Intramedullary Plate Assisted Correction with Transposition (IMPACT) Procedure for Minimal Incision HAV Surgery: A Surgical Technique Guide and Short-Term Follow-Up Series

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Statement of Purpose

The purpose of this study is to examine the short-term functional and radiographic outcomes of an innovative surgical technique for the correction of HAV deformity. This technique is a modification of the Hohmann osteotomy and shares similar objectives to the derotational, angulational, transpositional osteotomy (DRATO) described by Johnson and Smith in 1974 (1,2). We advocate the use of a transverse osteotomy with triplanar correction and robust fixation. This proposed technique is referred to as the intramedullary plate assisted correction with transposition (IMPACT) based on the nature of the method.

We aim to quantify the outcomes of this procedure with a short-term follow-up series on validated outcome measures and radiographic analysis. Our secondary aim is to describe this minimal incision surgical technique incorporating intramedullary plate fixation. We hypothesize that the IMPACT procedure for minimal incision hallux valgus surgery will provide triplanar correction of HAV deformity with excellent results in the short-term follow-up.

Methodology & Procedures

A retrospective chart review with IRB approval was performed at University of Florida Health. Patients were identified as eligible for participation utilizing CPT code for bunionectomy with metatarsal osteotomy (28296) between August 2016 and August 2018. Individuals who received the IMPACT procedure were further investigated for inclusion.

Pre- and post-operative AOFAS and LEFS scores were obtained at the pre-op, 8-week, 12-week, 6-month and 1-year post-operative visits. Tibial Sesamoid Position (TSP), First Intermetatarsal Angle (IMA), Hallux Abductus Angle (HAA), Lateral Shift, time to union and complications were calculated on the patient's pre-operative radiographs and 3-month post-operative films. Final follow-up radiographs at 1-year post-op were again evaluated for a loss of correction or hardware failure.

Statistical analysis was done using ANOVA model for functional scores. Mean scores were estimated using 95% confidence intervals (CI) at each time point. Tukey–Kramer adjusted *P*-values were used to preserve an overall error rate of 5%. Secondary analyses included comparisons between pre- and post-operative measurements for IM angle, TSP, HAA and lateral shift. These comparisons were done using the Wilcoxon sign rank tests for paired data. Statistical significance was defined at the 5% ($p \leq .05$) level. All analyses were done in SAS (3).

Literature review

Lack of attention to the frontal or coronal plane has previously led to inconsistent HAV correction, resulting in lower patient satisfaction (4-7). Dayton and colleagues hypothesized that pronation of the first metatarsal is the initial incident that provokes the chain of events resulting in HAV (8, 9).

Percutaneous, or minimally invasive methods of performing HAV surgery have gained recent attention. A percutaneous hallux valgus procedure involves the use of variable 2mm incisions about the metatarsal head, enough for insertion of the burr. Minimal incision hallux valgus surgery, in contrast, is defined as a technique that utilizes the smallest incision necessary to perform the osteotomy using a power saw blade (10). Current procedures utilized for minimally invasive HAV correction are largely variations of the SCOT and SERI techniques. These procedures involve a sub-capital osteotomy created with the use of a burr (SCOT) or sagittal saw (SERI) and fixated with a single k-wire (11,12).

Newer procedures have expanded to include percutaneous screw and intramedullary fixation (13,14). Minimally invasive hallux valgus corrections have been associated with complications stemming from the technical difficulty of the procedure.

Surgical Technique

~1.5cm vertical skin incision made proximal to the metatarsal head

Osteotomy site is visualized on intraoperative fluoroscopy

Transverse Osteotomy with use of sagittal saw

Osteotomy completed with flexible osteotome

Canal broached to allow entry of plate

Series of images depicting frontal plane rotation

Insertion of plate with provisional fixation followed by completion of construct

Results

Ten patients met our inclusion criteria. The average age at time of surgery was 57 years (range 35-78) with M:F ratio of 1:9 to include 5 left and 5 right feet. There was a minimum of 12 months and maximum of 16 months follow-up post-operatively. The mean pre-operative AOFAS score was 53.7; At the 8-week, 12-week, 6-month and 1 year follow up, the mean AOFAS values were 76.9, 83.3, 87.5, 90.8, respectively (table 1). There was a statistically significant difference in the AOFAS scores at each interval follow-up visit (P < 0.0001) (Table 2). The average pre-operative LEFS score was 55% improving to values of 68%, 74%, 84%, 89% at the 8-week, 12-week, 6-month and 1-year follow-up (Table 3). There was statistically significant improvement at the 12-week, 6-month and 1-year follow-up (P < 0.05 at 12-weeks, P< 0.0007 at 6-months and P < 0.0002 at 1-year) (Table 4). The radiographic data for IM angle, TSP, HAA, and lateral shift is reported (Table 5). The average time to radiographic union was 9.8 weeks (5-24 weeks) with no non-union, delayed union, mal-union or recurrence.

Table 1: Descriptive statistics for AOFAS scores (0-100)

Time of measurement	N	Mean	SD	Min	1st Quartile	Median	3rd Quartile	Max
Pre	10	53.7	12.36	33	52	55	59	72
8 weeks	10	76.9	13.88	60	64	78.5	90	92
12 weeks	10	83.3	11.92	67	74	82	92	100
6 months	10	87.5	8.42	72	79	91	95	95
1 year	10	90.8	8.22	79	82	91	100	100

Note: a) SD=standard deviation. Highlighted are mean values at each follow-up interval.

Table 2: Differences in mean AOFAS from mixed-model ANOVA

Time	From Time	Estimate mean difference in AOFAS	Standard Error for difference in AOFAS	Adjusted P-value	Lower limit 95% CI[a] for mean difference in AOFAS	Upper limit 95% CI[a] for mean difference in AOFAS
8 weeks	*Pre-op*	*23.2*	*3.2*	*<.0001*	*14.0*	*32.4*
12 weeks	*Pre-op*	*29.6*	*4.0*	*<.0001*	*18.1*	*41.1*
6 months	*Pre-op*	*33.8*	*4.4*	*<.0001*	*21.1*	*46.5*
1 year	*Pre-op*	*37.1*	*4.7*	*<.0001*	*23.7*	*50.5*

Note: a) CI = Confidence Interval. Highlighted values correspond to statistical significance (P ≤0.05).

Table 3: Descriptive statistics LEFS scores (0-80 / 100 for % of function)

Time of measurement	N	Mean	SD[a]	Min	1st Quartile	Median	3rd Quartile	Max
Pre-op	10	55%	19%	29%	40%	53%	66%	90%
8 weeks	10	68%	21%	29%	53%	73%	83%	95%
12 weeks	10	74%	14%	53%	64%	73%	86%	99%
6 months	10	84%	15%	62%	70%	86%	99%	100%
1 year	10	89%	11%	64%	85%	91%	99%	100%

Note: a) SD=standard deviation

Table 4: Differences in mean LEFS from mixed-model ANOVA

Time	From Time	Estimate mean difference in LEFS	Standard Error for difference in LEFS	Adjusted P-value	Lower limit 95% CI[a] for mean difference in LEFS	Upper limit 95% CI[a] for mean difference in LEFS
8 weeks	*Pre-op*	13%	0.05	0.0661	1%	27%
12 weeks	*Pre-op*	*19%*	*0.06*	***0.0208***	*2%*	*36%*
6 months	*Pre-op*	*29%*	*0.06*	***0.0007***	*10%*	*48%*
1 year	*Pre-op*	*33%*	*0.07*	***0.0002***	*14%*	*53%*

Note: a) CI = Confidence Interval. Highlighted values correspond to statistical significance (P ≤ 0.05).

Figure 1: Pre-operative Weight-Bearing AP radiograph

Figure 2: Post-operative Weight-Bearing AP radiograph with full healing at the osteotomy site.

Results

Table 5: IM Angle pre-op, post-op and difference from pre- to post-op (in degrees).

Variable	Time of Measurement/Unit	N	Mean	Std Dev	Min	1st Quartile	Median	3rd Quartile	Max
IMA[a]	Pre-op	10	13.59	2.75	10.3	12.3	12.5	14.7	20
	Post-op	10	6.82	1.76	3.8	5.5	6.8	7.9	10.1
	Difference	10	6.77	2.31	4	4.9	6.5	9.2	10.2
HAA[b]	Pre-op	10	25.31	8.27	12.5	19.4	24.6	32.4	36.8
	Post-op	10	10.51	1.67	8.7	9.5	9.9	10.6	13.5
	Difference	10	14.8	7.94	2.6	8.8	13.9	18.9	27.3
TSP[c]	Pre-op	10	4.3	1.34	2	3	4.5	5	6
	Post-op	10	2.3	0.82	1	2	2	3	4
	Difference	10	2	0.82	1	1	2	3	3
Lateral Shift	(mm)	10	7	1.16	5	6.4	7.3	7.8	8.7
	(%)	10	52.09	10.16	32.68	45.83	54.88	56.49	69.64
	(ln %)	10	13.57	1.32	11.2	12.8	13.45	14.4	15.4

Note: Difference is calculated as Post minus Pre; a) IMA= First Intermetatarsal Angle ; b) HAA= Hallux Abductus Angle; c) TSP= Tibial Sesamoid Position.

Analysis & Discussion

The IMPACT surgical technique facilitates the use of an intramedullary plate while utilizing equipment readily accessible to all surgeons. Our technique provides reproducible results with a minimal learning curve due to the use of a sagittal saw as opposed to a power burr. Triplanar correction is achieved with robust fixation allowing immediate weight bearing to increase patient satisfaction and reduce complications associated with immobilization. This procedure is designed to preserve the soft tissue envelope, leaving the patient a pleasant cosmetic outcome with minimal incision.

The results of this study suggest an excellent procedural outcome in regards to both functionality and radiographic correction (Figures 1 & 2). The improvement obtained through use of this technique is comparable to those previously reported for open distal metatarsal procedures. Future studies are warranted to examine the use of this procedure among a large population.

References

1. Janore JV. Hohmann Bunionectomy: Dinosaur or Versatile Gem? Podiatry Institute. Ch: 13 pg. 81-89.
2. Johnson JB, Smith SD. Preliminary report on derotational,angulational, transpositional osteotomy: a new approach to hallux valgus surgery. J Am Podiatry Assoc. 74:667. 1974.
3. The data analysis for this paper was generated using [SAS/STAT] software, Version 9.4 of the SAS System for Windows. Copyright © 2008 SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA
4. Iyer S, Demetracopoulos CA, Sofka CM, Ellis SJ. High rate of recurrence following proximal medial opening wedge osteotomy for correction of moderate hallux valgus. *Foot Ankle Int.* 36(7):756, 2015.
5. Jeuken RM, Schotanus MGM, Kort NP, Deenik A, Jong B, Hendrickx RPM. Long-term follow-up of a randomized controlled trial comparing scarf to chevron osteotomy in hallux valgus correction. *Foot Ankle Int.* 37(7):687-695, 2016.
6. Pentikainen I, Ojala R, Ohtonen P, Piippo J, Leppilahti J. Preoperative radiological factors correlated to long-term recurrence of hallux valgus following distal chevron osteotomy. *Foot Ankle Int.* 35(12):1262-1267, 2014.
7. Fokter SK, Podobnik J, Vengust V. Late results of modified mitchel procedure for the treatment of hallux valgus. *Foot Ankle Int.* 20(5):296-300, 1999.
8. Dayton P, Cifaldi A, Egdorf R. Why Frontal Plane Correction is a Vital Component of Bunion Surgery. Podiatry Today. 230 (7): 28-34, June 19, 2017.
9. Mortier JP, Bernard JL, Maestro M. Axial rotation of the first metatarsal head in a normal population and hallux valgus patients. *Orthop Traumatol Surg Res.* 98(6):677-683, 2012
10. Trnka HJ, Krenn S, Schuh R. *Minimally invasive hallux valgus surgery: a critical review of the evidence. International Orthopaedics, 37(9), 1731–1735, 2013.*
11. Bösch P, Wanke S, Legenstein R. Hallux valgus correction by the method of Bösch: a new technique with a seven-to-ten-year follow-up. Foot Ankle Clin. 5:485–498, 2000.
12. Giannini S, Ceccarelli F, Bevoni R, Vannini F. Hallux valgus surgery: the minimally invasive bunion correction (SERI). Tech Foot Ankle Surg. 2:11–20, 2003.
13.Biz C, Corradin M, Petretta I, Aldegheri R. *Endolog technique for correction of hallux valgus: a prospective study of 30 patients with 4-year follow-up. Journal of Orthopaedic Surgery and Research, 10(1).* 2015. doi:10.1186/s13018-015-0245-1
14. Fernández RD, Use of a percutaneous osteotomy with plate fixation in hallux valgus correction, Foot Ankle Surg, 2017.