Surgical Correction of Adult Flatfoot Deformity, Clinical and Functional Outcomes in Sudanese Patients

Sami Nogdallah [1], Mohammed Magzob [2], Ismail M. Saleem [3]

Address for correspondence:

Sami Nogdallah. Consultant orthopedic surgeon, Bashaer University Hospital, Sudan.

Abstract

Background: Adult acquired flatfoot deformity (AAFD), or posterior tibial tendon (PTT) insufficiency, is a complex progressive foot and ankle problem that leads to collapse of the medial longitudinal arch of the foot. Refine surgical management is indicated when conservative treatment fails. **Objectives**: To evaluate the outcome of surgical correction of adult acquired flatfoot deformity. **Materials and methods**: In Quasi-experimental 'before and after' Multi-centered study. 30 Adult patients (21 females and 9 males) with types II AAFD and failed to respond to conservative treatment were included. Surgical reconstruction has been performed for them. All kept on regular postoperative, scheduled clinical follow-up program for 6 months employing the Foot Function Index (FFI) structured questionnaire of the American Orthopaedic Foot and Ankle Society (AOFAS). **Results**: The AOFAS rating scale improved from a mean of 46.97 before operation to a mean of 85.73 on review. The mean preoperative FFI improved from 104.77 to 19.47 Postoperatively, 50% were very satisfied, 43.3% were satisfied with minor reservations and 6.7% were unsatisfied. **Conclusion**: Surgical correction of types II

and III AAFD with FDL transfer and medial calcaneal osteotomy is found to be valid surgical option with good clinical, functional and highly satisfactory outcomes.

Keywords: AAFD, PTT, Flatfoot, Quasi-experimental study, AOFAS, FFI

INTRODUCTION

Adult-Acquired Flatfoot Deformity (AAFD); originally known as Posterior Tibial Dysfunction (PTD); it is a complex process imputed to PTTD insufficiency, [1] which encompasses a wide range of malformations. [2] They can be due to inflammatory synovitis, degenerative rupture and acute trauma. [3] Trial of Prompt conservative, nonsurgical management could be started, [4] as it carried a success rate of more than 75% (67-90%). [1] However, if showed any signs of failure, surgical intervention should by carried by an expert orthopedic surgeon to avoid poor surgical outcome; due unacceptable misposition, poor function and restricted flexibility of the foot-ankle complex. [2] Although, dispute; remains as to how to manage normal flexibility with severe cases of Flatfoot Deformity. PTD can be classified in 3 stages: Stage I: having a semi-intact tendon with inflammation, but no clinical deformity, where one or two fine longitudinal splits, without evidence of Tran substance degeneration, but no clinical deformity. Treatment at this stage is conservative. [5] Stage II: The tendon is nonfunctional, narrowed with longitudinal ruptured or splits. It is evident with intramural degeneration, resulting in a planovalgus deformity which is passively correctable. Stage III: Diffuse swelling of the tendon with uniform degeneration. A few strands can be intact of the tendon is completely replaced by scar tissue. It is no longer correctable and osteoarthritis is seen in the subtalar joint. [3] A 4^{th} stage was added by some reporters, [6] in which there is the deltoid ligament is insufficient leading to lateral tilt and tibiotalar valgus deformity of the talus in the ankle joint with tibiotalar degeneration. In addition to tibiotalar deformity, ankle arthritis may also be present. [7] Surgical correction in Stages III and IV involves fusion of one or more joints, including the subtalar, calcaneocuboid, talonavicular and ankle joints [3,5] Although there are no large-scale epidemiological studies worldwide and in Sudan too. Reported rates were found to be more common in obese women than in males, ± hypertension, Diabetes Mellitus, corticosteroid use, seronegative inflammatory disorders, inflammatory arthropathy etc… [8] Often presents in geriatric population, [9] with 10% of geriatric patients

affected. in the ≥ sixth decade. >3% in those ladies over the age of 40 years and >10% of all adults over the age of 65 years; depending on the sex. [6]

A Foot Function Index FFI) and Foot Function Index-Revised (FFI-R)

A Foot Function Index (FFI) act as measure of foot pain and disability (or pain and stiffness). [10] FFI is used extensively worldwide; it is pioneered a quantifiable measure of foot health, and thus has shifted the paradigm of outcome measure to subjective, patient-centered, valid, reliable and responsive hard data endpoints. Edited FFI-R into four response categories will enhance its user friendliness for measuring foot health. It is a self-administered questionnaire which can be used to evaluate the extent of foot pain and stiffness, the effect on daily foot-related activities, and the quality of life. It was developed by AOFAS [11] group of foot experts to measure the impact of foot pathology on function, in terms of pain, disability and activity restriction, composed of 23 items divided into 3 sub-scales. It has been revised (A Foot Function Index-Revised) [12] by many authors to a more large-scale version with 68 items (FFI-R). [10] Deferent tested and modified and translated versions emerged in literature. [12] [13] Some supported the validity and reliability of the FFI. [13, 14]

MATERIALS AND METHODS

In Quasi-experimental 'before and after' Observational retrospective studies conducted at Sharg Elneel and El Shaikh specialized hospitals in Khartoum, Sudan. Thirty (n=30) Adult Sudanese patients diagnosed with AAFD were involved including. 21 (70%) females and 9 (30%) males; in one period; 1st June2015 to 1st june 2016. All included patients were diagnosed clinically and found to have asymmetrical type II or type III flatfoot with an abduction deformity of the forefoot ('too-many toes' sign), inability to perform a single heel rise and pain with swelling of the medial aspect of the ankle. Moreover, the chosen candidates had been free from neuropathic arthropathy and seropositive arthritis. All failed to respond to conservative treatment.

Then each clinically suspicious patient for AAFD was assessed before surgery by clinical examinations. Then confirmed with weight-bearing anteroposterior (AP), lateral foot and AP ankle plain radiograph in two planes, utilizing the 'Foot Function Index' of the American Orthopaedic Foot and Ankle Society (AOFAS). [11] These views will help to assess arch collapse. (best assessed by Meary's angle:

the angle between the long axis of the talus and first metatarsal bone, where more than more than 4° convex downward is considered a flatfoot) [15] or the lateral first tarsometatarsal angle, [16] forefoot abduction (at the talonavicular joint), talar head uncoverage and talar tilt in stage IVAAFD.

Surgical correction of the deformity with Flexor Digitorum Longus (FDL) tendon transfer with medializing calcaneal osteotomy (MCO). Transfer and medial calcaneal osteotomy have been performed for all candidates. Each patient is then followed for at least 6 months after the operation

OPERATIVE TECHNIQUES

For the procedure, the patient is placed in the supine position on the operating table with clean sand-bag positioned under the ipsilateral hip and buttock so that the affected side is internally rotated, allowing access to the lateral aspect of the calcaneus for the osteotomy; which is performed first. A thigh tourniquet is applied to gently controlling the *exsanguination* of the leg by well observed inflation, and eventually keeping the site of surgery free of unnecessary bleeding. The *leg* skin is prepped; short below the knee and the *foot is wrapped* in a separate *drape*.

An Obliquely parallel skin incision, inferior to the peroneal tendons, approximately 2 cm distal to the lateral malleolus was well done. Then dissection is carried down to the bony surface of the calcaneus; through a periosteum incision and elevation in the line of the skin incision to allow subperiosteal osteotomy with broad osteotome. Care not to injure the sural nerve was maintained throughout the dissection.

Then a calcaneal osteotomy is performed with sagittal saw at an angle of approximately 45° to the sole of the foot, with utmost care not to injure the neurovascular bundle. The distal segment is displaced medially for 1 cm and held by a cannulated, partially-threaded, 6.5 mm cancellous screw.

The lateral wound is closed and A medial incision is then made along the line of the PTT and extended distally to expose the tendon of FDL. The PTT, spring ligament and FDL are identified. Approximately 5 cm of the PTT are excised, which is the diseased portion. The tendon of FDL is followed to the knot of Henry and divided distally. A 4.5 mm drill hole is made from the dorsal to plantar direction in the navicular, and the tendon of Flexor Digitorum Longus (FDL) is rerouted through the navicular from plantar to dorsal, holding the forefoot inverted and sutured back on itself. The wound is closed and a backslab plaster was applied in a position of moderate equinus and varus for 12 to 14 days.

The intraoperative and postoperative surgical course was uneventful; as no patient develop Deep Vein Thrombosis (DVT) or Pulmonary Embolism (PE).
(FDL)

Inspection of the wound is carried out at this time with removal of the sutures and a full, lightweight below-knee fiberglass cast applied in a neutral position for a further four weeks. The patient remains non-weight-bearing for six weeks, the cast is then removed and radiographs taken to assess the healing of the osteotomy. After removal of the cast the patient gradually increases weight-bearing as pain allows and physiotherapy is undertaken until a single-heel rise can be performed comfortably. All patients attended for routine follow-up during the first 6 months.
The Brazilian-Portuguese version of the Foot Function Index (FFI) questionnaire (B-P FFI Q) was used to assess postoperative AOFAS foot function scores. It was found to be a valid and reliable instrument for foot function evaluation, and can be used both in scientific settings and in clinical practice. [13]

The entire data were coded and entered in a Microsoft excel spreadsheet in a personal computer. Then subjected to 'Statistical Analysis' by Statistical program for social sciences (SPSS) version 20 (Manufactured by IBM SPSS Inc. PASW Statistics for Windows, Version 20.0; 2009. Chicago: SPSS Inc., IL, USA). Categorical variables were analyzed using frequencies and percentage. Continuous variables were summarized using mean, percentile, range, and standard deviation. Significant differences and associations were determined by p values < 0.05.

Ethical approvals were obtained from Sudan Medical Specialization Board (SMSB) IRB (Institutional Review Board), State Ministry of Health (MOH) informed written consents with Verbal interview and explanation the procedures. Confidentiality and anonymity of each infant and family identity were adhered.

DISCLAIMER:

The authors hold no financial or conflict of interest

RESULTS

Thirty (n=30) Adult Sudanese patients diagnosed with AAFD were involved in the current study including: 21 (70%) females and 9 (30%) males; *[Figure 1]*in one-year period; 1st June2015 to 1st june 2016. The average age group between: 15-30 years were 20% and 20-40 years were 56.7%. *[Table 1]*
In 15 (50%) patients, the left foot was affected, and in 14 (46.7%) patients the right foot was affected, while one patient (3.3%) had bilateral involvement. *[Figure 2]* The majority of patients (96.7%) had symptoms for more than 6 months before presentation and only one patient presented after 3 months from the start of symptoms. *[Figure 3]*

14 patients (46.7%) were student, 9 patients (30%) were employees and 7 patients were (23.3%) House-Wives. *[Figure 4]* 26 patients (86.7%) claimed to have had pre-existing trauma or injury to the foot with a clear relation between injury and onset of the symptoms. 4 (1.5%) patients have uncontrolled hypertension and rheumatoid arthritis. *[Figure 5]* At a mean of 6 months after surgery, the 30 patients reviewed, 15 patients (50%) were very satisfied with the operation, 13 patients (43.3%) were satisfied with minor reservations and two patients (6.7%) were unsatisfied. *[Figure 6]* The American Orthopaedic Foot and Ankle Society (AOFAS) 'foot Function Index (FFI)' and 'rating scale' tested by B-P FFI Q, [11,13] improved from a mean of 46.97 before operation to a mean of 85.73 on review postoperative, giving a success rate of 82.7%. *[Table 2]*

The FFI score improved from a mean of 104.77 before operation to a mean of 19.47 on review, with some patient complain from mild medial pain after activity, which did not require analgesia. *[Table 3]* The majority or postoperative patients attended regularly to the clinic for close follow up according their planed follow-up scheme, and others were unable to attend for clinical review but were contacted by telephones and asked the same questions in FFI and FFI-R questionnaires regarding function, pain and outcome the reported in their files. All of these were satisfied with the result. Post operatively the majority of our patients (93.3%) had an excellent surgical outcome, they didn`t show any signs of failure. Their FFI-R; within 6-months post-operative; satisfaction score; presented in table 6: 50% were very satisfied + 43.3% were still satisfied but with minor complains that can be resolved by more physiotherapy sessions. While 6.67% were not satisfied. *[Figure 6]* While only 2 (6.7%) patients proved to have some degree of operation failure. *[Table 4]* One of them sustained direct trauma to the foot after the surgery, surgical revision was planned. The 2nd one (3.3%) came late from remote countryside's with wound dehiscence

and deep infection, admitted for the suitable managements. Post-operative wound Infection occurred in another more 2 patients; a part from the one above; with the infected dehiscent wound. These 2 developed simple wound infection which were treated conservatively by surgical dressing and antibiotics. *[Table 5]* One patient (3.3%) came after more than 6 months with deformity recurrence, possible due to physiotherapy care non-accessibility. *[Table 6]* Clinical recovery and radiological osteotomies` healing during follow-up were uneventful. Although 8 cases (27%) had pain at the site of the calcaneum screw, which could be due harmless rubbing-off against a hard shoe. Repeated re-evaluations proof not to require surgical intervention. [Figure 7] Two patients (6.7%) develop sural neuritis, present with pain and paresthesia in the lateral side of the foot. All the cases spontaneously resolved without treatment. [Figure 8]

DISCUSSION

In the current study the commonly affected mean age group (56.7%) was between 2nd and 4th decades' (20-40 years) and the least affected (6.7%) was in the 7th-8th decades (61-80 years). This was in contrary with other 2 international reports, one by Wacker JT and fellows (Australia, 2002). [17] and the other by Henry JK tudy and colleagues [6] (NY-US, 2019). Both reported high prevalence of AAFD in older Females groups of more than 63 years in average (ranged from 61to 80 years). A possible explanation could be due to differences in prevelance of females` Obesity and overweight that may contribute with early lower limbs weight-bearing problems, in the 3-study population, Africans, Asian and Caucasians. [18, 19, 20, 21] Importantly, it is predicated that overweight put tremendous pressure on lower Skeletal-joints` system, eventually Flatfoot Deformities. [22, 23] Younger adult women, with somewhat sedentary lifestyle, in Sudan, like in some Sub-Saharan African [24] childbearing ladies, usually gain high prevalence of central obesity and overweight, roughly double than men. [20, 25, 26, 27] Shibuya and collegues (US,2020) [22] also noticed that male-females` African Americans, with AAFD had an equal mean age of 44 year, which older than ours (20-40 years), both genders had a higher prevalence of flatfoot, possible due high obesity and higher BMI statuses. [28] Montgomerie et al, reported the association of sedentary lifestyle and physical inactivity with incident obesity in South Australia adults. [29]

Shibuya (US,2020) and Hohls-Gatzoulis et al (England; 2009) didn`t relate age and gender to the prevalence of AAFD in agreement with each other but in disagreement with the present study and others

in literatures. [30, 31] Montgomerie et al, reported the association of physical inactivity with incident obesity in South Australia adults. [29]

The mean age of respondents was almost the same in both genders; both round about 44 years; males-females. [31] In this study age is not a significant factor for developing tibialis posterior dysfunction, in contrary of gender which was a significant factor associated with flatfoot deformity. England, Hohls-Gatzoulis (England; 2009) and El-Sayed (Egypt; 2017) with their colleagues [30, ,32] also did not find age to be a significant factor for developing AAFD, PTTD. The lack of a clinically significant association between our older age group (7^{th}- $>8^{th}$ decades) and the flatfoot may also be attributable to inactivity and indolence, in the older population, resulting in less weight-bearing stress on their lower limbs and feet.

Okezue OC (2019, Nigeria) documented a prevalence of flatfoot of11.6%, which mostly had a unilateral pattern, in agreement with the current study where unilaterality was 96.7% (50% for left and 46.7% for right, 3.3% for bilateral involvement. [28] The present work showed; the left foot was affected in 50% of patients and 46.5% in the right foot. While only one (3.3%) patient had bilateral involvement. In contrast to Funk DA et al [33] and Wacker JT et al; [17] both reported an exact similar inversed percentage but in different study populations. Vaughan P and fellows (2016) reported a good functional result with high patient satisfaction into the medium term in case of one-set bilateral ankle surgeries, especially in cases of bilateral ankle arthritis (AA). [34]

Shibuya (US,2020) noted that poverty was closely associated with poor health status, which was a significant factor for predicting flatfoot in some poor communities. [31] Although, this was not tested in the current study, but an impression of such situation can be deduced indirectly from the places from which patients were recruited, most of them came far poor countryside's areas and states.

The majority of the patients in the present work (96.7%) had symptoms for more than 6 months before presentation and only one patient presented after 3 months from the start of symptoms. Which is common in literature; Zaw H (UK, 2010) their patient might develop medial pain over the posterior tibial tendon or lateral pain from subfibular impingement, [35] Most of the present study patients presented with

symptoms of medial ankle pain and functional rigidity for more than 6 months (96.67%), in agreement with Vulcano E et al (NY, US;2013).[36, 37]

Pre-Existing of foot trauma was found almost in half (46.7%) of our cases of AAFD with clear relation between injury and onset of the symptoms, Crevoisier X attributed the cause of AAFD after trauma due to development of consequence rheumatoid arthritis. [38] Cataldi C et al describes reported cases some of tibialis posterior tendon rupture associated with pronation-type ankle fractures treated acutely with open reduction and internal fixation and primary tendon repair. [39]
Obesity with hypertension and diabetes Mellitus (DM) can aggravate the possibility of occurrence of AAFD, in adult patients, supported by many studies in the literature, [36] 13% of our study population were hypertensive and no DM.

In the present study; AOFAS FFI up to 82.7%; (46.97 to 85.73). The FFI rating scale achieved, 104.77 to19.47 preoperatively. Feldman NJ et al, achieved mean improvement of 38.8 to 78.1 postoperatively. [36, 40] Ruffilli A and fellows addressed Surgical Treatment of Stage II PTTD, which reported AOFAS hindfoot score of 89 ± 10 points at final follow-up. 86% of their patients were satisfied or satisfied with minor reservations. Overall satisfaction score; in this study was 93.3% overall with the same minor reservations in 2 cases. One complained of pain in the lateral aspect of the ankle with instability, and the other was satisfied until 18 months after the operation, with when he noticed recurrence of the collapsed arch and discomfort when wearing shoes without orthotics. At a mean follow- up of 17.5 months the results showed an increase in the AOFAS score from 51.4 to 82.8 and a statistically significant maintenance of the correction of the planovalgus deformity radiologically.

A tenodesis of the distal FDL to flexor hallucis longus was not performed because the tendons are conjoined distal to the knot of Henry. None of our patients complained of weakness of flexion of the lesser toes. Lengthening of the lateral column is preferred by some authors. [41] We believe that this more extensive operation is not always necessary, but that in some patients with gross preoperative malalignment, improvement could be achieved by an additional procedure, such as lengthening of the lateral column in addition to the calcaneal osteotomy and FDL tendon transfer. However, if the alignment

is fair and the patient is free from pain, even with the use of insoles the extra morbidity of lengthening of the lateral column may not be required.

The authors did not fully study the radiological changes in all patients because the preoperative radiographs were not always available at the follow-up time and there was no standardization. There was an old doubtful concept about the correlation between the radiological evaluation, the clinical findings and patient satisfaction, stated in 1986 by Funk DA and others. [33] Recently, this idea was repasted by the development of modern evidence-based radiographic technology: where De-Cesar Natto and co-investigators (Johns Hopkins; 2018) [42] found significant positive correlation between radiographic and clinical hindfoot alignment in patients with stage II AAFD. However, radiographic measurements of HAA demonstrated significantly more pronounced valgus alignment than the clinical evaluation. [43]

Although conventional MRI plays a significant role in diagnosis, contemporary management increasingly relies on advanced new imaging techniques remain the best predictor of the surgical outcome, especially with reconstruction of Ankle and Foot surgeries. [44] giving better delineation of the pathology than intra operative inspection, as it helps in the management of intratendinous tears and degeneration that was not obvious at surgery. [45]

Rare deformity recurrence which occurred in one patient after 6 months failure in follow up, possibly due to physiotherapy care non-accessibility. Choi HJ and Lee WC (2017; Seoul, Korea), [46] Hatic 2nd SO, Philbin TM (2012; OH,USA.) [47] comments on surgery revision can be considered in active young people unlike elderly, low-demand patients who can be care with more physiotherapy.

In the current study 6.7% developed sural neuritis with pain and paresthesia in the lateral side of the foot. Cutaneous nerve injury is common after ankle surgery as a result of incision as reported in literature which can be resolved spontaneously in 6–9 months [48, 49] or by nerve block. [50]

[Table 1] Age Group Distribution of the study population

Age group	Frequency	Percent%

15-30	17	56.7%
31-45	5	16.7%
46-60	6	20%
61- 80	2	6.7%
Total	30	100.0%

[Table 2] FFI Mean Distribution According to Pre- Post-operative

FFI	Mean	Std Deviation	No.
Pre-operative	104.77	18.234	30
Post-operative	19.47	26.862	30

Note: FFI: Foot Function Index

***. Correlation is significant at the 0.01 level (2-tailed).*

[Table3] Distribution According to American Orthopaedic foot *& ankle scale (AOFAS)*

AOFAS	Mean	Std Deviation	No.
Pre-operative	46.97	10.05	30
Post-operative	85.73	9.924	30

**. Correlation is significant at the 0.05 level (2-tailed).*

[Table 3a] AOFAS & FFI Mean Distribution According to *Pre- Post-operative (Combined table)*

Variable	**Mean**	**Std. deviation**
AOFAS		
Preoperative	46.9	10.05
Postoperative	85.7	9.92

FFI		
Preoperative	104.77	18.23
Postoperative	19.47	26.86

[Table 4]

Distribution According to Operation Failure

Operation Failure	Frequency	Percent%
Yes	2	6.7%
No	28	93.3%
Total	30	100.0%

[Table 5] Distribution According to Post-operative Infection

Post-operative Infection	Frequency	Percent%
Yes	3	10%
No	27	90%
Total	30	100.0%

[Table 6] Distribution According to Recurrence of Deformity

Recurrence of Deformity	Frequency	Percent%
Yes	1	3.3%
No	29	96.7%
Total	30	100.0%

[Table 7] Distribution According to the Study Varaibles

Variable	**Frequency; n=30**	**Percentage%**
Age, years		
15-45	22	73.3
46-60	6	20
61-75	2	6.7

Gender		
Male	9	30
female	21	70
Occupation		
Employee	10	30
Student	6	23
Housewife	14	47
Affected foot		
Right	14	40
Left	15	50
Both	1	10
Duration of symptoms		
More than 6 months	29	97
Less than 6 months	1	3
Post-operative infection	3	10
Recurrence of deformity	1	10
Patient satisfaction		
Satisfied	15	50
Moderate	13	43
unsatisfied	2	7

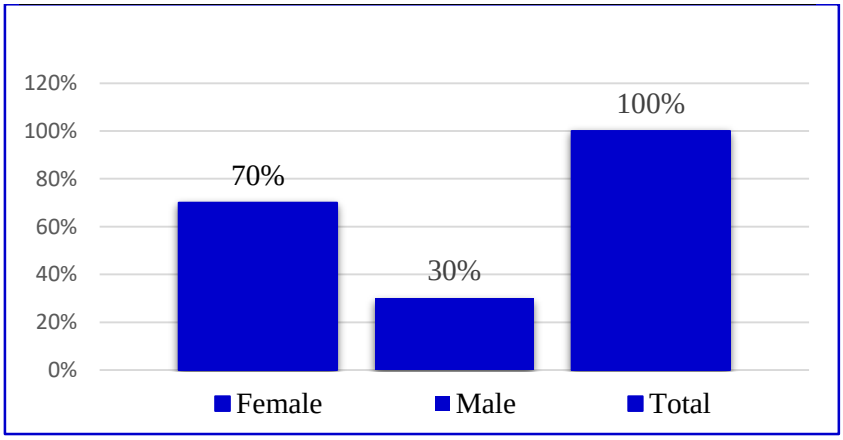
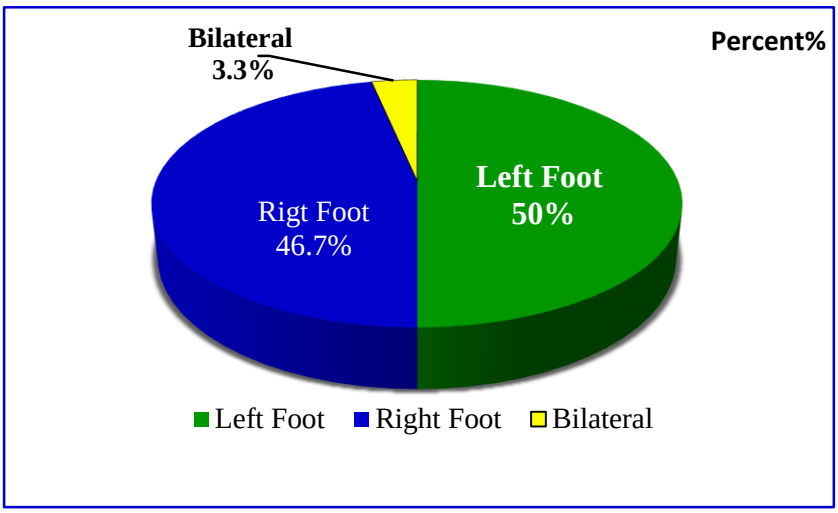
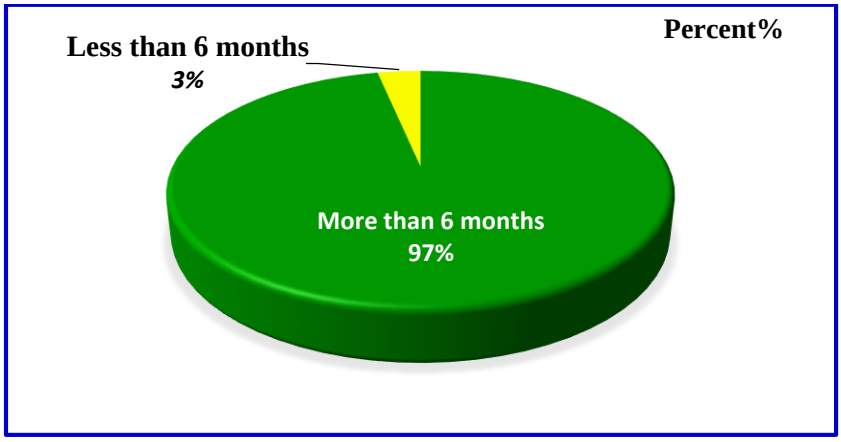


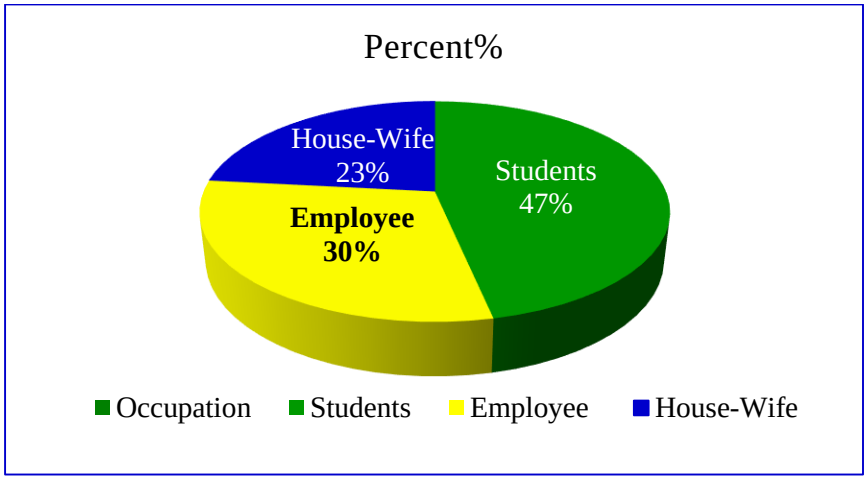
Figure 1 Sex distribution



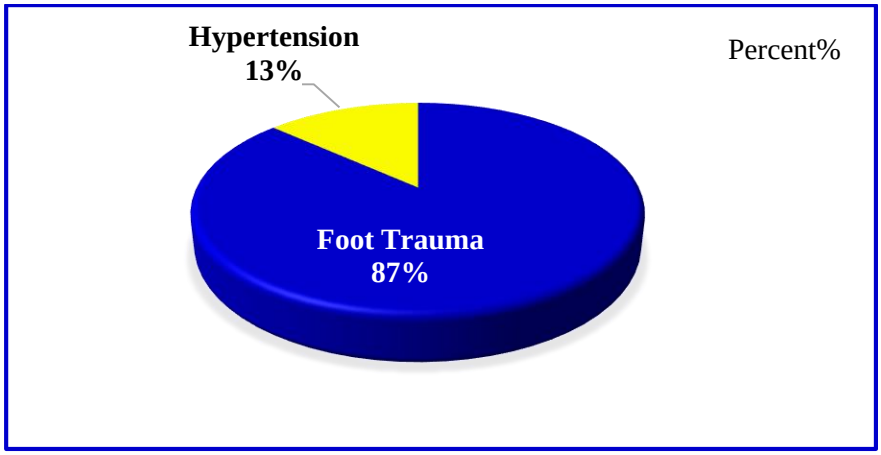
[Figure 2] Patients Distribution According to affected site of the foot.



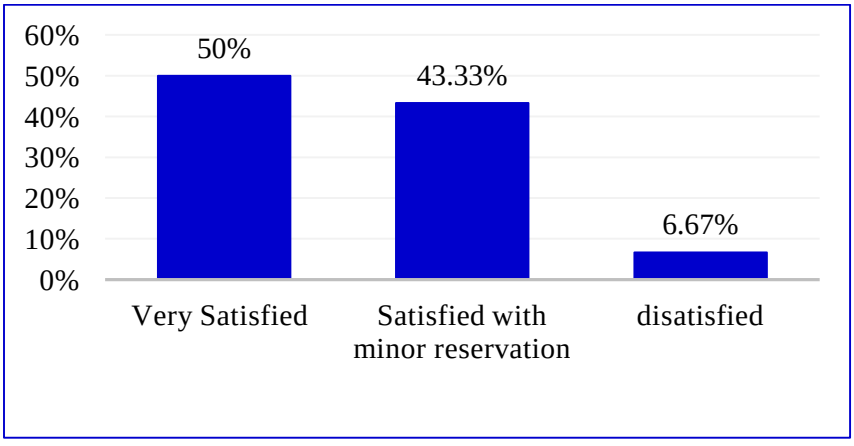
[Figure 3] Patients` Distribution according to duration of symptoms before the operation.



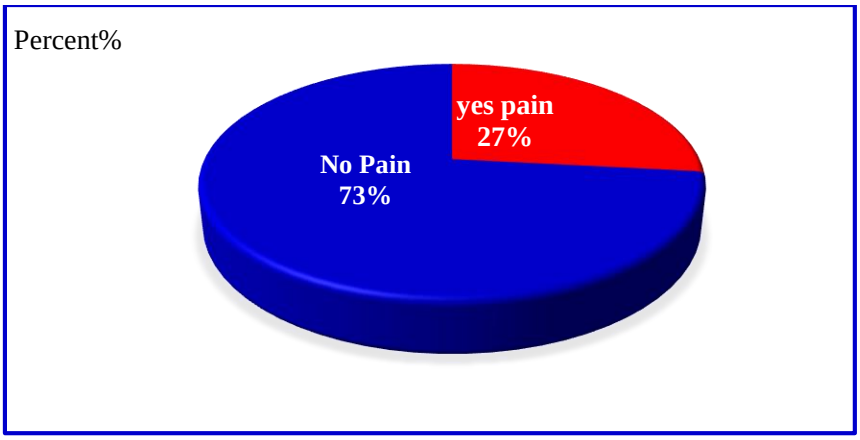
[Figure 4] Patients Distribution According to Occupation.



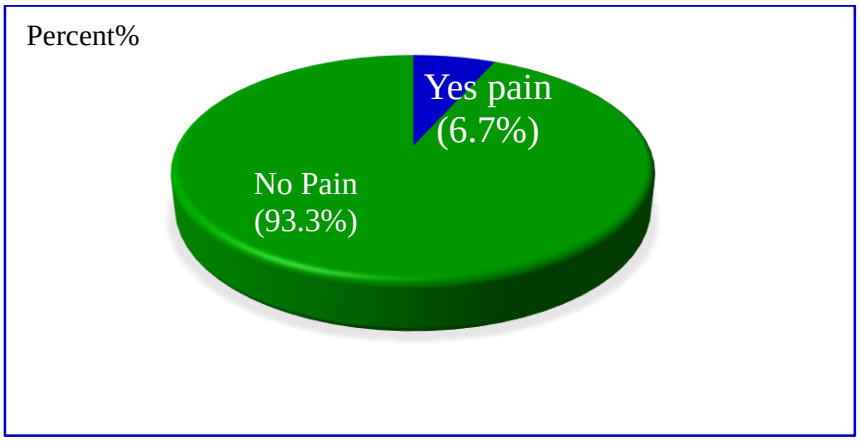
[Figure 5] Patients Distribution According to The Risk Factors



[Figure 6] Patients Distribution According to Operation Satisfaction



[Figure 7] Patients Distribution according Calcaneum pain (screw site)



[Figure 8] Patients Distribution according Sural Neuritis

REFERENCES

1. Abousayed MM, Alley MC, Shakked R, Rosenbaum AJ. Adult-Acquired Flatfoot Deformity; Etiology, Diagnosis, and Management. JBJS Reviews; August 2017 - Volume 5 - Issue 8 - p e7; NY, US. DOI: 10.2106/JBJS.RVW.16.00116.

2. Deland JT. Adult-acquired Flatfoot Deformity, Journal of the American Academy of Orthopaedic Surgeons: July 2008 - Volume 16 - Issue 7 - p 399-406; NY, US.
3. Bubra PS, Keighley G, Rateesh S, Carmody D. Posterior Tibial Tendon Dysfunction: An Overlooked Cause of Foot Deformity. J Family Med Prim Care. 2015 Jan-Mar; 4(1): 26–29. doi: 10.4103/2249-4863.152245
4. Jari S, Barrie J, Roberts N. Non-surgical management of tibialis posterior insufficiency. Foot and Ankle Surgery. 8(3):197 - 201 · October 2002. DO - 10.1046/j.1460-9584.2002. 00324.x
5. Fuhrmann RA, Trommer T, Venbrocks RA. The acquired buckling-flatfoot. A foot deformity due to obesity.? Orthopade. 2005 Jul; 34(7):682-9.
6. Henry JK, Shakked R, Scott J. Ellis SJ. Adult-Acquired Flatfoot Deformity. Foot and Ankle Orthopaedics 2019, Vol. 4(1) 1-17 [a] The Author(s) 2019 DOI: 10.1177/2473011418820847 journals.sagepub.com/home/FAO.
7. Bluman EM, Title CI, Myerson MS. Posterior tibial tendon rupture: a refined classification system. Foot Ankle Clin. 2007;12:233–249, v. [PubMed]
8. Ikpeze TC, Brodell JD Jr, Chen RE, Oh I. Evaluation and Treatment of Posterior Tibialis Tendon Insufficiency in the Elderly Patients. Geriatr Orthop Surg Rehabil. 2019; 10:2151459318821461. Published 2019 Jan 24. doi:10.1177/2151459318821461
9. Kohls-Gatzoulis J, Angel J, Singh D. Tibialis posterior dysfunction as a cause of flatfeet in elderly patients. Foot. 2004;14(4):207–209. doi: 10.1016/j.foot.2004.06.003.
10. Budiman-Mak E, Conrad KJ, Mazza J, M Stuck RM. A review of the foot function index and revised. J. J Foot Ankle Res 6, 5 (2013). https://doi. the foot function index – org/10.1186/1757-1146-6-5
11. Van Lieshout EMM, De Boer AS, Meuffels DE, Den Hoed PT, Van der Vlies CH, Wim E Tuinebreijer WE, Verhofstad MHJ. American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score: a study protocol for the translation and validation of the Dutch language version. Van Lieshout EMM, et al. BMJ Open 2017;7: e012884. doi:10.1136/bmjopen-2016-012884
12. Stéfani KC, Filho MVP, Oliveira PR, Lam Wun PY. Translation, Cultural Adaptation and Validation of The Foot Function Index - Revised (FFI-R). Acta ortop.bras.vol.25 no.5 São Paulo Sept./Oct. 2017.http://dx.doi.org/10.1590/1413-785220172505172107.Accessed20.6.2020

13. Martinez BR, Staboli IM, Kamonseki DH, Budiman-Mak E, Yi LC. Validity and reliability of the Foot Function Index (FFI) questionnaire Brazilian-Portuguese version. Springerplus. 2016;5(1):1810. Published 2016 Oct 18. doi:10.1186/s40064-016-3507-4
14. Ankle-Hindfoot Score: a study protocol for the translation and validation of the Dutch language version. Van Lieshout EMM, et al. BMJ Open 2017;7: e012884. doi:10.1136/bmjopen-2016-012884
15. Hastings MK, Sinacore DR, Mercer-Bolton N, et al. Precision of foot alignment measures in Charcot arthropathy. Foot Ankle Int. 2011;32(9):867-872. doi:10.3113/FAI.2011.0867
16. Mason LW, Tanaka H. The first tarsometatarsal joint and its association with hallux valgus. Bone Joint Res. 2012;1(6):99-103. Published 2012 Jun 1. doi:10.1302/2046-3758.16.2000077
17. Wacker J, Michael H, Saxby, T. Calcaneal osteotomy and transfer of the tendon of flexor digitorum longus for stage-II dysfunction of tibialis posterior: three- to five-year results. The Journal of bone and joint surgery. British volume, Vol. 84 (1) 54-8;2002; DO - 10.1302/0301-620X.84B1.0840054
18. Marques A, Peralta M, Naia A , Loureiro N, Gaspar de Matos M. Prevalence of adult overweight and obesity in 20 European countries, 2014. European Journal of Public Health, Volume 28, Issue 2, April 2018, Pages 295–300, https://doi.org/10.1093/eurpub/ckx143
19. Kumar BN, Meyer HE, Wandel M, Dalen I, Holmboe-Ottesen G. Ethnic differences in obesity among immigrants from developing countries, in Oslo, Norway. Int J Obes 30**,** 684–690 (2006). https://doi.org/10.1038/sj.ijo.0803051, accessed 26.6. 2020.
20. Ali YA, Almobarak AO, Awadalla H, Wadie M. Elmadhoun WM, Ahmed MH. Obesity among Sudanese adults with diabetes: a population-based survey. Ann Transl Med 2017;5(12):252
21. Wen CP, Cheng TYD, Tsai SP, Chan HT. Are Asians at greater mortality risks for being overweight than Caucasians? Redefining obesity for Asians. Public Health Nutrition,2009; 12(4), pp. 497-506, doi: 10.1017/S1368980008002802
22. Suciati T, Adnindya MR, Septadina IS, Pratiw PP. Correlation between flat feet and body mass index in primary school students. 2019 J. Phys.: Conf. Ser. 1246 012063
23. Shree S , Revathi S , Thiyagarajan A Kumar D. Does Obesity Cause Flat Foot? J Obes Ther Vol: 2(1); (2018)

24. Biadgilign S, Mgutshini T, Haile D, Gebremichael B. Epidemiology of obesity and overweight in sub-Saharan Africa: a protocol for a systematic review and meta-analysis. BMJ Open 7(11): e017666; November 2017; DOI: 10.1136/bmjopen-2017-017666
25. Amugsi DA, Dimbuene ZT, Mberu B, Muthuri S, Ezeh AC. Prevalence and time trends in overweight and obesity among urban women: an analysis of demographic and health surveys data from 24 African countries, 1991-2014. BMJ Open. 2017;7(10): e017344. Published 2017 Oct 27. doi:10.1136/bmjopen-2017-017344
26. Swinburn BA, Sacks G, Hall KD, et al. The global obesity pandemic: shaped by global drivers and local environments. Lancet 2011; 378:804-14. [PubMed]
27. Chukwuonye II, Chuku A, John C, Ohagwu KA, Imoh ME, Isa SE, Ogah OS, Oviasu E. Prevalence of overweight and obesity in adult Nigerians - a systematic review. Diabetes Metab Syndr Obes. 2013; 6:43-47. doi:10.2147/DMSO.S38626
28. Okezue OC, Akpamgbo OA, Ezeukwu OA, John JN, John DO. Adult Flat Foot and its Associated Factors: A Survey among Road Traffic Officials. Nov Tech Arthritis Bone Res 3(4): NTAB.MS.ID.555616 (2019).
29. Montgomerie AM, Chittleborough CR, Taylor AW. Physical Inactivity and Incidence of Obesity among South Australian Adults. PLOS ONE. November 10, 2014, https://doi.org/10.1371/journal.pone.0112693. Accessed 27.6.2020.
30. Kohls-Gatzoulis J, Woods W, J.C. Angel JC, Singh D. The prevalence of symptomatic posterior tibialis tendon dysfunction in women over the age of 40 in England. Foot and ankle surgery: official journal of the European Society of Foot and Ankle Surgeons; 15(2):75-81, 2009; DO:10.1016/j. fas.2008.08.003.
31. Shibuya N, Jupiter DC, Ciliberti LJ, VanBuren V, La Fontaine J. Characteristics of Adult Flatfoot in the United States. J Foot Ankle Surg 49(4): 36-68.Article in Press: accessed 25.6.2020.
32. El-Sayed NS, Fadel MM , Yosef AO, Soliman AMM. Medial displacement calcaneal osteotomy in treatment of stage II posterior tibial tendon deficiency. Egypt Orthop J 2018:53: 14-20.
33. Funk DA, Cass JR, Johnson, KA. Acquired adult flat foot secondary to posterior tibial-tendon pathology. J. Bone and Joint Surg. Jan. 1986. 68-A: 95-102.

34. Vaughan P, Gordon D, Goldberg Obe A, Cullen N, Singh D. Patient satisfaction and function after bilateral ankle arthrodeses. Foot and Ankle Surgery 21(3):160-3; September 2015. DO: 10.1016/j.fas.2014.11.001
35. Zaw H, Calder JDF. Operative management options for symptomatic flexible adult acquired flatfoot deformity: a review. Knee Surg Sports Traumatol Arthrosc (2010) 18:135–142. Published online: 5 January 2010, Springer-Verlag 2009. DOI 10.1007/s00167-009-1015-6
36. Vulcano E, Deland JT, Ellis SJ. Approach and treatment of the adult acquired flatfoot deformity. Curr Rev Musculoskeletal Med. 2013;6(4):294-303. doi:10.1007/s12178-013-9173-z
37. Adult acquired flatfoot. Available at http://orthoinfo.aaos.org/topic.cfm? topic=a00173. Accessed 27.6 2020.
38. Crevoisier X. Crevoisier X, Assal M, Stanekova K. Hallux valgus, ankle osteoarthrosis and adult acquired flatfoot deformity: a review of three common foot and ankle pathologies and their treatments. EFORT Open Reviews. Vol. 1, No. 3Foot & Ankle. Published Online:22 Mar 2016https://doi.org/10.1302/2058-5241.1.000015. Accessed 26.6.2020.
39. Cataldi C, Bacci CN, Colsanti CB, Mondanelli F, Muratori F, Giannotti S. Posterior Tibial Tendon Rupture Associated with Anterolateral Distal Tibial and Medial Malleolar Fracture and a Novel Pattern of Tibiofibular Syndesmotic Injury: A Case Report and Review of the Literature. The. Available online 30 April 2020; Accessed 27.6.2020.
40. Feldman NJ, Oloff LM: In situ tibialis posterior to flexor digitorum longus tendon transfer for tibialis posterior tendon dysfunction: A simplified surgical approach with outcome of 11 patients. Clin Orthop. 1999; 365:50-70.
41. Wilder J, Catanzariti A. Addressing Deltoid Ligament Insufficiency in Stage III/IV Adult-Acquired Flatfoot. Podiatry Today; Vol 30 (5) May 2017; P 40-4.
42. de Cesar Netto C, Kunas GC, Soukup D, Marinescu A, Ellis S. Correlation of Clinical Evaluation and Radiographic Hindfoot Alignment in Stage II Adult-Acquired Flatfoot Deformity. Foot Ankle Int; 2018 Jul;39(7):771-779. doi: 10.1177/1071100718762113. Epub 2018 Mar 28
43. Ruffilli A, Traina F , Sandro Giannini S , Roberto Buda R , Fabrizio Perna F , Cesare Faldini C. Surgical Treatment of Stage II Posterior Tibialis Tendon Dysfunction: Ten-Year Clinical and

Radiographic Results. Eur J Orthop Surg Traumatol; 2018 Jan;28(1): 139-145.doi: 10.1007/s00590-017-2011-z. Epub 2017 Jul 11.

44. Bae WC, Ruangchaijatuporn T, Chung CB. New Techniques in MR Imaging of the Ankle and Foot. Magn Reson Imaging Clin N Am. 2017;25(1):211-225. doi: 10.1016/j.mric.2016.08.009
45. Xiao J, Cui GQ. Clinical and Magnetic Resonance Imaging Results of Arthroscopic Repair of Intratendinous Partial-thickness Rotator Cuff Tears. Chin Med J (Engl). 2015;128(11):1496-1501. doi:10.4103/0366-6999.157669
46. Choi HJ, Lee WC. Revision Surgery for Recurrent Pain after Excision of the Accessory Navicular and Relocation of the Tibialis Posterior Tendon. Clin Orthop Surg. 2017;9(2):232-238. doi:10.4055/cios.2017.9.2.232
47. Hatic 2nd SO, Philbin TM. Management of the Recurrent Deformity in a Flexible Foot Following Failure of Tendon Transfer: Is Arthrodesis Necessary? Foot Ankle Clin; 2012 Jun;17(2):299-307. doi: 10.1016/j.fcl.2012.03.007. Epub 2012 Apr 6.
48. Bai L, Han YN, Zhang WT, Huang W, Zhang HL. Natural history of sensory nerve recovery after cutaneous nerve injury following foot and ankle surgery. Neural Regen Res. 2015;10(1):99-103. doi:10.4103/1673-5374.150713
49. Tzika M, Paraskevas GK, Kitsoulis P. The accessory deep peroneal nerve: a review of the literature. Foot (Edinb) 2012; 22:232–234. [PubMed]
50. Nader A, Doty Jr R, Brodskaia A, Kendall MC, McCarthy JR. Sensory Testing of Distal Sural and Posterior Tibial Nerves Provides Early Prediction of Surgical Anesthesia After Single-Injection Infragluteal-Parabiceps Sciatic Nerve Block.