Incidence of floating toe with Weil Osteotomy

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Introduction

In 1985, the first Weil Osteotomy (MWO) was performed, by Dr. Weil. It entailed an oblique osteotomy of the distal metatarsal neck paralleling the weight-bearing surface. This is done to control the transverse plane while translating the capital fragment posteriorly to shorten it overall length. Doing so prevents elevation or depression of the metatarsal head. This procedure has become an established, effective, and popular surgical treatment for lesser metatarsalgia and other forefoot pathologies.

Despite having a reputable history of patient satisfaction, high complication rates are frequently associated with this osteotomy. This study examines one of these complications, known simply as floating toe. Floating toe by definition is the inability of the toe to make contact with the weight-bearing surface while in stance or in motion. A consistently high incidence of floating toe is reported in the literature, specifically in a systematic review done by Highlander et al in 2011 with a floating toe incidence of 36%.

This systematic review aims to re-evaluate the floating toe incidence reported in studies published since Highlander. This will provide a mass data collection to allow authors and readers to assess for the risks and complications of undertaking surgical intervention using the Weil osteotomy procedure. Our hypothesis is that floating toe incidence has decreased since 2011.

Adjunctive procedures, such as bunion corrective surgery, plantar plate ligament repair, and tendon lengthening, are now commonly done with a Weil Osteotomy. A meta-analysis was performed to determine the effect these adjunctive procedures have on floating toe incidence.

Figure 1

Methods

Following PRISMA guidelines, a comprehensive search was conducted on PubMed, SCOPUS, and Cochrane Library using the keywords "Weil osteotomy," "floating toe," "float toe," and "second metatarsal phalangeal joint." The study's inclusion criteria encompassed individuals aged 18 years or older, while the exclusions are listed as follows:

- Under 18 years old
- Inflammatory arthropathies
- Prior/revision surgeries
- Rheumatoid arthritis
- Traumatic dislocation
- Under chronic pain therapy

This yielded a total of 2258 articles for review. The screening process involved the exclusion of articles published prior to 2012, resulting in a pool of 1192 articles. Subsequent removal of duplicates further refined the selection, leaving us with 782 articles. Each study underwent analysis, with a particular focus on ascertaining whether the title and abstract had relevance to the study. Studies investigating the Weil osteotomy in patient populations that met our exclusion criteria were omitted from our analysis. However, studies with sub-populations meeting criteria specifying both the total number of Weil osteotomies performed and the subsequent incidence of floating toe were included, thereby augmenting our study population. No distinction was made regarding varying fixation techniques to ensure maximal inclusivity and maintain focus on the osteotomy itself. This approach facilitated evaluation across various conditions, including pre-dislocation syndrome, metatarsalgia, abnormal forefoot parabola, and associated deformities, culminating in a final selection of 18 pertinent articles for in-depth examination. Subsequently, nine of these articles were excluded from further analysis due to either incomplete patient information, inadequate description of post-operative procedures, or an insufficient breakdown of complication statistics. This meticulous process left us with a final set of 9 articles for comprehensive scrutiny and subsequent analysis. The data was organized and summarized using both Google Sheets and Microsoft Excel. An examination of the data was undertaken to ascertain if there were any discernible shifts in the complication rates pertaining to a floating toe and the Weil osteotomy procedure. Additionally, a meta-analysis was performed involving the incidence of floating toe when adjunctive procedures were performed with a Weil osteotomy. First ray procedures and plantar plate repair were the adjunctive procedures included for the meta-analysis. Sample size T-tests were performed with our research in comparison to the previously reported literature (Highlander et al) for assessments of standard deviations and p-values to determine significance. T-tests were then employed in the meta-analysis to evaluate any significance of the adjunctive procedures listed above with the MWO.

Results

The analysis incorporated demographic attributes like age and sex, alongside complication frequencies concerning floating toe. Other pertinent variables included follow-up durations and postoperative protocols if any were explicitly provided by the authors in their respective, referenced articles. As shown in Table 1 below, there was a one-sided demographic as the majority of the cohort encompassed females as the data indicated 49 male and 350 female participants. The average age of said participants were 58.8 years with ranges outlined if specified. The study comprised 479 patients and 305 feet*. Across the studies incorporated into this systematic review, a total of 741 Weil osteotomies were recorded. The mean follow-up duration, as detailed in the table below, averaged at 24 months, with ranges outlined if specified. The overall incidence of floating toe subsequent to 741 Weil osteotomy procedures in this systematic review stood at 20.2% with an associated p-value of 0.02. This new finding is significant in comparison to the previous reported percentage by Highlander et al in 2011.

Post-operative protocols were detailed in each study, although it is noteworthy that some studies did not provide explicit specifications. As illustrated in the table below, it is evident that divergent protocols existed for each study following a Weil osteotomy. However, a prevailing trend was observed, wherein immediate weight-bearing (WB) was permitted post-surgery, contingent upon individual patient tolerance. Only one study was contrary to the consensus and had their patients non-weight bearing (NWB) for 6 weeks in a forefoot offloading shoe.

A meta-analysis was performed on adjunctive procedures. One-sided T-test analysis was performed on isolated adjunctive procedures reported in articles used in this systematic review. Adjunctive procedures were defined as bunion correction alone, plantar plate repair (PPR) alone and bunion correction plus plantar plate repair. Two PPR articles (Flint et al, Weil Jr et al) isolated and a mean floating toe incidence of 14.7% was determined to not be statistically significant in comparison to Highlanders 36% ($p = 0.08$). Two bunion articles were isolated (mac-iver et al, Johansen et al) with a mean floating toe incidence of 3.4%. This is statistically significant $p < 0.05$) in comparison to Highlander. This result indicates that bunion or broader first ray surgery is an indicative factor for lower floating toe incidence. Combination of bunion and PPR resulted in 4 articles for analysis (2,4,7,8). The mean floating toe incidence combined is 14.7% with a non-significant p-value of 0.08.

Table 1

Article Name	Men : Women	Age (Range)	# of Pt	# of feet	# of MWO	# of Floating Toe	Solo MWO	Bunion	PPR	Mean Follow-up Time (months) (range)	Post-Op Protocol
The Conventional Weil Osteotomy Does Not Require Screw Fixation	20 M : 135 F	63 (26-88)	155	96	278	22	104	112		54 (10-81)	2 weeks NWB, 2-6 weeks WB as tolerated with offloading shoe.
Plantar Plate Repair for Lesser Metatarsophalangeal Joint Instability	10 M : 81 F	59 (32-82)	91	97	138	25	11	23	11	12	Tape support for 5 weeks and WB on heel for 6 weeks following surgery, full WB at 6 weeks
Plantar plate radiofrequency and Weil osteotomy for subtle metatarsophalangeal joint instablity	5 M : 14 F	59	19	__	35	5			35*	20 (12-47)	6wks NWB in a forefoot offloading shoe
Anatomic plantar plate repair using the Weil metatarsal osteotomy approach	3 M : 10 F	57 (50-69)	13	15	15	0			15	22.5 (13-33)	1 wk WB as tolerated in a surgical shoe
Hallux valgus with second metatarsalgia: Is second metatarsal Weil osteotomy necessary?	1 M : 13 F	60.8	14		14	0		14		24	Immediate WB as tolerated in flat-soled shoes
Influence of the Length Ratio Between Second and Third Metatarsals After Modified Weil Osteotomy on Clinical Outcomes	__	54.2 (26-86)	37	53	53	23		0		18.8 (10-30)	__
Incidence and Functional Impact of Floating Toe after Distal Metatarsal Minimal Invasive Osteotomy Compared to Open Modified Weil Osteotomy	4 M : 73 F	57	77	__	120	68	120			39.4	__
Clinical and radiological outcomes after Weil osteotomy compared to distal metatarsal metaphyseal osteotomy in the treatment of metatarsalgia—A prospective study	6 M : 24 F	59 (36-75)	30	30	45	2	3	13		13	Partial WB 6 wks in stiff sole shoe
Comparative analysis of outcomes of multiplanar static forefoot deformity accompanied by flexible second mallet toe deformity treated with various techniques	___	60.4	43	__	43	5		37	25	12	2 days NWB, 3 weeks gradual WB in Baruk Shoe
Total	49 M : 350 F	58.8	479	291	741	150	238	199	51	24	

Discussion

Our results indicate that floating toe continues to be an unfortunate outcome after the Weil osteotomy. 741 cases of Weil osteotomies were included in this systematic review. Floating toe overall incidence was found to be 20.2%. This is a notable decline from the seminal study conducted by Highlander et al in 2011. The approximate 16% decrease in floating toe incidence is a significant finding compared to the benchmark study.

Adjunctive procedures, specifically 1st ray corrective surgery, were found to have a statistically significant relationship with the reduction of floating toe incidence following a Weil Osteotomy. This is a valuable finding as it indicates that stabilizing the first ray is more important than soft tissue correction in cases of lesser metatarsalgia and lesser ray pathologies in relation to a floating toe complication. This prompts discussion on what kind of 1st ray stabilizing procedures elicit a lower floating toe incidence. Due to the immensity of data, we categorized 1st metatarsal base and distal head osteotomies as 1st ray procedures and did not report on if there was discrepancy between the types of 1st ray surgeries in relation to floating toe. Further studies are warranted to further distinguish whether there is a stronger association, if any, between either.

In principle, it was more readily agreed in previous studies that correcting the soft tissue, specifically plantar plate ligament repair, lowered the incidence rate of floating toe. One of our studies discussed that plantar plate repairs in conjuncture with a Weil osteotomy was inversely associated with the the floating toe occurrence. A limitation to our review is the number of studies specifically examining this supposed association. Further investigation is warranted to illustrate such association. Our data did not confirm any significant relationship with plantar plate repair and a lower floating toe complication rate.

Limitations of our conducted research include the evidence levels of studies making up the systematic review, with only half being at a level of evidence of 2 and the remaining being below. Prospective studies are indeed necessary to void any bias; personal or data driven and validate our paradigm shifting view and explore possible etiologies. This observed trend prompts further investigation on the underlying factors in floating toe incidence reduction post Weil osteotomy.

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