Maintenance of Correction and Time to Union for Lapidus Arthrodesis with Biplanar Staple Fixation

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Purpose and Literature Review

First tarsometatarsal joint (TMTJ) arthrodesis fixation constructs for hallux abductovalgus (HAV) correction have continued to evolve over time to improve patient outcomes and minimize recovery time. Locking plate technology has become more common as it allows for earlier weight-bearing and improved union rates (1,2,3,4), however complications exist, as the hardware is itself may become symptomatic and require removal, ranging from 3% to 8% for locking plate constructs as reported in current literature (5,6,7). The use of dynamic compression staples for 1st TMTJ arthrodesis has been examined previously and found satisfactory correction with nonunion rates comparable to locking plate constructs. The purpose of the present study was to radiographically quantify initial correction, maintenance of correction, and time to union of a nitinol staple construct for 1st TMTJ arthrodesis.

Methods and Technique

15 feet status-post TMTJ arthrodesis via staple fixation were radiographically reviewed. Short term results were quantified by assessing intermetatarsal angle(IMA), tibial sesamoid position(TSP) and hallux abductus angle(HAA), measured preoperatively and again at one month postoperatively and at final follow up appointment. Radiographic time to union was also recorded based on congruence of cortices on 2+ views.

Linear mixed-effects modeling was used to examine the change in IMA, HVA, and TSP through the final follow-up evaluation while accounting for within-subject correlation. Correction power was set as the change from pre to postoperative radiographic values. Maintenance of correction was analyzed via comparison of post op to final follow up radiographic values. Statistical significance was set at $P < .05$.

First TMTJ arthrodesis was performed utilizing a dorsomedial longitudinal incision overlying the first TMTJ extending distally to the first metatarsophalangeal joint. 1st TMTJ was reciprocally planed using sagittal saw. Lateral distal first metatarsal soft tissue release was done in standard fashion. IMA and TSP were reduced, held using provisional K-wire and fixed using 2 or 3 nitinol staples, typically placed orthogonally. If HAA was not adequately reduced, akin osteotomy was performed.

Results

	% Union at 6 weeks (n)	% Union at 8 weeks (n)	% Union at 10 weeks (n)	% Union at Final Follow Up (n)	Mean Time to Union (weeks)	Mean Length of Follow Up (months)
N=15	20.00% (3)	60.00% (9)	100% (15)	100% (15)	7.33 ± 2.11	6.533 ± 2.61

Table 1: Time to union, as evidence by number of patients who had achieved union at 3 sequential intervals (n=15). Mean time to union and length of follow up reported with standard deviation

	Pre-Op IMA	1st Post-Op IMA	Final Post Op IMA	Mean Initial IMA Correction	Mean Final IMA Correction	Delta IMA (final – post op)
n=15	13.700 ± 2.584	6.31 3±2.007	6.326 ±1.747	7.386 ±2.259	7.373 ±2.729	0.0133 ±1.354
				p < 0.00001	p < 0.00001	p <0.4925

Table 2. Intermetatarsal Angle (IMA) pre-op, post-op and at final follow up. Mean correction from pre- to 1st post-op and from pre- to final post op (in degrees), means reported with standard deviations.

	Pre-Op HAA	1st Post-Op HAA	Final Post Op HAA	Mean Initial HAA Correction	Mean Final HAA Correction	Delta HAA (final – post op)
n=15	28.867 ± 10.409	16.47± 7.694	15.533 ± 7.862	12.407 ±7.896	13.333 ±7.533	-0.927 ±2.356
				p < 0.00017	p < 0.00007	p <0.3763

Table 3. Hallux Abductus Angle (IMA) pre-op, post-op and at final follow up. Mean correction from pre- to 1st post-op and from pre- to final post op (in degrees), means reported with standard deviations.

	Pre-Op TSP	1st Post-Op TSP	Final Post Op TSP	Mean Initial TSP Correction	Mean Final TSP Correction	Delta TSP (final – post op)
n=15	4.4 ± 1.540	1.73± 0.679	1.80 ± 0.653	2.667 ±1.398	2.60 ±1.451	-0.0667 ±0.249
				p < 0.00001	p < 0.00001	p <0.3957

Table 4. Tibial Sesamoid Position (TSP) pre-op, post-op and at final follow up. Mean correction from pre- to 1st post-op and from pre- to final post op (in degrees), means reported with standard deviations.

Analysis & Discussion

First TMTJ arthrodesis was performed utilizing a dorsomedial longitudinal incision overlying the first TMTJ extending distally to the first metatarsophalangeal joint. 1st TMTJ was reciprocally planed using sagittal saw. Lateral distal first metatarsal soft tissue release was done in standard fashion. IMA and TSP were reduced, held using provisional K-wire and fixed using 2 or 3 nitinol staples, typically placed orthogonally. If HAA was not adequately reduced, akin osteotomy was performed.

The mean IMA, HVA, and TSP were 6.313 ° ± 2.01, 16.47° ± 7.69, and 1.73 ± 0.679, respectively, at one month postoperatively; and 6.326° ± 1.747, 15.533° ± 7.86, and 1.80 ± 0.653, respectively at final follow up. Both immediate postoperative and final follow up radiographic values all fell within acceptable ranges. IMA correction power (ΔIM) was found to be significant (p<0.0001) at both one month postoperatively (7.386 ° ± 2.259) and at final follow up (7.373 ° ±2.729). HAA and TSP correction power were also found to be statistically significant (see Table 3 and 4). At 1 month postoperatively, mean HAA correction was 12.407 ° ±7.896 while mean TSP correction was 2.667 ±1.398. At final follow up, mean HAA correction was 13.333 ° ±7.533 and mean TSP correction was 2.60 ±1.451. HAA and TSP correction were found to be significant at both time intervals.

A retrospective radiographic review performed by McAlister et al. (8), reported that from one month to six months post operatively mean IMA increased by 2.6, mean HAA increased by 3.5 and mean TSP increased by 0.9, each of which were statistically significant. The results of the present study seem to provide comparable if not better results in terms of maintenance of reduction over the postoperative course, while also producing acceptable values for IMA, HAA, and TSP. Our results found IMA to increase by 0.0133 ±1.354, HAA decreased by 0.927 ±2.356, while TSP was also found to decrease by 0.0667 ±0.249. 7/15 had reduction in IMA after first postoperative XR, 8/15 had reduction in HAA, 14/15 showed no change is TSP over time. These reported rates seem to agree with the previously reported rates found in the literature and correlate with the reported rates of other fixation methods.

In terms of complications, non-union rates have been reported as low as 5.1% for screw fixation, 3.4% for staple fixation, 1.1% for locking plate fixation, and 8.1% for pin fixation (9). Mallete et al., reported pain from staple prominence in 22.2%, and an overall return to OR rate of 30.6% (10).

No incidence of hardware complication or non-union was found in this cohort. Mean time to radiographic fusion was 7.33 ± 2.11 weeks for the cohort, which is a significant improvement over previous times to union reported in the literature. Average overall follow up was 6.53 months (range=5-11). All patients were ambulatory in normal shoe gear and had to returned to preoperative activity levels at time of final follow up.

Figure 1. TwoStaple Fixation

A) Pre-operative AP radiograph with an IMA= 18.0 degrees, HAA= 37.9 degrees, TSP = 6.
B) 1 month Post-operative AP radiograph depicting effective triplanar HAV correction via orthogonal staple construct. IMA= 7.8 degrees degrees, HAA= 22.8 degrees, TSP = 1.
C) 6 month Post-operative AP, fully consolidated arthrodesis. IMA= 6.9 degrees degrees, HAA= 19.4 degrees, TSP = 1.

Patient went on to union by 10 weeks, remainder of post-operative course was uncomplicated.

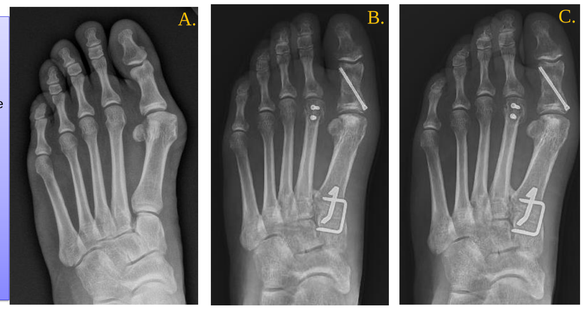

Figure 2. TwoStaple Fixation

A) Pre-operative AP radiograph with an IMA= 13.0 degrees, HAA= 31.3 degrees, TSP = 6.
B) 1 month Post-operative AP radiograph depicting effective triplanar HAV correction via orthogonal staple construct. IMA= 7.6 degrees degrees, HAA= 20.4 degrees, TSP = 3.
C) 6 month Post-operative AP, fully consolidated arthrodesis. IMA= 7.7 degrees degrees, HAA= 19.4 degrees, TSP = 3.

Patient went on to union by 10 weeks, remainder of post-operative course was uncomplicated.

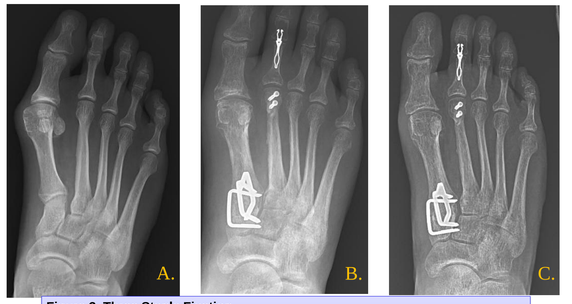

Figure 3. Three Staple Fixation

A) Pre-operative AP radiograph with an IMA= 12.7 degrees, HAA= 21.8 degrees, TSP = 6.
B) 1 month Post-operative AP radiograph depicting effective triplanar HAV correction via orthogonal staple construct. IMA= 6.1 degrees, HAA= 12.5 degrees, TSP = 1.
C) 6 month Post-operative AP, fully consolidated arthrodesis. IMA= 5.6 degrees, HAA= 11.0 degrees, TSP = 1.

Patient went on to union by 5 weeks, remainder of post-operative course was uncomplicated.

Conclusion

This study suggests satisfactory short-term outcomes and maintenance of correction with staple fixation for 1st TMTJ arthrodesis, correlating with what has been previously reported in the literature. Not only does correction power of staple fixation correlate with other methods of fixation, but it correction was maintained more effectively with a theoretically stronger locking plate construct. Staple fixation may allow for shorter tourniquet time, along with smaller incision requirements for joint preparation and fixation.

Limitations to this study are numerous, most obvious being the small cohort size and short term follow up period. However, this study should prompt further examination of a staple construct for 1st TMTJ arthrodesis in a larger cohort to determine the validity of the reported findings.

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