RESEARCH ARTICLE

The use of an Intra-medullary fusion system in hammer toe surgery; mid-term follow-up

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Abstract

Objective: To assess the efficacy of a new hammer-toe locking fusion system.

Method: The retrospective study was conducted at Kutahya Evliya Çelebi Education and Research Hospital, and comprised data from March 2014 to January 2017 of patients of either gender with hammer toe deformity. The American Orthopaedic Foot and Ankle Society and visual analogue scale scoring systems were used. Radiological evaluation was also used to determine the lateral interphalangeal angle measurements. All patients were subjected to hammer toe surgery using new two-block interlocking fusion system, and were followed up for about 2 years. SPSS 25.0 for windows was used for analysis.

Results: According to gender, 13(65%) of patients were female and 7(35%) of patients were male. The overall mean age was 51.5±16.31 years (range: 20-72 years). Of all the surgeries, 9(45%) were performed on the right foot, and 11(55%) on the left foot. The follow-ups ranged 21-32 months. Compared to baselines values, American Orthopaedic Foot and Ankle Society scale and visual analogue scale scores significantly improved post intervention ($p<0.05$).

Conclusion: Significantly favourable outcomes were noted, indicating the efficacy of the fusion process.

Key Words: Toes, Hammer, Interphalangeal, Lesser toe, Arthrodesis. (JPMA 73: 2383; 2023)

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Introduction

Hammer toe is among the common deformities of the forefoot and greatly impairs quality of life, while hallux valgus is commonest forefoot deformity, and both the deformities can be seen together It generally affects people between the 4th and 7th decade of life. There are many techniques for small toe arthrodesis[1,2]. Approximately 30% of hammer toe patients have a deformity of a single toe, and the incidence of hammer toe involving more than three toes is approximately 40%[2,3]. The aetiology of the deformity is multifactorial. Hammer toe is defined as the proximal phalangeal dorsiflexion of the metatarsophalangeal (MTP) joint and intermediate phalangeal plantar flexion related to the proximal interphalangeal (PIP) joint. Insufficiency of soft tissues in plantar structures, neuromuscular problems and inappropriate shoe use are part of the hammer toe deformity aetiology. It is preferred for non-surgical purposes in hammer toe deformity, but a surgical approach is the accepted method. Soft tissue and bone procedures are performed in hammer toe correction surgery. In addition, soft tissue procedures are less likely to achieve permanent results than bone procedures. The Kirschner wire (K-wires) used for bone procedure is preferred because of its easy availability and low cost. Pin-tract infection, wire migration, inconvenience and rotational problems are some of its complications[2]. The surgical indication depends upon the degree of deformity and the severity of pain. The aim of surgery is to provide stable correction of the deformity and to balance the forces between the flexor and extensor muscle elements relating to the toe[2].

More complex hammer toe deformity accompanies PIP flexion and MTP hyperextension at the distal interphalangeal (DIP) joint, which is in a neutral or sometimes hyperextended position. This serious deformity is as severe as any other of the many other deformities of the foot, but hammer toe may also present in more moderate forms, and may have a flexible or rigid type[1,2,3]. The size and severity of the deformity may be a factor in the success of the treatment modality used. In the cases that conservative treatment is ineffective, surgical management options are used which include plantar plate repair, arthrodesis, and interphalangeal joint arthroplasty[4]. The operation involves resecting the DIP surface of the proximal phalanx and the interphalangeal

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surface of the middle phalanx[5]. Achieving complete union with stable fixation is vital for good clinical outcomes. Many fixation methods have been identified for the resection and fixation of joint surfaces[6,7]. Temporary fixation methods, such as wire-loop and absorbable implants, have been developed as alternatives in the correction and fixation of hammer toe deformities[8,9].

The current study was planned to assess the efficacy of a new two-block interlocking fusion system in hammer toe surgery.

Materials and Methods

The retrospective study was conducted at Kutahya Evliya Çelebi Education and Research Hospital, and comprised data from March 2014 to January 2017 of adult patients of either gender with hammer toe deformity. Time-based sampling method was used as the sampling method. Accordingly, March 2014 to January 2017 files were scanned and all appropriate patient files were included in the study. Each file dates were given in the Table 1. Patient files were evaluated, and researchers worked on the project between October 2021and December 2021. All patients had a persistent painful hammer toe deformity of one of their lesser toes either isolated or with hallux valgus deformity. Clinical data and radiological fusion results were used to correlate the observations. Patient evaluations were done using the American Orthopaedic Foot and Ankle Society (AOFAS) score, the visual analogue scale (VAS) for pain status, and lateral IP angle measurements.

ERC approval was taken from Kütahya Health Science university Evliya Çelebi Educational Research Ethical Committee. Since the research is retrospective, informed consent was not applicable.

For the purpose of the study, hammer toe was defined as a flexion deformity at the PIP joint of the toe. Flexion deformity at the PIP joint of toes 2, 3 and/or 4 were included. Isolated flexion deformities at the DIP joint (mallet toe) were excluded. Also excluded were hammer toe deformities in toes 1 and 5. Inflammatory arthritis, post-infection arthritis, or Charcot neuroarthropathy patients were also excluded.

After administering antibiotic prophylaxis and peripheral block anaesthesia, patients were admitted to the operating room (OR), and a 250mmHg tourniquet was placed on the leg. The PIP joint was reached at the level of 10-12mm through a dorsal longitudinal incision. The extensor tendon was split with a longitudinal incision and was divided. The collateral ligaments were excised

Figure-1: Nextra Hammertoe Correction System.

proximally and distally, and the joint cartilage tissues were excised using Nextra® Hammertoe Correction System (Medartis Inc.-The Switzerland-Hochbergerstrasse 60E Basel) (Figure 1). Two peek, interlocking surfaces were created, contacting the bone surfaces through the proximal and distal intramedullary placement of the implants. Owing to the interlocking design of the implant system, this was observed to shorten the duration of surgery. The implant is designed at a neutral 100 angle, and this angulation easily provided physiological access. The extensor tendon was sutured longitudinally, and the skin was closed primarily. Wound care was provided post-operatively and patients were moved to the ward to undergo regular circulatory examinations.

After an overnight stay at the hospital following surgery, the patients were discharged. They were instructed to mobilise on their heels, as tolerated, during the 3-week post-operative period. After that time, sutures were removed.

In the next three post-operative weeks, weight-bearing was allowed on the forefoot and a physical therapy programme was commenced. Wearing closed shoes was followed by full weight-bearing use at the end of the 6th week. Given good recovery, and in the absence of any complications, the patients were fully discharged at the end of six weeks. Surgical procedures and follow-ups were done by the same operating surgeon. Post-operative follow-up evaluations were made at 3 weeks, 6

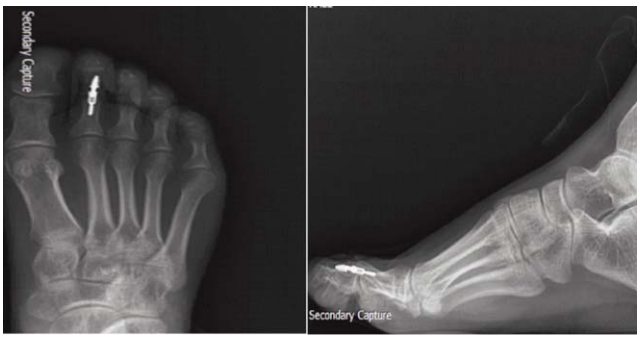

Figure-2: Six-week postoperative radiological views of the forefoot and lateral foot.

weeks, and 6 months. X-rays were taken at each patient visit (Figure 2).

Data was analyzed using SPSS 25. By applying the Doornik-Hansen and Omnibus tests to the data, the Mardia technique was used to assess the data's suitability for a multivariate normal distribution. A power analysis test was used to estimate the sample size.

Pairwise t-tests with two stages of bootstrapping correction were used to assess the effects on the lateral IP angle and AOFAS scoring. Since linearization has deviations[10], non-parametric Wilcoxon signed-rank test was used in conjunction with the outcomes of a Monte Carlo simulation to investigate the effects on VAS ratings.

Quantitative variables were expressed as mean ± standard deviation and median (minimum/maximum), while categorical variables were expressed as frequencies and percentages. All the variables were examined at a confidence level of 95%. P<0.05 was considered significant.

Results

Of the 20 patients, 13(65%) were female and 7(35%) were male. The overall mean age was 51.5±16.31 years (range: 20-72 years). Of all the surgeries, 9(45%) were performed on the right foot, and 11(55%) on the left foot. There was no deformity in any transverse and rotational planes among the cases. The median patient follow-up time was 24 months (range: 20-32 months).

Table-1: Comparison of preoperative and postoperative values in hammer toe surgery cases (n=20).

Variable	Preoperatively	Postoperatively	
Vas	6 (3 / 9)	1 (0 / 2)	<0,001[b]
AOFAS score	30,30±3,56 - (24 / 38)	90,90±5,41 - (75 / 98)	0,001[a]
Lateral IP angle	78,00±6,21 - (65 / 85)	17,75±3,49 - (11 / 22)	0,001[a]

[a]Paired Samples T Test(Bootstrap), [b] Wilcoxon Sing rank Test(Monte Carlo)
SD.:Standard Deviation, Med.:Median; AOFAS: American Orthopaedic Foot and Ankle Society, IP: Interphalangeal angle, VAS: Visual analogue scale.

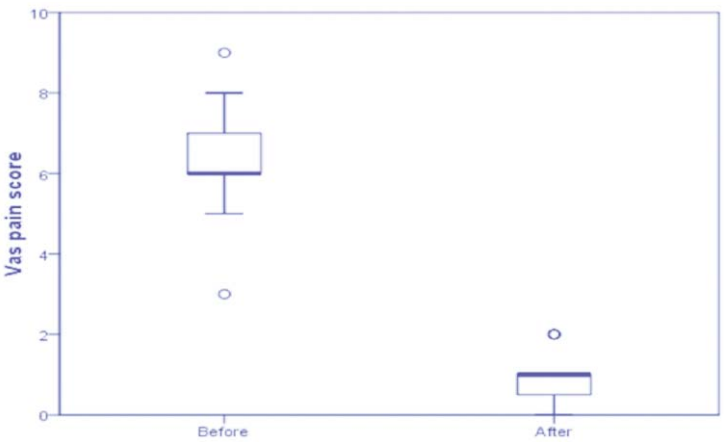

Figure-3: Comparison of pre- and post-operative visual analogue scale (VAS) scores.

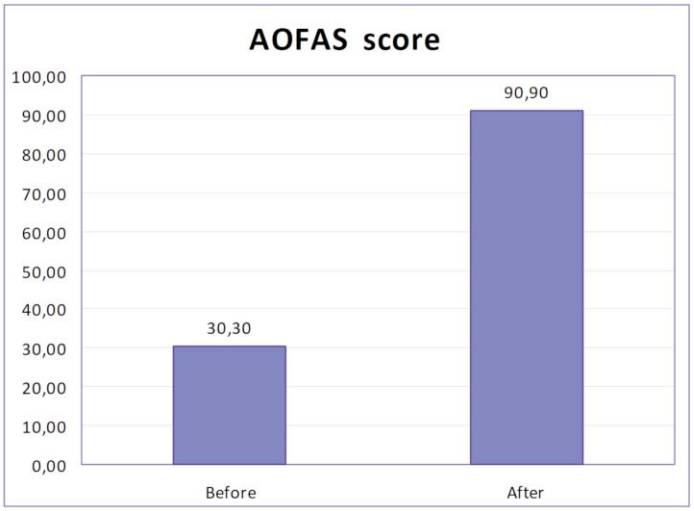

Figure-4: Comparison of pre- and post-operative American Orthopaedic Foot and Ankle Society (AOFAS) scores.

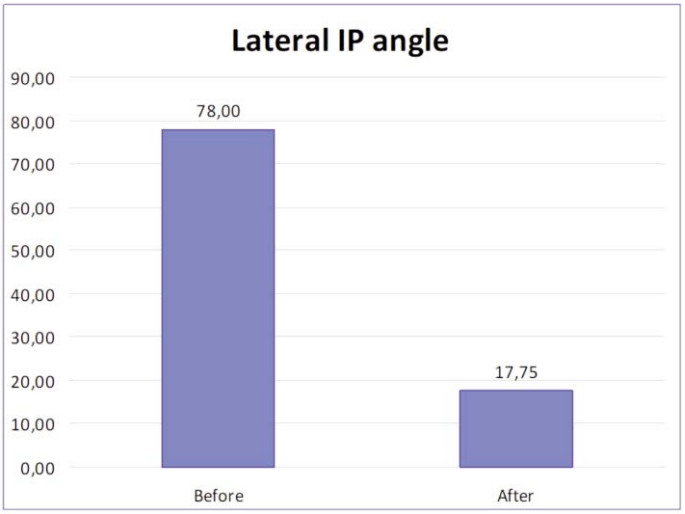

Figure-5: Comparison of pre- and post-operative lateral interphalangeal (IP) angle

Compared to baselines values, VAS scores (Figure 3), AOFAS scores (Figure 4) and lateral IP values (Figure 5) significantly improved post intervention (Table 1).

No patient had vascular complications (Table 2).

Table 2: Individual data of the cohort (n=20).

patient no	Date	Age	side	Vas pain score		AOFAS score		Complication	Follow up	Gender	Lateral IP angle	
				before	after	before	after				before	after
1	04.15	64	Left	3	1	24	75	none	21	female	65	11
2	01.15	62	Right	6	0	25	85	none	24	male	69	14
3	05.15	55	Left	7	0	27	87	none	20	female	68	13
4	04.14	52	Left	5	1	28	88	none	32	female	75	16
5	04.15	20	Right	6	1	32	89	none	21	female	79	20
6	02.15	21	Right	7	1	33	92	none	23	female	85	21
7	03.15	45	Right	6	0	38	94	none	22	male	77	16
8	11.14	58	Left	6	1	25	88	none	25	female	75	20
9	10.14	72	Left	5	2	26	92	none	26	female	80	21
10	02.15	23	Left	6	1	28	90	none	27	male	85	21
11	03.15	24	Right	7	2	32	95	none	23	male	80	15
12	03.15.	58	Left	6	1	31	95	none	22	female	75	16
13	12.14	52	left	5	0	33	94	none	25	female	70	19
14	11.14.	64	Right	6	1	32	96	none	26	female	85	20
15	12.14.	63	Left	6	1	33	91	none	25	female	84	18
16	01.15	62	Right	6	2	32	84	none	24	male	85	21
17	12.14.	61	Left	8	1	33	98	none	23	female	84	20
18	10..14	53	Left	7	2	32	96	none	26	female	80	20
19	12.14	67	Right	7	0	31	94	none	25	male	81	22
20	01.15	54	Right	9	1	31	95	none	24	male	78	11

Discussion

Different surgical approaches exist for hammer toe surgery, with each having its advantages and disadvantages. The most commonly used method for ensuring permanent correction of hammer toe deformity is the arthrodesis procedure[6,7,11]. The most commonly used implant for this process is the K-wire. Non-union, malunion, pin area infection, implant failure, and similar complications are frequently observed in patients treated with K-wire[12-14]. When performing an arthrodesis with K-wire, the fusion site cannot be compressed, and only the bone ends in the fusion field may be in contact[2]. The arthrodesis operation can be done on its own, but can also be paired with hallux valgus surgery. Excessive rotation of the bone ends in the fusion field cannot be prevented by K-wire. Patients who have had the K-wire placed may become alarmed when they see the implant post-surgery, making this method unacceptable to some patients. Infection of the surgical field in the area of the pin bottom can lead to patients requesting the immediate removal of the implant[2]. As a result, problems with the union can be encountered. Reece et al. reported pin-tract infection rates to be 18%, and Zingas et al. reported a K-wire failure rate of 3.2% in a large case series involving 1,002 toes. Other common problems are pin migration and pin bending, which may lead to mal-alignment and deformity. In one case series, the rate of revision surgery was 33% due to the burrowing of the K-wire under the skin in the later post-operative period[2,5,11]. Baig et al. applied the K-wire at the PIP joint during arthrodesis surgery on 19 patients. Fusion was obtained in 83% of the cohort, but 11 of the patients required a repeat surgery[6]. Different methods are used to eliminate this as well as similar problems, and one of them is to use the intramedullary compression screw. The most important problem with this method is that it comes with an element of discomfort under the skin, depending on the size of the screw-head used. Absorbable pins have been used to circumvent this problem, but implant failures can occur[5-7].

The current used a two-block interlocking correction system in which the implant does not allow rotational movement after locking, thereby providing full contact

with the compression of the bone ends[2,6]. Improvement of symptoms and a high clinical improvement rate were observed post-operatively. Post-operative patient satisfaction with the surgical technique was also high. Two (10%) of the patients were not satisfied with the swelling of the toe after surgery, and 1(5%) patient developed cellulitis and was given a 7-day course of oral cephalosporin to reduce the infection. Implant failure was not observed in any of the patients.

In the current study, the patients were instructed to bear weight on the heel of the affected foot for 3 weeks post-operatively, and to put half the load on the toes in order to mobilise them over the subsequent 3 weeks. At the end of the 6th week, full weight-bearing was allowed as tolerated. This is probably the reason that implants failure or implant fracture was not observed in any of the cases. The intramedullary implant technique we used involved "reamerising" the phalanges at the proximal and distal PIP joints; the implant has a locking mechanism that can penetrate prosthetic as well as distal phalanges. The rigidity that this full locking mechanism added to intramedullary fusion provided an anti-rotation effect that did not allow post-operative malunion or deformity. This also made PIP joint fusion much more convenient.

The current study has limitations as it had a small sample size, and no comparison was done with different surgical procedures, like K-wire and pin fixation.

Conclusion

Significantly favourable outcomes were noted, indicating the efficacy of the fusion process.

Disclaimer: None.

Conflict of Interest: None.

Source of Funding: None.

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