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Outcomes of The Modified Mcbride Procedure For Hallux Valgus: Analysis of The Radiographic Measurements

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ABSTRACT

The current study aimed to analyze both the modified McBride procedure's radiographic outcomes and the relationships between radiographic measurements after this technique.

Forty-five feet of 42 patients who underwent isolated modified McBride procedure were included in the study. Preoperative and postoperative radiographic measurements, including hallux valgus angle (HVA), intermetatarsal angle (IMA), tibial sesamoid position (TSP), and fibular sesamoid distance (FSD) to second metatarsal, as well as their relationships were assessed. Postoperative pain was evaluated using the visual analog scale (VAS).

Mean age of the patients was 44.6±16.8 (range, 17-78) years, and the mean follow-up period was 42.4±9 (range, 25-59) months. Postoperatively, mean HVA, IMA, and TSP significantly decreased from 37.4° to 14.9°, from 15.1° to 11.5°, and from 2.2 to 1.1, respectively ($p<0.01$). FSD did not change significantly ($p=0.47$). Recurrence of the deformity was observed in 23 feet. Feet with HVA>35° did not have a higher recurrence rate than feet with HVA<35° ($p=0.15$). VAS was not significantly different in recurrent and non-recurrent feet ($p=0.69$). While TSP correction was significantly reduced in feet with preoperative IMA>15°, FSD correction was significantly higher in feet with HVA correction >20° ($p<0.01$ for both).

Modified McBride was sufficient for reducing the HVA, IMA, and TSP but did not influence FSD. Recurrence was observed in more than half of the feet, but having a preoperative HVA>35° was not associated with higher recurrence rates, as well as worse pain. Further studies may be needed to better understand the complicated relationship between angular measurements and sesamoids.

Keywords: Hallux valgus, modified McBride, sesamoid bones, radiographic measurements, recurrence

Introduction

To date, over one hundred surgical methods have been described for hallux valgus (HV) treatment. Distal soft tissue procedure (DSTP) is a well-known and frequently used technique alone or combined with metatarsal osteotomies (1,2).

After the initial description of DSTP by Silver (3) in 1923, McBride (4) was the first to modify the technique. Further revisions and modifications were applied in the following years by both himself and the other authors (5-8). The current concept of this technique includes medial capsulotomy, excision of the medial prominence, releasing the lateral capsule and adductor tendon with leaving the sesamoids in place, and finally plication of the medial capsule (1,2,9).

According to Easley and Trnka (1), it is difficult to make a specific recommendation for its isolated use without a metatarsal osteotomy due to limited evidence. Nonetheless, several studies have reported favorable results using the modified McBride technique alone (9-13). It was recommended for mild to moderate deformities when hallux valgus angle (HVA)<30° and intermetatarsal angle (IMA)<15° (14). However, its indication has been widened up to 50°s of HVA and 20° of IMA in previous studies (10,12,13). On the other hand, there has been an arbitrary determination of HV deformity's severity regarding the current literature. Therefore an accurate range of angular degrees for defining the

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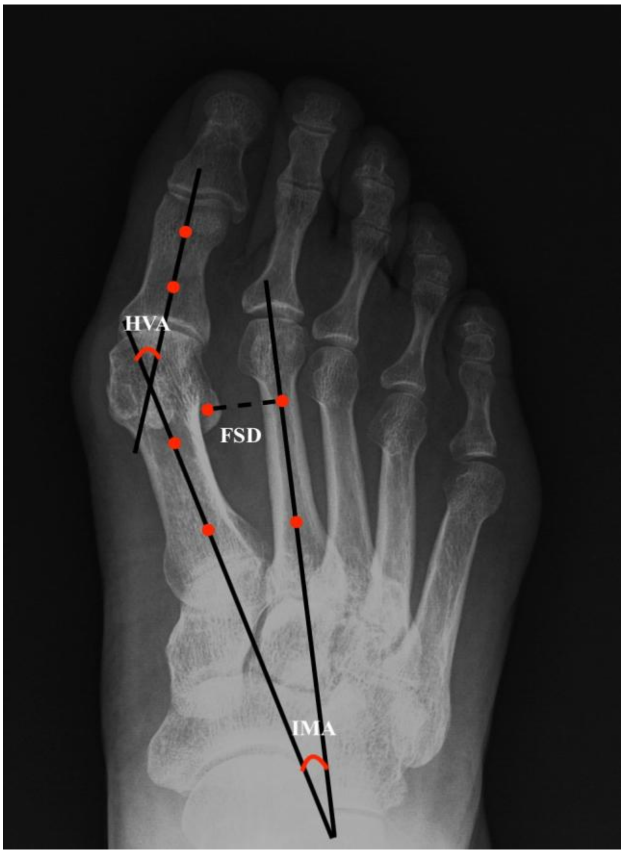

Fig. 1. Radiographic measurements of hallux valgus angle (HVA), intermetatarsal angle (IMA), and fibular sesamoid to second metatarsal distance (FSD)

HV severity as mild, moderate, or severe can not be possible (15).

Several studies assessed the relationship between radiographic measurements about basically sesamoid positions compared to the feet with or without HV deformity or the effect of DSTP on these measurements when combined with metatarsal osteotomies (16-18). However, no study has extensively investigated these relationships in isolated modified McBride procedure to the author's knowledge. Therefore, the current study aimed to analyze the radiographic outcomes and the relationships between different radiographic measurements, including sesamoid positions after modified McBride.

Materials and Methods

The present study was approved by the hospital's local ethical committee (approval no: 2020/14-39). Medical records of the patients who underwent isolated modified McBride procedure for HV between March 2015 and December 2018 were retrospectively reviewed. All the operations were performed for symptomatic HV deformities unresponsive to non-surgical modalities. The patients who were at least 17 years old at the time of the surgery, with a minimum two-year follow-up, had had proper dorso-plantar weight-bearing foot plain radiographs at preoperative and postoperative final follow-ups were included in this study. The exclusion criteria were previous foot surgery (2 patients) or significant foot injury (1 patient) at the operated side and neurological or rheumatological disorders (a total of 5 patients) of the foot. Although seven patients underwent bilateral surgery, only three patients' feet met the inclusion criteria. Finally, the present study included 45 feet of 42 patients (34 female, 81%).

Surgical Technique: Four different senior orthopedic surgeons performed the modified McBride procedures in this study. The patients were placed in the supine position. All the operations were performed under a pneumatic tourniquet. After skin preparation, a longitudinal incision was made medially to the first metatarsophalangeal joint. The joint capsule was dissected using a "V" or "Y" shaped capsulotomy according to the surgeon's preference; then medial bunion was resected using an oscillating saw. Next, the lateral release of the soft tissue structures was performed through a longitudinal incision on the first web-space dorsal aspect. The deformity was corrected, and joint congruency was obtained by tightening the medial capsule. Finally, the redundant capsule was excised, and the incision was closed.

An elastic bandage was applied by placing a roll gauze to the first web space of the foot. The patients were allowed weight-bearing on their heel and lateral side as they tolerated on the postoperative second day. The bandage was discontinued after suture removal at the end of the two weeks. The use of a toe separator and a night splint was indicated for three months after removing the bandage.

Radiographic Assessment and Evaluation of Pain: Radiographic assessment was performed with dorso-plantar weight-bearing radiographs obtained both pre-and postoperatively at final follow-up. The measurements were performed using a picture-archiving and communications system (PACS) from the hospital's database. HVA and IMA were measured using the mid-diaphyseal reference points placed on the proximal phalanx and first and second metatarsals (19) (Figure 1). The position of the tibial sesamoid (TSP) was graded from 0 to 3 about the mid-diaphyseal axis of the first metatarsal (20) (Figure 2). Fibular sesamoid distance (FSD) was measured

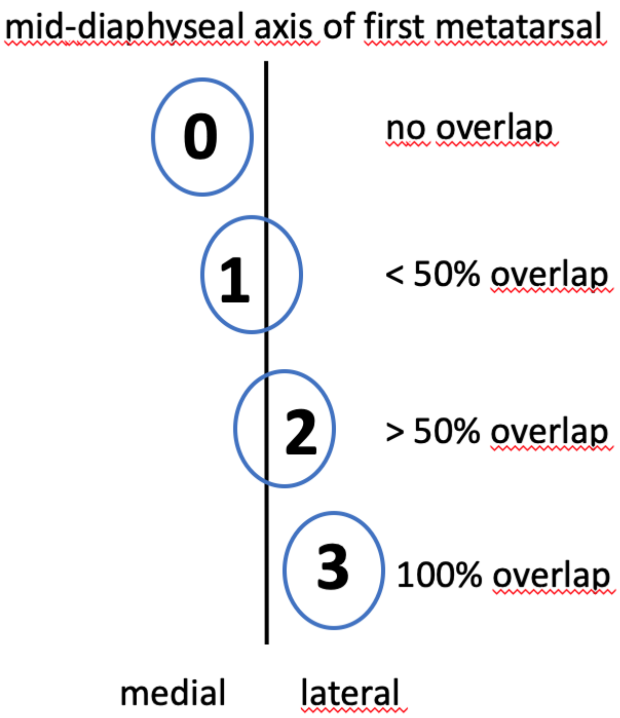

Fig. 2. Determination of tibial sesamoid position

as the shortest distance between the center of the lateral sesamoid and mid-diaphyseal axis of the second metatarsal (17) (Figure 1). All the measurements were performed by the same author who was not involved in the surgeries.

At the final follow-up visit, the subjective level of pain was graded with the use of a visual analog scale (VAS) from 0 to 10, which indicates "no pain" and "maximum pain," respectively (11).

Statistical Analysis: Statistical package for social sciences (SPSS) version 17 was used for statistical analysis. Shapiro Wilk test was used for the determination of continuous data distribution. If the data were distributed normally, Student's t-test was used for the comparison of the groups. Mann Whitney-U test was used for the comparison of non-normally distributed data. Fisher exact was used for comparison of the groups among categorical data. A p-value less than 0.05 was accepted as statistically significant.

Results

The patients' mean age was 44.6 ± 16.8 (range, 17-78) years and the mean follow-up period was 42.4 ± 9 (range, 25-59) months. Pre-and postoperative mean values of the radiographic measurements and the correction values were summarized in Table 1. Mean HVA, IMA, and TSP significantly decreased postoperatively (p<0.001). However, no significant difference was observed in preoperative and postoperative mean FSDs (p=0.47).

There were 29 (64.4%) feet with preoperative HVA>35°. Postoperative mean HVA was significantly higher in feet with preoperative HVA>35° than the feet with HVA <35° (p=0,02). In contrast, other radiographic parameters were not significantly different (Table 2).

There were 24 patients with preoperative IMA>15°. Postoperative mean IMA and mean correction of IMA were significantly higher in feet with preoperative IMA>15° compared to feet with preoperative IMA<15° (p <0.001, and 0.03, respectively). Mean TSP correction was also significantly different between the two groups (p<0.01) (Table 2).

In order to assess the effect of HVA correction on postoperative radiographic measurements, feet were grouped based on the correction degree of HVA as <20° (n=18, 40%), and >20°. While postoperative mean FSD was significantly lower (11.28 ± 2.55 mm vs 13.15 ± 2.26 mm) and mean correction of FSD was significantly higher (1.13 ± 1.99 mm vs -1.14 ± 1.72 mm) in feet with HVA correction >20° (p= 0.02, and < 0.01 respectively), postoperative mean IMA (11.6° ± 2.8° vs 11.3° ± 2.5°, p= 0.75), mean correction of IMA (4.2° ± 2.9° vs 2.9° ± 3.2°, p= 0.16), mean TSP (1.2 ± 0. 8 vs 1.1 ± 0.6, p= 0.73), and mean correction of TSP (1.2 ± 0.8 vs 1 ± 0.8, p= 0.46) did not affected by the correction degree of HVA.

Postoperative HVA>15° was considered as a recurrence of the deformity (9,11). No statistically significant differences were found between the feet with recurrent (n= 23; 51,1%) and non-recurrent deformity in terms of preoperative HVA (38.2° ± 7.6° vs 36.7° ± 6.8°, p= 0.48), IMA (15.3° ± 3.6° vs 14.9° ± 2.9°, p= 0.67), TSP (2.3 ± 0.8 vs 2.1 ± 0.8, p= 0.45) and FSD (11.92 ± 2.44 mm vs 12.59 ± 1.39 mm, p= 0.27). Besides, recurrence rates did not significantly differ between the feet with preoperative HVA>35° and HVA<35° (58.6% vs. 37.5%, p= 0.15). Moreover, this study assessed the effect of HV recurrence on postoperative pain scores and found no statistically significant differences in terms of VAS between the feet with recurrent and non-recurrent deformity (2.4 ± 2.1 vs. 2.3 ± 2.3, p= 0.69).

Discussion

This study initially demonstrated that the modified McBride method alone was sufficient to reduce HVA, IMA, and TSP ($p<0.001$) but had not influenced FSD. Besides, preoperative HVA>35° and IMA>15° was directly associated with significantly higher postoperative HVA and IMA, respectively (p= 0.02, and <0.001). In addition, recurrence of deformity was observed in more than half of the feet (51.1%). However, feet with HVA>35° did not show a significantly higher recurrence rate than feet with HVA<35° (p=0.15). Furthermore, VAS was not considerably different between the recurrent and non-recurrent feet (p= 0.69). In contrast, TSP correction was significantly reduced in feet with preoperative IMA>15°compared to feet with IMA<15°, FSD correction was significantly higher in feet with HVA correction >20° (p<0.01 for both).

Some studies demonstrated postoperative outcomes of isolated modified McBride procedure for mild to moderate HV. Kayalı et al. (11) reported a mean of 17.9° of HVA correction, which was less than the mean 22.5° of HVA correction, and 3.3° of IMA correction, which was comparable to mean 3.6° of IMA correction in the current study. Yucel et al. (9) demonstrated that preoperative mean HVA decreased from 32.7° to 10.1° in the early postoperative period; however, it significantly increased to 20.6° at the final follow-up at a mean of 79.6 months. In the current study, 22.5° of HVA correction representing the difference between preoperative and postoperative final follow-up measurements was comparable to their early postoperative correction of 22.6°, but not to the correction of 12.1° measured at last follow-up. Probably, it's due to their longer follow-up time compared to the current study. Mean correction of HVA in the present study may decrease when the follow-up period lengthens. Furthermore, in a study with one of the most extended follow-ups nine years after the original McBride's technique, Gebuhr et al. (13) reported only 8° of mean HVA correction. This result may also support that assumption.

Mann and Coughlin (6) demonstrated that when preoperative IMA was <15°, the mean HVA correction amount was 16.5°, and when preoperative IMA was >15°, the mean HVA correction was 20.5° by modified McBride. They stated that higher correction could be obtained if the deformity had higher preoperative IMA and HVA measurements. In the current study, when preoperative IMA was >15°, mean HVA correction was found to be also higher (23.2° vs. 21.6°). However, this was not statistically significant (p=0.055). Both mean postoperative IMA and mean IMA correction amounts were significantly higher (p=<0.001 and 0.03, respectively). Besides, when preoperative HVA was >35°, the mean postoperative HVA was also significantly higher (p=0.02). However, the mean HVA correction was not statistically different in these feet than the feet with preoperative HVA<35° (p=0.056).

An additional proximal metatarsal osteotomy was recommended when more than 20° of HVA correction is necessary (6). In the current study, the mean 22.5° of HVA correction, which was higher than the previous studies (6,10,11,13) reported the results of DSTP, was obtained without an additional osteotomy. This high correction amount may be related to higher mean preoperative HVA (37.4°) in the current study. Because the present study demonstrated that if preoperative HVA and IMA were higher (>35° and >15°, respectively), the mean postoperative HVA and IMA were also significantly higher. Furthermore, higher IMA correction was obtained when more than 20° of HVA correction was achieved after the surgery (4.2° vs. 2.9°). However, this difference was not significant (p= 0.16). It was noteworthy that there was no relationship between the amount of HVA correction and IMA correction. Therefore, these results may contradict the previous suggestion regarding the necessity of metatarsal osteotomy to obtain more than 20° of HVA correction. Metatarsal osteotomy may affect the correction degree of IMA rather than the correction degree of HVA, which is probably correlated with performing the DSTP appropriately.

The effect of various types of HV surgery on sesamoid position is still challenging. While TSP was significantly decreased postoperatively, FSD did not significantly change after modified McBride in the current study. Similar to these findings, some studies reported a significant decrease in TSP after modified McBride (9,21). Conversely, Jhonson et al. (22) did not find a significant reduction in TSP, and Mittal et al. (10) found a significant decrease in FSD in their studies.

Table 1. Preoperative and postoperative radiographic measurements

		Preoperative	Postopereative	Correction	p value (pre - vs postoperative)
HVA (°)	Mean ± SD	37.4 ± 7.2	14.9 ± 8.2	22.5 ± 9.2	<0.001$^{\alpha}$
	Min – max	23.2 – 54	-2.9 – 30.4	5.2 – 40.2	
IMA (°)	Mean ± SD	15.1 ± 3.2	11.5 ± 2.6	3.6 ± 3.1	<0.001$^{\alpha}$
	Min – max	9.3 – 23.3	6.3 – 19.8	-3.9 – 11.2	
TSP (0-3)	Mean ± SD	2.2 ± 0.8	1.1 ± 0.7	1.1 ± 0.8	
	Min – max	1 – 3	0 – 3	-1 – 3	<0.001$^{\beta}$
FSD (mm)	Mean ± SD	12.25 ± 2.01	12.03 ± 2.58	0.22 ± 2.18	
	Min – max	7.42 – 16.17	7.88 – 17.72	-5.34 – 5.88	0.47$^{\beta}$

$^{\alpha}$= Student's t-test

$^{\beta}$= Mann Whitney-U test

HVA: hallux valgus angle, IMA: intermetatarsal angle, TSP: tibial sesamoid position, FSD: fibular sesamoid distance

Table 2. Effect of severity of hallux valgus deformity on postoperative radiographic measurements and their correction values

Preoperative	Postoperative HVA (°)	HVA correction (°)	Postoperative IMA (°)	IMA correction (°)	Postoperative TSP (0-3)	TSP correction (0-3)	Postoperative FSD (mm)	FSD correction (mm)
HVA (°)								
<35 (n=16)	10.8 ± 8.5	18.9 ± 9.6	10.7 ± 2.2	2.9 ± 2.5	0.87 ± 0.72	1.1 ± 0.9	12.33 ± 2.66	0.19 ± 2.56
>35 (n=29)	17.3 ± 7.2	24.4 ± 8.6	11.9 ± 2.8	4 ± 3.3	1.24 ± 0.69	1.1 ± 0.8	11.86 ± 2.56	0.23 ± 1.99
p value	0.02$^{\beta}$	0.056$^{\alpha}$	0.12$^{\alpha}$	0.23$^{\alpha}$	0.11$^{\beta}$	0.89$^{\alpha}$	0.56$^{\alpha}$	0.96$^{\alpha}$
IMA (°)								
<15 (n=21)	13.9 ± 6.9	21.6 ± 10.4	10 ± 2.2	2.6 ± 2.8	1.05 ± 0.67	0.8 ± 0.7	11.76 ± 2.61	0.29 ± 2.71
>15 (n=24)	15.9 ± 9.2	23.2 ± 8.2	12.8 ±2.4	4.6 ± 3	1.17 ± 0.76	1.4 ± 0.8	12.26 ± 2.59	0.16 ± 1.64
p value	0.41$^{\alpha}$	0.055$^{\alpha}$	<0.001$^{\alpha}$	0.03$^{\alpha}$	0.65$^{\beta}$	<0.01$^{\beta}$	0.53$^{\alpha}$	0.83$^{\alpha}$

$^{\alpha}$= Student's t-test

$^{\beta}$= Mann Whitney-U test

HVA: hallux valgus angle, IMA: intermetatarsal angle, TSP: tibial sesamoid position, FSD: fibular sesamoid distance

Choi et al. (16) performed lateral soft tissue release in addition to distal chevron osteotomy. Similar to the current study, they reported a significant decrease in TSP, but not in fibular sesamoid position. In that study, lateral soft tissue procedures were combined with the distal chevron osteotomy, and these findings may be due to lateral displacement of the metatarsal head relative to sesamoids. However, the current study directly demonstrated the effect of DSTP on sesamoid positions without combining any osteotomy. Furthermore, a recent study showed that FSD was not different between the feet with or without HV deformity and concluded that the fibular sesamoid's lateral movement could be a radiographic misinterpretation in HV (17). Indeed, sesamoids remain in their positions and retain this position to the second metatarsal. That can explain the unchanged FSD after modified McBride in the current study.

Agrawal et al. (18) found a good correlation between HVA and lateral sesamoid position and a high degree of correlation between IMA and lateral sesamoid position. Due to this correlation, one should expect that if HVA or IMA reduces after the surgery, the lateral sesamoid position will also reduce simultaneously. Despite the significant correction of HVA and IMA postoperatively, FSD did not change significantly in the current study. Nevertheless, the present study showed that the mean FSD correction was considerably higher when more than 20° of HVA correction was achieved after the surgery. This finding may provide some evidence of the study above. Moreover, when the assessment was performed regarding the severity of HV deformity, if preoperative IMA>15°, TSP correction was significantly higher. However, both TSP and FSD correction were not significantly different between the feet with HVA >35° and HVA<35° in the current study.

Postoperative HVA>15° was considered as recurrence same as the previous studies (9,11,21). Up to 72.2% recurrence rates have been reported after modified McBride (9). Kayalı et al. (11) reported only 10% recurrence and stated that preoperative HVA was more than 35° in all their cases without any statistical data. In the current study, the overall recurrence rate was 51.1%, and recurrence rates were not significantly different between the feet with preoperative HVA>35° and HVA<35° (58.6% vs. 37.5%, p= 0.15). Choi et al. (21) reported an overall 43.8% recurrence rate and demonstrated that all the recurrences were seen in moderate deformities. In that study, there was no recurrence in mild deformities defined as HVA<20° and IMA≤11°. Therefore, it may correspond to an estimation of high recurrence rates in more severe deformities. However, the current study could not find a statistical difference based on preoperative HVA (38.2° vs. 36.7°, p= 0.48) and IMA (15.3° vs. 14.9°, p= 0.67) between the feet with recurrent and non-recurrent deformity.

The present study was also unable to demonstrate significant differences in pain scores between the feet with recurrent and non-recurrent deformity. Although the feet with seconder disorders which can cause comorbidity burden were excluded in this study, arthrosis of the first MTP joint, complications such as callus formation and dorsal skin thickening, as well as lesser toe deformities which may contribute to foot pain were not taken into account due to primary aim of the study that was radiographic assessment.

The first limitation of the present study was its retrospective design. The second was that the patients were operated on by four different surgeons. Therefore, minor technical variations could be possible, although all intended to perform McBride's standard, modified technique. In addition, all the measurements in the current study were performed by the same author. However, this should not cause a bias as the author was not involved in the operations.

In conclusion, the modified McBride technique's isolated use was sufficient to reduce the HVA, IMA, and TSP. However, recurrence of the deformity was observed in more than half of the feet. Having a preoperative HVA>35° was not associated with higher recurrence rates and worse postoperative pain. The relationship between angular measurements and sesamoids was complicated, probably due to the sesamoids' misinterpreted radiographic appearance. Further studies may be needed to understand this relationship better.

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