more commonly affected than males. Wearing of narrow shoes with high heel is an important extrinsic factor in the development of hallux valgus.²

Many theories have been proposed for the pathogenesis of hallux valgus including genetic predisposition, structural abnormalities, ligamentous hyperlaxity and muscle imbalance.³

The controversy continues over which deformity is the essential in hallux valgus: metatarsus primus varus or lateral angulation of the great toe. Each is claimed to be the cause of the other.⁴ Hawkins and his colleagues stated that the main cause of failed surgeries of hallux valgus was incomplete correction of the intermetatarsal angle.⁵ A study by

Antrobus showed that the medial deviation of the first metatarsal was secondary to the hallux valgus which proved after surgical correction of the increased inter-metatarsal angle.⁶

Many surgical techniques have been developed for correcting hallux valgus. The goal of all these operations is to achieve full correction with the least invasive maneuvers and fewer hazards. There was no gold standard single surgery suitable for all cases and surgical management of each patient should be tailored.⁷

Now, most of the present operative procedures for correction of the first intermetatarsal angle associated with hallux valgus rely on performing either a distal or a proximal first metatarsal osteotomy. The location of the osteotomy depends on the severity of the deformity. The expected drawbacks resulting from first metatarsal osteotomies include mal-union, non-union, loss of fixation, shortening of the first metatarsal and osteo-necrosis of the metatarsal head (with distal osteotomies).⁸ To alleviate these complications, the osteotomy sparing technique using TightRope® device was developed and used as a minimally invasive procedure to correct the medially shifted first metatarsal associated

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Table 1
The demographic characteristics of the studied patients.

Age		
Mean $\pm$ SD	27.04 $\pm$ 4.6	
Range (years)	(18–35)	
Follow up time		
Mean $\pm$ SD	19.5 $\pm$ 4.1	
Range (months)	(12–27)	
Injured side		
Right	13 (50 %)	
Left	9 (34.6 %)	
Bilateral	4 (15.4%)	
Occupation		
Manual worker	6 (23.1 %)	
Farmers	4 (15.4 %)	
Sport man	3 (11.5 %)	
Engineer	3 (11.5 %)	
Policeman	2 (7.7 %)	
Teacher	3 (11.5 %)	
Doctor	2 (7.7 %)	
Barber	3 (11.5%)	

*Data are presented as number (n) and percentage (%).
SD; standard deviation.

with hallux valgus.¹

The purpose of our study was to assess the clinical outcomes of osteotomy-sparing technique using the TightRope® fixation system in surgical correction of moderate hallux valgus especially in young adult with strong larger bones.

2. Materials and methods

From August 2014 to February 2016, we had 26 patients (30 feet) presented with moderate hallux valgus deformity in Zagazig University Hospital. All patients suffered from pain not responding to conservative treatment with insoles, orthopedic footwear and NSAIDs for at least 6 months. The mean age was 27.04 $\pm$ 4.6 years (range 18–35 years) with 15 females and 11 males. The right side was affected in 13 patients; the left side was affected in 9 patients, while bilateral affection was present in 4 patients (Table 1). Approval from our local ethical committee and informed consents were obtained from all cases. All patients were managed by bunionectomy, soft tissue release, and application of TightRope® implant. The patients were followed up for a minimum of 12 months (range 12–27 months, average 19.5 $\pm$ 4.1 months). The exclusion criteria were severe hallux valgus (HVA > 40° and IMA > 20°), age > 35, small bone with poor quality, degenerative changes of the first metatarsophalangeal joint and hypermobility of the first tarsometatarsal joint.

2.1. Preoperative evaluation

A detailed history was taken and thorough examination was performed to detect degree of the deformity, pain (onset, site and severity), associated foot deformity and neurological status.

A weight-bearing dorsoplantar (Fig. 1) and lateral x-rays were taken to detect the hallux valgus angle (HVA), the first intermetatarsal angle (IMA), the position of the sesamoids, and the presence or absence of degenerative changes in the first metatarsophalangeal and tarsometatarsal joints.

2.2. Operative technique

In the supine Fig. 2e decubitus, all patients were operated under regional anesthesia. A pneumatic tourniquet was applied. Three incisions were made. The first was curved connecting the center point of the medial side of the 1st metatarsal shaft through the center point of the metatarsal head and to the center point of the medial side of the

proximal phalanx of the big toe. Skin and subcutaneous tissues were incised with cauterization of any bleeding vessels till reaching the capsule. The capsule was raised in two flaps an inferior one reaching the abductor hallucis and a superior flap with dorsal digital nerves. A dorsomedial capsulotomy was then done. Hohmann's retractors were then put around the metatarsal neck exposing the bunion. Bunio-nectomy was done using an osteotome or a small saw blade starting at the medial edge of the articular surface and directed proximally to the medial cortex of the metatarsal (Fig. 2A). The second incision was made for a modified McBride's procedure starting at the 1st web space and running obliquely proximally towards the 2nd metatarsal neck to allow for the passage of the TightRope guide pin. After skin incision, blunt dissection was performed till exposing the fibular sesamoid bone and the adductor hallucis tendon inserting into it. The tendon was sharply shaved from the sesamoid from proximal to distal. Next the sesamoid bone itself was released from the capsule allowing it to return to its normal position. Afterwards, the lateral side of the 2nd metatarsal neck and shaft was exposed for later retrieval of the TightRope® guide pin. The 3rd and last incision was made dorso-medially over the cuneiform metatarsal joint. Extensor hallucis was retraced laterally and cutaneous branches of superficial peroneal nerves medially. Capsular release was performed under direct vision allowing mobilization of the 1st ray and correction of the intermetatarsal angle (Fig. 2B). A pointed reduction forceps at the level of metatarsal necks was used to make and hold that correction (Fig. 2C). After fluoroscopic checking of the reduction, a Hohmann's retractor was placed laterally under the 2nd metatarsal neck. The TightRope® guide was introduced through the cortical part of the medial side of 1st metatarsal neck projecting dorso-lateral traversing four cortices to come out from the lateral side of the 2nd metatarsal shaft proximal to the neck. Digital and fluoroscopic assuring of the correct position was made again. Over drilling was done using a cannulated drill pit. The needle and pull-through sutures were passed along the drill hole and out of the 2nd metatarsal shaft proximal to the neck. The button should seat easily along the lateral cortex. The lateral pull-through sutures were cut and removed. A blunt hemostat was inserted under the medial button. The white strands were pulled straight back towards the surgeon one at a time. The hemostat was removed before final tightening. Alternating simple surgical ties were made for assurance then the sutures were cut with a small tail. The reduction forceps was removed and maintenance of the reduction was assured by fluoroscopy (Fig. 2D). Capsular repair and medial imbrication were done then all wounds were closed in layers. A below knee splint was applied for 3 weeks then, heel weight-bearing was allowed in athletic shoe for another 3 weeks.

2.3. Postoperative evaluation

Follow-up was made 1, 2, 3 and 6 weeks post-operatively, then at 3, 6 and 12 months. Radiologic evaluation was made immediate post-operatively and along with the clinical evaluation at 6 weeks and 3, 6 and 12 months. Clinical scores and radiological measurements at the 12th month follow-up were used for comparison with the pre-operative ones. Pain VAS score was obtained from a score 1 to 10 where 1 is no pain at all and 10 is extremely agonizing pain. Measurement of the IMA, HVA and the position of the sesamoids according to the American Orthopedic Foot and Ankle Score (AOFAS) grading scale were made and compared. In the AOFAS grading scale, grade 0 means no lateral displacement of the medial sesamoid in relation to the longitudinal axis of the first metatarsal, grade 1 means overlap of less than 50% of the sesamoid to the longitudinal axis, grade 2 means overlap greater than 50%, finally, grade 3 means the sesamoid is completely displaced laterally beyond the longitudinal axis of the first metatarsal. The overall AOFAS score according to the rating system out of 100 was finally documented.

Fig. 1. Pre-operative dorso-planter x-ray showing right moderate hallux valgus.

2.4. Statistical analysis

The results were presented as mean $\pm$ standard deviation. Paired *t*-test was used to compare the means before and after surgery. All statistical analyses were performed with SPSS version 24.0 (SPSS Japan Inc., Tokyo, Japan). $P < 0.05$ was considered statistically significant.

3. Results

Clinically, the hallux valgus deformity was corrected in all patients with no evidence of recurrence during follow up. Superficial infection occurred in one case and managed conservatively. One case had over-correction, due to over plication of the medial capsule that was managed with percutaneous pie crusting of the medial capsule under local anesthesia. No fractures happened and no other complications. Pain subsided (the mean preoperative VAS was 7.3 ± 1.2 while the mean postoperative VAS was 1.6 ± 0.9). Radiological, the mean IMA improved from $14.2^\circ \pm 2.8^\circ$ preoperatively to $8.2^\circ \pm 2.3^\circ$ postoperatively at the final follow-up visit, the mean HVA improved from $33.4^\circ \pm 7.6^\circ$ preoperatively to $13.6^\circ \pm 5.4^\circ$ postoperatively at the final follow-up visit. The position of the sesamoids according to AOFAS grading scale improved from 1.9 ± 0.8 preoperatively to 0.4 ± 0.2 postoperatively at the final follow-up visit. The overall AOFAS score improved from 42.6 ± 6.3 points preoperatively to 85.8 ± 6.8 points postoperatively at the final follow-up visit according to the rating scale. All results were statistically significant (Table 2).

4. Discussion

Hallux valgus deformity is a common pathological condition that frequently produces painful disability. It is considered a combined deformity with a malpositioning of the first metatarsophalangeal joint caused by medial deviation of the first metatarsal and lateral deviation of the great toe. The controversy continues over which deformity is the primary in hallux valgus; varus deformity of the 1st ray or lateral shift of the big toe. Each is incriminated as the cause of the other.⁴ Typical

initial treatment options are footwear modification (e.g. lower heels with greater width), bunion pads and analgesics. Other conservative treatments include braces and foot exercises to stretch and strengthen affected soft tissues.⁹

Surgical management is considered for failed conservative treatment and progressive deformity. Selection of the optimal surgical strategy is always a controversial topic. It is well known that there are various pathological changes in hallux valgus deformity, so it is impossible to use one specific procedure to solve all the problems.

Surgical correction of the first intermetatarsal angle is the mainstay to treat such deformity using either a distal or a proximal first metatarsal osteotomy. The site of the osteotomy is dependent on the degree and location of the deformity but there were many problems were recorded with these procedures.⁸

The osteotomy – sparing technique using the TightRope® device was developed and used as a less invasive technique to avoid the complications associated with the first metatarsal osteotomy. The most common complications associated with the use of the TightRope fixation were fracture of the second metatarsal and rupture of the TightRope® system with migration of the implant. So, we preserved the procedure for young adult patients with good bone stock and larger stronger bones. The risk of second metatarsal fracture can be reduced by proper placement of the drill hole (the drill hole should be placed centrally midway between the dorsal and plantar aspects of the second metatarsal and proximal to the metatarsal neck), avoidance of full weight-bearing in the immediate postoperative period (as recovery is dependent on soft tissue scarring to hold the correction and unload the device), and avoidance of using the device in osteoporotic patients.

In our study, there were 26 patients (30 feet) in the age group 18–35 years (average 27.04 ± 4.6 years) presented with moderate hallux valgus deformity and managed using a TightRope® implant. The mean IMA improved from $14.2^\circ \pm 2.8^\circ$ preoperatively to $8.2^\circ \pm 2.3^\circ$ postoperatively, the mean HVA improved from $33.4^\circ \pm 7.6^\circ$ preoperatively to $13.6^\circ \pm 5.4^\circ$ postoperatively, and the mean AOFAS score improved from 42.6 ± 6.3 points preoperatively to 85.8 ± 6.8 points postoperatively. Also, the mean AOFAS sesamoid grading was improved

Fig. 2. Intra-operative fluoroscopy pictures showing; (A): Bunionectomy, (B): Locating of the cuneiform metatarsal joint, (C): A pointed reduction forceps at the level of metatarsal necks was used to correct and hold the intermetatarsal angle and (D): After TightRope implant placement and final tightening, the reduction forceps was removed and maintenance of the reduction was assured.¹

from 1.9 ± 0.8 preoperative to 0.4 ± 0.2 postoperative. Superficial infection occurred in one case, overcorrection in another, no fractures and no other complications.

Comparing to other related studies, in the study of Martinez et al.¹⁰ there were 32 patients (36 feet) with moderate hallux valgus deformity managed by the osteotomy sparing technique and fixed with TightRope. The mean IMA improved from $13.8^\circ \pm 3.4^\circ$ preoperatively to $9^\circ \pm 2.6^\circ$ postoperatively, the mean HVA improved from $26.8^\circ \pm 8.1^\circ$ preoperatively to $16.8^\circ \pm 6.1^\circ$ postoperatively, and the mean AOFAS score improved from 47.71 ± 5.2 points preoperatively to 88.0 ± 8.2 points postoperatively. Fracture of the second metatarsal occurred in 2 cases and managed by non-weight bearing for 6 weeks. Rupture of the system occurred in another 2 cases that required reoperation. Cellulitis

in one case managed by oral antibiotics and stiffness of the metatarsophalangeal joint that was not painful. Almalki et al.¹ reported their outcomes on 4 patients with hallux valgus deformity who underwent the TightRope® procedure. The mean IMA improved from 15.75° preoperatively to 4.5° postoperatively, the mean HVA improved from 31.25° preoperatively to 5.75° postoperatively. In the study by Kayiaros et al.¹¹ there were 36 patients (44 feet) with hallux valgus deformity managed by using the TightRope® device. The mean IMA improved from 14.6° preoperatively to 8.2° postoperatively, the mean HVA improved from 32.2° preoperatively to 15.2° postoperatively, and the mean AOFAS score improved from 45.44 points preoperatively to 84.22 points postoperatively. Recurrence occurred in one patient. Angthong et al.¹² showed satisfactory improvements of all scores and angular

Table 2

Pre-operative and the final follow up results.

	Pre-operative scores (mean $\pm$ standard deviation)	Final follow up scores (mean $\pm$ standard deviation)	P-value
VAS	7.3 ± 1.2	1.6 ± 0.9	< 0.01
IMA	$14.2^\circ \pm 2.8^\circ$	$8.2^\circ \pm 2.3^\circ$	< 0.01
HVA	$33.4^\circ \pm 7.6^\circ$	$13.6^\circ \pm 5.4^\circ$	< 0.01
AOFAS sesamoids grade for rotation	1.9 ± 0.8	0.4 ± 0.2	< 0.01
Overall AOFAS rating score	42.6 ± 6.3	85.8 ± 6.8	< 0.01

(VAS: Visual analogue scale, IMA: First intermetatarsal angle, HVA: Hallux valgus angle, AOFAS: American Orthopedic Foot and Ankle Score).

* The results were presented as mean $\pm$ standard deviation. All changes were statistically significant (P-value < 0.05).

values in all postoperative periods with no significant complications in their study. The results in our study were consistent with the previous studies.

The limitations of our study; it was done on small number of cases; it was a short term one that needs long term follow up to detect recurrence and joint arthritis. There was no control group to compare this technique with other surgeries. Finally, the nature of scar tissue maintaining the reduction of the 1st tarso-metatarsal joint was not studied.

5. Conclusion

The osteotomy-sparing technique using TightRope implant device gives good short term outcome with few complications for moderate hallux valgus provided that good patient selection, adequate surgical technique, and proper post-operative program are followed.

Conflict of interest

There was no conflict of interest related to our study.

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