Al-Azhar University Journal
for Virus Research and Studies

Management of Ankle and Hindfoot Deformities by Supramalleolar Osteotomy: Systematic Review

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Abstract

Deformities in foot and ankle characterized by many causes of congenital, traumatic and neurologic pathologies. Conventional techniques can surgically correct the deformities of the club feet, but adult deformities and burn contractures are hard to be controlled This article aimed to review the literature of management of ankle and hindfoot deformities by supramalleolar osteotomy systematic review. Electronic databases have been searched from 2010 to 2020. All available studies concerning the management of ankle and hindfoot deformities by supramalleolar osteotomy have been reviewed. Mean age from all studied article's was 48.58±15.22 and males were 47.8% and 52.2% were females. As regarding time of union per weeks, pooled analysis showed that the mean time for union (14.87±3.85). As regarding hind foot moment arm (HMA) score evaluation before and after treatment. All studies showed significant decrease regarding HMA with pooled decrease from 4.36±1.36 to 2.36±0.75. As regarding TAS (tibial anterior surface) assessment, all studies showing significant increase regard TAS with pooled increase from 83.0±4.98 and 91.1±3.9, also TLS (tibial lateral surface angle), all studies showed no significant regard TLS with pooled increase from 78.0±8.88 and 81.2±10.2. Supramalleolar osteotomy corrects the deformity of the ankle with improved functional outcome and restore the disturbed mechanics. Our systemic review declared that supramalleolar osteotomy is effective technique for dealing with hind foot deformities.

Keywords: Hindfoot Deformities, Supramalleolar osteotomies, Tibial Anterior Surface.

1. Introduction

Complex deformity in foot is a multiplanar malformation with or without shortening of foot and may involve the deformed feet with poor coverage of soft-tissue, lower leg deformity, relapsed cases, osteomyelitis, leg-length discrepancy and nonunion complications. The main cause of such deformities is trauma, burn contractures, neuromuscular diseases, resistant congenital contractures follow clubfoot, poliomyelitis and osteomyeliti .[1]

Unlike osteoarthritis of the hip and knee joints which is predominantly degenerative, traumatic insult or its sequel represents the main cause of end-stage tibiotalar osteoarthritis in about 80% of patients. Post-traumatic articular affection or angular deformities of the tibia with hindfoot varus/valgus deformity represent

the most common causes of ankle arthrosis that is more prevalent in young andmore active patients. Biomechanical studies have shown that varus or valgus hindfoot deformity during altering the load distribution in the ankle resultling in medial or lateral joint overload and degeneration of the ankle joint in the short-term or medium-term follow-up.[2]
Supramalleolar osteotomies (SMOT) can correct the ankle deformity with improvement in the functional outcome and to restore the mechanics and load distribution assuring additional protection of the tibiotalar joint articular surface that loaded asymmetrically with angular deformities.[3]
Treatment by Supramalleolar osteotomies is recommended for ankle osteoarthritis especially early to midstage and correction of the osseous deformities without ankle joint sacrificing. So, supramalleolar osteotomy technique is of exacting interest in ankle osteoarthritis even in young or adult patients.[4]
Therefore, this study aimed to evaluate the literature of management of ankle and hindfoot deformities by supramalleolar osteotomy systematic review.

2. Patients and Methods

This study was performed by online search using PUBMED, Google Scholar and SCINCEDIRECT database from 2010 to 2020; all published studies in English language were identified with the search keywords, management of ankle and hindfoot deformities by supramalleolar osteotomy, role of supramalleolar osteotomy in ankle and hind foot deformities.
Literature search database on PUBMED, Google Scholar and SCINCEDIRECT showed 186 studies.1ry screening: 99 studies were excluded due to other languages and other topics not related to our search goals. 2ry screening: We excluded 47 studies due to duplicates. 3ry screening: full text review was done, and 30 articles were excluded because of lack data about functional outcome and 10 studies were included.

Inclusion criteria:

Studies which are included in our systematic review met the following guidelines: all cases with supramalleolar osteotomy, surgery or minimal invasive treatment of ankle and hindfoot deformities, pediatric and adolescent. As well isolated or associated with other diseases.

Exclusion Criteria:

Any study discusses conservative methods for ankle and hindfoot deformities. Articles with no clinical data. Non-English language

Statistical analysis:

The data pooled from PubMed, Medline, Google scholar and Cochrane Library database and analyzed for the meta-analysis using RevMAN5.4 software.

3. Results

The present study revealed the distribution of socio demographic, the mean age from all studied was 48.58±15.22 and males were 47.8% and 52.2% were females (Table 1). Pooled analysis showing time for union was 14.87±3.85 (Table 2). Regarding AOFAS (American Orthopaedic Foot and Ankle Society). All studies showing significant increase regard AOFAS with pooled increase from 52.0±15.3 to 81.6±18.3 with P= 0.00** (Figure 1) .
The present study was included homogeneity among studies. No bias account for differences among studies that due to chance, after quantifying all factors. There was no significant heterogeneity and we found agreement between the included studies (Table 3).
Regarding HMA (Hind Foot Moment Arm). All studies showed significant

decrease with pooled decrease from 4.36±1.36 to 2.36±0.75 with P= 0.012* (Figure 2). Regarding TAS (Tibial Anterior Surface). All studies showed significant increase with pooled increase from 83.0±4.98 and 91.1±3.9 with P= 0.00** (Figure 3). TLS (Tibial Lateral Surface Angle). All studies showed no significant regard TLS with pooled increase from 78.0±8.88 and 81.2±10.2 with P= 0.123 (Figure 4). Pooled analysis founded those overall complications rate was 24.9% (Table 4).

Table (1): Distribution of demographic data

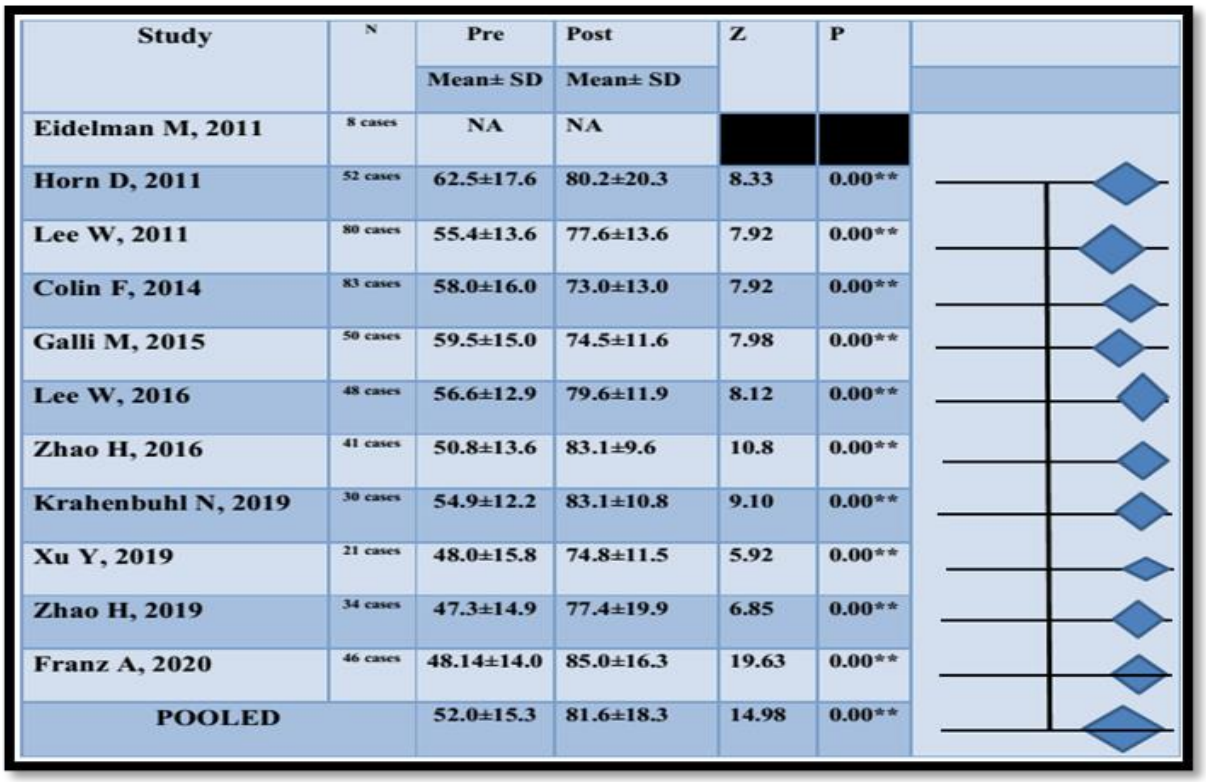
Study	N	AGE	SEX	
			Male	Female
Eidelman M, 2011	8 cases	15.11±3.25	87.5%	12.5 %
HornD, 2011	52 cases	44.0±13.0	44.2%	55.8 %
Lee W, 2011	80 cases	48.6±9.58	NA	NA
Colin F, 2014	83 cases	43.8±10.85	71.0%	29.0%
Galli M, 2015	50 cases	57.6±10.22	NA	NA
Lee W, 2016	48 cases	51.63±10.58	46.8%	53.2%
Zhao H, 2016	41 cases	50.29±12.36	31.7%	68.3%
Krahenbuhl N, 2019	30 cases	52.66±9.36	56.7%	43.3%
Xu Y, 2019	21 cases	53.7±5.8	14.3%	85.7%

Table (2): Distribution of demographic data

Study	N	Union time/ Wee
Eidelman M, 2011	8 cases	13.85±2.89
Horn D, 2011	52 cases	NA
Lee W, 2011	80 cases	NA
Colin F, 2014	83 cases	15.88±4.25
Galli M, 2015	50 cases	NA
Lee W, 2016	48 cases	NA
Zhao H, 2016	41 cases	14.95±3.55
Krahenbuhl N, 2019	30 cases	NA
Xu Y, 2019	21 cases	NA
Zhao H, 2019	34 cases	NA
Franz A, 2020	46 cases	NA
Pooled		14.87±3.85

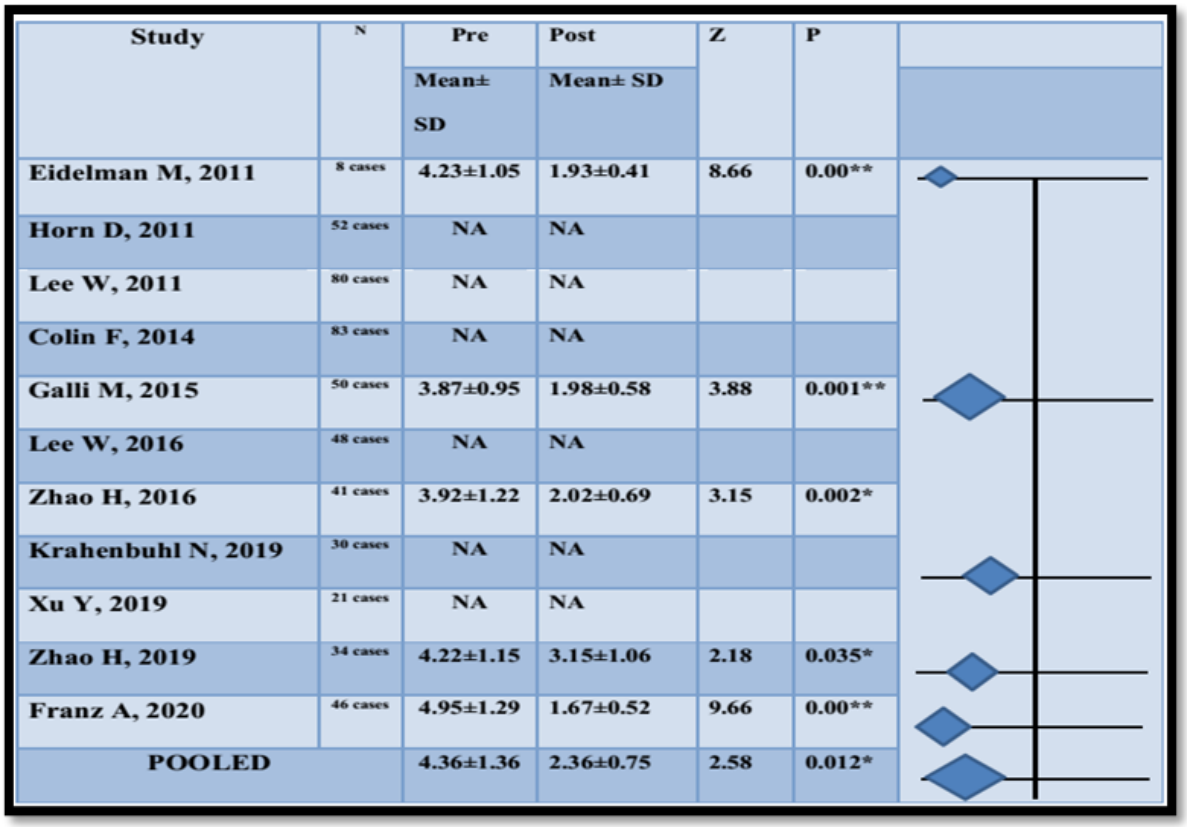
Table (3): Homogenicity and symmetry founded and illustrated in funnel plot

Test for heterogenicity	
Cochran Q	3.97
P	0.566
I2 (Inconsistency)	5.38
95% CI for I^2	0.958-10.36



Study	N	Pre	Post	Z	P
		Mean± SD	Mean± SD		
Eidelman M, 2011	8 cases	NA	NA		
Horn D, 2011	52 cases	62.5±17.6	80.2±20.3	8.33	0.00**
Lee W, 2011	80 cases	55.4±13.6	77.6±13.6	7.92	0.00**
Colin F, 2014	83 cases	58.0±16.0	73.0±13.0	7.92	0.00**
Galli M, 2015	50 cases	59.5±15.0	74.5±11.6	7.98	0.00**
Lee W, 2016	48 cases	56.6±12.9	79.6±11.9	8.12	0.00**
Zhao H, 2016	41 cases	50.8±13.6	83.1±9.6	10.8	0.00**
Krahenbuhl N, 2019	30 cases	54.9±12.2	83.1±10.8	9.10	0.00**
Xu Y, 2019	21 cases	48.0±15.8	74.8±11.5	5.92	0.00**
Zhao H, 2019	34 cases	47.3±14.9	77.4±19.9	6.85	0.00**
Franz A, 2020	46 cases	48.14±14.0	85.0±16.3	19.63	0.00**
POOLED		52.0±15.3	81.6±18.3	14.98	0.00**

Figure 1: AOFAS Pre and Post-treatment.



Study	N	Pre	Post	Z	P
		Mean± SD	Mean± SD		
Eidelman M, 2011	8 cases	4.23±1.05	1.93±0.41	8.66	0.00**
Horn D, 2011	52 cases	NA	NA		
Lee W, 2011	80 cases	NA	NA		
Colin F, 2014	83 cases	NA	NA		
Galli M, 2015	50 cases	3.87±0.95	1.98±0.58	3.88	0.001**
Lee W, 2016	48 cases	NA	NA		
Zhao H, 2016	41 cases	3.92±1.22	2.02±0.69	3.15	0.002*
Krahenbuhl N, 2019	30 cases	NA	NA		
Xu Y, 2019	21 cases	NA	NA		
Zhao H, 2019	34 cases	4.22±1.15	3.15±1.06	2.18	0.035*
Franz A, 2020	46 cases	4.95±1.29	1.67±0.52	9.66	0.00**
POOLED		4.36±1.36	2.36±0.75	2.58	0.012*

Figure 2: HMA Pre and Post-treatment.

Study	N	Pre	Post	Z	P
		Mean± SD	Mean± SD		
Eidelman M, 2011	8 cases	NA	NA		
Horn D, 2011	52 cases	NA	NA		
Lee W, 2011	80 cases	NA	NA		
Colin F, 2014	83 cases	76.1±9.5	91.2±8.69	12.83	0.00**
Galli M, 2015	50 cases	NA	NA		
Lee W, 2016	48 cases	NA	NA		
Zhao H, 2016	41 cases	81.2 ± 3.0	88.3 ± 2.5	9.98	0.00**
Krahenbuhl N, 2019	30 cases	86.36±4.3	93.8±2.3	5.22	0.00**
Xu Y, 2019	21 cases	82.8±2.4	92.3±2.3	11.36	0.00**
Zhao H, 2019	34 cases	80.2±2.6	89.1±3.3	10.58	0.00**
Franz A, 2020	46 cases	80.7±6.0	90.8±2.2	12.36	0.00**
POOLED		83.0±4.98	91.1±3.9	13.74	0.00**

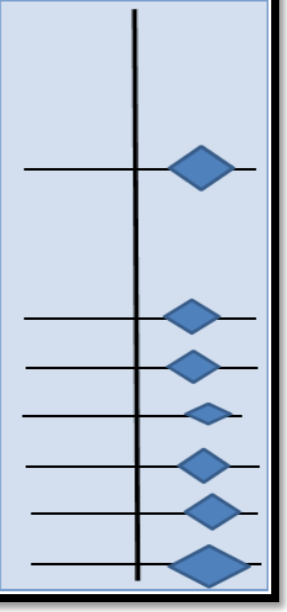


Figure 3: TAS Pre and Post treatment.

Study	N	Pre	Post	Z	P
		Mean± SD	Mean± SD		
Eidelman M, 2011	8 cases	NA	NA		
Horn D, 2011	52 cases	NA	NA		
Lee W, 2011	80 cases	NA	NA		
Colin F, 2014	83 cases	79.0±10.0	80.0±8.0	1.031	0.369
Galli M, 2015	50 cases	NA	NA		
Lee W, 2016	48 cases	NA	NA		
Zhao H, 2016	41 cases	82.0 ± 8.0	83.0 ± 9.5	0.987	0.385
Krahenbuhl N, 2019	30 cases	79.52±6.39	83.6±7.63	1.74	0.108
Xu Y, 2019	21 cases	78.5±9.4	80.5±2.3	1.363	0.226
Zhao H, 2019	34 cases	76.8±9.6	80.5±8.63	1.268	0.269
Franz A, 2020	46 cases	71.8±7.3	75.1±7.6	1.541	0.17
POOLED		78.0±8.88	81.2±10.2	1.44	0.123

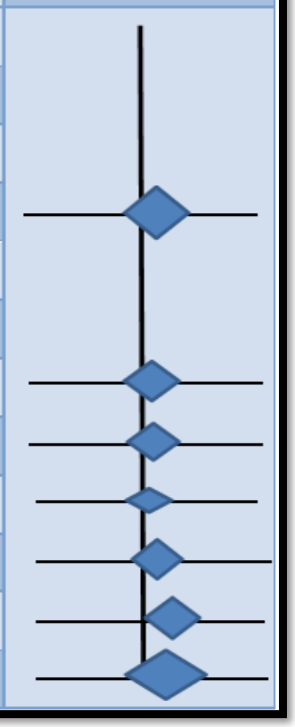


Figure 4: TAS Pre and Post treatment.

Table (4): Distribution of complication

Study	N	Complication
Eidelman M, 2011	**8 cases**	**37.5 %**
Horn D, 2011	**52 cases**	**11.5 %**
Lee W, 2011	**80 cases**	**12.5%**
Colin F, 2014	**83 cases**	**NA**
Galli M, 2015	**50 cases**	**NA**
Lee W, 2016	**48 cases**	**10.6%**
Zhao H, 2016	**41 cases**	**31.7%**
Krahenbuhl N, 2019	**30 cases**	**30.0%**
Xu Y, 2019	**21 cases**	**NA**
Zhao H, 2019	**34 cases**	**31.3%**
Franz A, 2020	**46 cases**	**23.9%**
POOLED	**315 cases**	**24.9%**

4. Discussion

Ankle Osteoarthritis (OA) is the majority result of trauma and a possible debilitating disease which affecting about 1% of adults over all the world. Patients with OA in ankle joint turn out to be symptomatic at 12 to 15 years earlier than those with arthritis hip or knee joints [5]. The mean age from all included studies was 48.58±15.22, males were 47.8% and 52.2% were female. Saltzman et al. [6] concluded that, mean age of ankle OA patients was 40.58±17.42. To acquire a prevalence of the lower extremity arthritis etiologies, they assessed all patients with ankle arthritis for one year. They revealed that 639 arthritic ankles which included 445 were post-traumatic etiology (70%), 76 were rheumatoid disease (12%) and 46 were primary osteoarthritis (7%). Patients with the post-traumatic ankle arthritis were mostly associated with past rotational ankle fractures. The ankle arthritis is associated with earlier trauma, while knee or hip arthritis is idiopathic. Therefore, strategies for treating post-traumatic arthritis of the ankle are required.

As regarding time for union per weeks, pooled analysis showed that the mean time for union (14.87±3.85). OA of ankle joint arising from posttraumatic osteoarthritis (PTOA) and comprises approximately 12% of all patients with OA and extend about 10 years earlier than patients with primary OA. However, the secondary OA of trauma differ by anatomic site, 90% accounting for ankle joint and 2 to 10% for the hip and knee joints. Any cooperation's of ankle has probable to amplify posttraumatic ankle arthritis (PTAA), the alteration of the biomechanics of the ankle leading to alter the ankel mechanical loading that develops a degenerative mechanical determined remodeling process.[7]

In a study done by Rizk et al. [8], they concluded that patients have an osteotomy united in the mean duration of 10±4.8 weeks which range from 7 to 15 weeks with no surgical complications separately from the delayed healing of the wound in two cases that is near to results from the included studies.

American Orthopaedic Foot and Ankle Society (AOFAS) score is applied to assess the patients progress post-surgery in foot and ankle [9] and commonly used for measuring the patient’s outcome after a complex ankle or hind foot injury treatment.[10]

In our study, all studies showed significant increase as regard mean AOFAS with

pooled increase from 52.0±15.3 to 81.6±18.3 with (P= 0.00**). And this reflects the functional improvement in the included patients underwent that procedure.

Our results were comparable to other techniques, in the study Tellisi et al., [11] used distraction arthroplasty for treating ankle osteoarthritis. About 91% of the patients reported pain and the follow-up showed an improvement occur at 30 months with the mean AOFAS score developed from 55 preoperatively to 74 postoperatively.

As regarding TAS (tibial anterior surface) assessment, all studies showing significant increase regard TAS with pooled increase from 83.0±4.98 and 91.1±3.9 with P= 0.00**, also TLS (tibial lateral surface angle), All studies showed significant regard TLS with pooled increase from 78.0±8.88 and 81.2±10.2 with P= 0.123. The outcome of Supramalleolar osteotomy was studied in 83 cases by Colin et al [12] concluded that during follow-up, the mechanical axis was 1.3◦ and 7.5◦ in the varus group and valgus group, respectively. The AOFAS score was improved significantly (P < 0.001) in by 15 and 13 points in patients with a varus deformity and a valgus deformity, respectively. The disappearance of pain as a positive sidewalk sign was correlated with a good outcome with a positive predictive value of 0.88 (CI: 0.77–0.95) (P <0.001). They concluded a supramalleolar osteotomy is a conservative surgical choice for the ankle arthritis management especially with varus or valgus deformities. The satisfactory results for indications of arthritis either with varus and valgus deformities and relief of pain on a surface slope angled in the deformity opposite direction (a positive 'sidewalk' sign). Level of evidence: Level IV: retrospective case series.

Cheng et al. [13] assessed that patient with good to excellent results distal tibial osteotomy for both OA and PTOA. Also, Pagenstert et al [14] revealed a mean of 5 years on 35 consecutive patients viewing outcome improvement in pain and clinical function for the majority, while 10 patients were required a revision including 3 TAAs.

5. Conclusion

Supramalleolar osteotomies correct the deformity of the ankle with improved functional outcome and restore the disturbed mechanics. Our systemic review declared that Supramalleolar osteotomies are effective techniques for dealing with hind foot deformities.

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