Fixating the Weil Metatarsal Osteotomy: A Radiographic Review and Cost-Analysis

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Statement of Purpose

In 1985, Weil first performed a distal metatarsal osteotomy to allow for shortening of the capital fragment and subsequent correction of the metatarsal length (1). This is typically performed at the lesser metatarsal head with an osteotomy parallel to the weight bearing surface The osteotomy is typically fixated with 1-2 screws or k-wire with reports of the use of intramedullary devices (2). The optimal fixation choice for this osteotomy has not been clearly defined in the current literature.

There has been a recent evolution in the fixation of this osteotomy due to the creation of "snap-off" screws in contrast to the conventional headless compression screw. The use of one versus two fixation points has been debated to fixate this osteotomy. Typically, osseous complications of this procedure may involve a non-union, malunion, pseudoarthrosis, or avascular necrosis (AVN) of the capital fragment.

Our primary objective is to evaluate the type of fixation utilized in performing the Weil metatarsal osteotomy. We will specifically investigate the incidence of complications utilizing a "snap-off" screw versus a k-wire or headless compression screw and the use of one versus two screws in fixation of the osteotomy. Our secondary aim is to perform a cost-analysis based on the cost of the device, complication rates, and return to operation.

Methodology & Procedures

The appropriate IRB approval was obtained prior to a retrospective investigation into patient's protected health information. A medical record search was performed to obtain the population cohort based on CPT 28308 for metatarsal osteotomy over dates 01/2013 – 08/2019 at UF Health Jacksonville. Patients over the age of 18 having undergone the above named procedure within the date range with a minimum of 1-year postoperative follow-up and the appropriate weight bearing imaging at each interval visit met the inclusion criteria for the study. Those under the age of 18, inadequate follow-up or imaging, or with metatarsal osteotomy performed at a location away from the metatarsal head were excluded from the analysis.

The type of fixation and number of screws utilized for each procedure were recorded. These were categorized based on the use of a headless compression screw versus "snap-off" screw. Radiographic images at each sequential follow-up visit were analyzed specifically for hardware failure or loosening as well as time to union and any incidence of malunion, non-union or AVN. The average price of a "snap-off" screw and headless compression screw was obtained from the surgical billing department. From this information, conclusions were drawn based on the necessity for return to OR for hardware removal or revision and the overall price of the fixation utilized.

Statistical analysis performed were means, medians, ranges, standard deviation and interquartile range.

Methodology & Procedures Contd.

Figure 1: Post-operative hardware complication necessitating removal of screw (right)

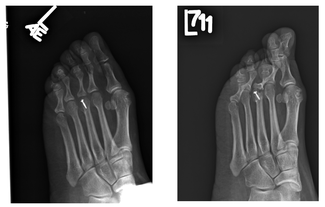

Figure 2: Progressive bone resorption at the third metatarsal head in absence of infection suggestive of AVN onset (right).

Of the Weil osteotomies that met our inclusion criteria, these were sorted into 5 subgroups according to their fixation types (1 screw, 2 screws, 1 snapoff, 2 snapoffs, other). Group "other" consisted of fixation with k-wires with or without a screw. These groups were then analyzed using ANOVA statistical analysis for their time to union as well as their complication rate (Tables 1-5). ANOVA was chosen over t-tests due to its inherent ability to limit type 1 error. An alpha value of <0.05 was chosen to denote statistical significance and if the ANOVA analysis produced an alpha value less than this, then the Tukey-Kramer Post HOC Test was performed to determine where the significance was noted. The Tukey-Kramer Post HOC Test was chosen due to its ability to limit type 1 error as well as the ability to control for unequal sample sizes. The Q value for the Tukey-Kramer Post HOC test was obtained by utilizing the studentized q table and rounding down the within group degrees of freedom to 60.

Our University does not disclose pricing on products from its suppliers, but instead presented us with an average cost of $400/screw, $700/snapoff, and $30/k-wire that varies by supplier. A Weil procedure is often done concomitantly with other procedures, thus it is difficult to determine the exact amount of operating room time spent performing the procedure. We used an estimate of 30 minutes for the procedure for our analysis and an OR cost of 37$/minute (3). In order to account for the radiographic complications, the probability of complication rate was utilized to find the odds for a subsequent operation. Another assumption was that the subsequent procedure would be performed with the same hardware.

Literature review

Complications of the weil osteotomy in regard to non-union, malunion and AVN have been reported with minimal incidence in current literature (4-7). The authors found no statistical difference in structural stiffness between the groups. Their results indicated a trend towards better biomechanical stability with the 2.4-mm cannulated screw than the 2.0-mm non-cannulated screw for fixation of the osteotomy (8). To our knowledge, there has yet to be a cost analysis comparison of the types of fixation utilized in conjunction with overall complication rates.

Results

No statistically significant difference was found amongst any of the groups when looking at time to union (Figures 2 & 3). After performing an ANOVA with the subsequent Tukey-Kramer Post HOC Test, it was determined that there was a significant difference in the radiographic complication rates between the 2 snapoff fixation and both the 1 screw and the 2 screw fixation groups (Figures 4, 5, & 6). It was found that the most cost-effective fixation manner is with the use of other fixation (Figure 7).

Fixation	Complications
1 Screw	0
2 Screws	0
1 Snapoff	AVN of Met Head, Hardware Backout
2 Snapoffs	Floating Toe (x2), Malunion
Other	Malunion

Figure 1: Orthopedic complications by fixation type

Groups	Count	Range of Time to Union (Weeks)	Average Time to Union (Weeks)	Variance
1 Screw	15	(4,10)	5.53	2.98
2 Screws	42	(4,8)	5.33	1.40
1 Snapoff	28	(4,8)	5.79	2.10
2 Snapoffs	12	(4,16)	6.33	21.70
Other	6	(4,10)	7.83	4.17

Figure 2: ANOVA for time to union

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	38.16	4.00	9.54	2.25	0.07	2.46
Within Groups	415.28	98.00	4.24			
Total	453.44	102.00				

Figure 3. ANOVA for time to union. SS=sum of square, df= degrees of freedom, MS=mean of squares

Groups	Count	Total Complications	Probability of Complications	Variance
1 Screw	15	0	0.00	0.00
2 Screws	42	0	0.00	0.00
1 Snapoff	28	2	0.07	0.07
2 Snapoffs	12	3	0.25	0.20
Other	6	1	0.17	0.17

Figure 4: ANOVA for orthopedic complication rates

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.710009246	4	0.18	3.52	0.01	2.46
Within Groups	4.94047619	98	0.05			
Total	5.650485437	102				

Figure 5: ANOVA for orthopedic complication rates. SS=sum of square, df= degrees of freedom, MS=mean of squares. With the F value > F crit and a P-value <0.01 we needed further analysis with a post HOC test.

Results

Comparative Groups	Difference	n1	n2	SE	q
1 screw vs 2 screws	0.00	15	42	0.05	0.00
1 screw vs 1 snapoff	0.07	15	28	0.05	1.41
1 screw vs 2 snapoffs	0.25	15	12	0.06	4.07
1 screw vs other	0.17	15	6	0.08	2.17
2 screws vs 1 snapoff	0.07	42	28	0.04	1.84
2 screws vs 2 snapoffs	0.25	42	12	0.05	4.81
2 screws vs other	0.17	42	6	0.07	2.41
1 snapoff vs 2 snapoffs	0.18	28	12	0.05	3.26
1 snapoff vs other	0.10	28	6	0.07	1.33
2 snapoffs vs other	0.08	12	6	0.08	1.05

Figure 6. Tukey-Kramer Post HOC Test results. Difference=difference between the probability of complications in the subgroups as determined through ANOVA, n1=amount in subgroup 1, n2=amount in subgroup 2, SE=standard error.

Fixation	Expected Cost
1 Screw	$1,510.00
2 Screws	$1,910.00
1 Snapoff	$1,936.70
2 Snapoffs	$3,137.50
Other	$1,333.80

Figure 7. Cost Analysis of expected cost based off the fixation type.

Analysis & Discussion

This is the first cost-analysis study of it's kind for a Weil osteotomy. It helps to create a starting point as to how we can help to control cost in a world where healthcare costs are constantly rising.

Overall, the specific type of fixation chosen did not have great statistical significance in favoring one discernable fixation type. However, the groups where headless compression screws were used revealed no complications and faster healing times, suggesting promise in its use as opposed to wire or snapoff fixation. Due to the inherent stability of the Weil osteotomy, it can be argued that this procedure will heal regardless of the choice of fixation chosen, some surgeons electing to utilize no fixation at all (9).

Our study has notable sources of limitation. Examination of a large cohort of osteotomies arranged into multiple small subgroups caused an increase in variance to any particular group.

In conclusion, our results were consistent with those reported in current literature with a low complication rate among all fixation groups. Future studies are warranted in the analysis of the utilization of healthcare costs in terms of fixation choice for the shortening metatarsal osteotomy.

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