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Is chronic ACL tear a cause of adult acquired flat foot?

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ABSTRACT

Purpose: To verify the concept of adult acquired flat foot following ACL rupture by Podogram method comparing injured and non injured sides.
Material and method: From January 2017 to July 2017, Patients who had unilateral and chronic ACL rupture, confirmed clinically and on MRI, formed the material of present study. In all the patients who could stand a Podogram was obtained of foot on a Graph paper including both injured and uninjured sides. On the podograms the area occupied by weight bearing portion of foot was measured.
Results: Total number of patients studied were 23. Total number of podograms were 46. The mean value of area occupied on podogram on injured and non injured side were 115.26 and 102.36 respectively. The range of difference between the podograms of both limbs (ACL ruptured and normal) was 0.00 cm^2 −43.75 cm^2 calculated p value was 0.0109 which was statistically significant.
Conclusion: The Podogram data of ACL ruptured limb and uninjured contralateral limb are in support of our hypothesis of Adult Acquired Flat foot in ACL ruptured patients.

1. Introduction

The knee joint is the most commonly injured of the all joints and the ACL is the most common injured ligament.[1] The modern high speed vehicle trauma and sporting lifestyle has lead to increased ligament injury to the knee. The ACL is the primary stabilizer of the knee which prevents anterior translation of knee[2] and provides secondary rotational stability.[3]

In the United States The annual incidence is 68.6 per 1,00, 000 persons per year, in India no accurate statistical data available as no centralized registry to be followed but in all major centers arthroscopic ACL reconstruction is a regularly done surgery accounting for approximately 80% of post traumatic knee arthroscopy. Incidence is significantly higher in male patients than in females. Age specific pattern differs in male and female with peak incidence between 14 and 18 years in females and 14 to 25 in males.[4]

ACL insufficiency results in deterioration of the normal physiological knee bending leading to increase in anterior tibial translation, internal tibial rotation and increase in valgus instability. This leads to increased mean contact stress in the posterior, medial and lateral compartments, producing early OA changes in the knee.[5] To counter act valgus instability in ACL deficient knee, patients develop flattening of medial arch producing flat foot on the affected side. This type of adult acquired flat foot is less recognised and published studies on this peculiar aspect of adult acquired flat foot in ACL ruptured limbs are rare.

According to our knowledge and experience this is the first study of its kind. This article aims to assess twenty three cases of ACL ruptured knee, evaluated using podogram and compared with contralateral foot to find out any statistical significance. We hypothesize that there is no difference in podogram of a normal knee and an ACL ruptured knee.

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2. Material and method

This is a consecutive case study done in department of Orthopaedics, from January 2017 to July 2017. It includes 23 cases of isolated unilateral chronically ruptured (>6 months) ACL deficient knees. It also includes cases of failed ACL reconstruction. We excluded patients with multi ligamentous injury, isolated PCL injury and patients with pre existing causes of flat foot.

After taking proper history of selected patients, all patients were evaluated clinically with Lachman test, Anterior drawer test by the same senior surgeon. MRI was done for all patients.

All MRI proven ACL injured patient's podogram taken pre operatively for both the feet. For taking podogram, first both feet washed and then cleaned with spirit. After that thorough ink applied with ink pad evenly all over one foot. Then subject is asked to stand on one graph paper on plain surface with single leg stance, and footprint recorded on graph paper. Same procedure is then repeated on other side. Borders of footprint are marked on graph paper and then squares covered by foot print measured and area calculated in square centimetres (Figs. 1 and 2).

3. Results

Out of total 23 cases evaluated, 18 patients were male and 5 were female.

Maximum age was 49 years and minimum being 17 (mean age – 32.2 years). Maximum age among male patients was 47 years and minimum was 19. In female patients maximum age was 49 and minimum 17 (Table 1).

Right side was affected in 14 patients and left in 9.

Highest difference among the calculated area between affected and non affected foot was 43.75 cm^2. One patient had no difference between the affected and non affected feet.

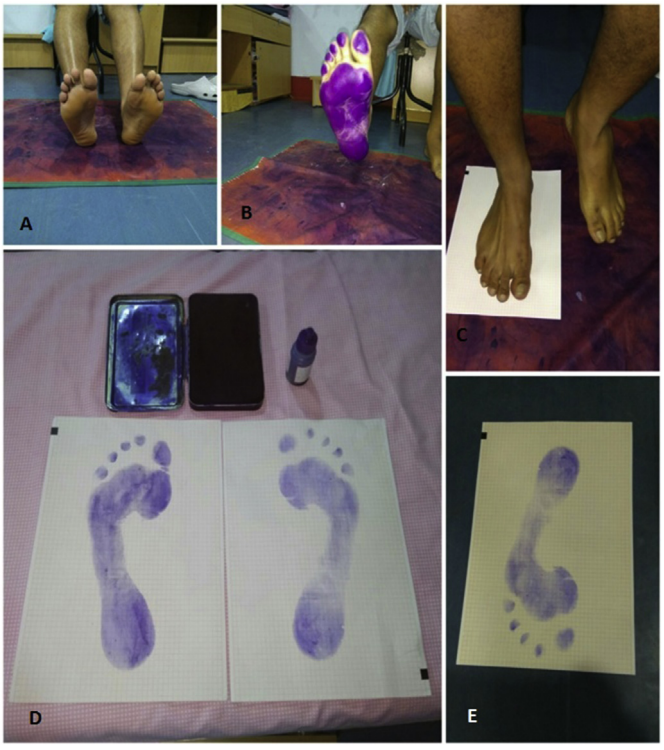

Fig. 1. 1 A-prepared feet after cleaning with spirit 1 B- ink applied thoroughly on the foot 1 C- podogram being taken with full weight bearing on one leg. 1 D & E-shows podogram of both the feet.

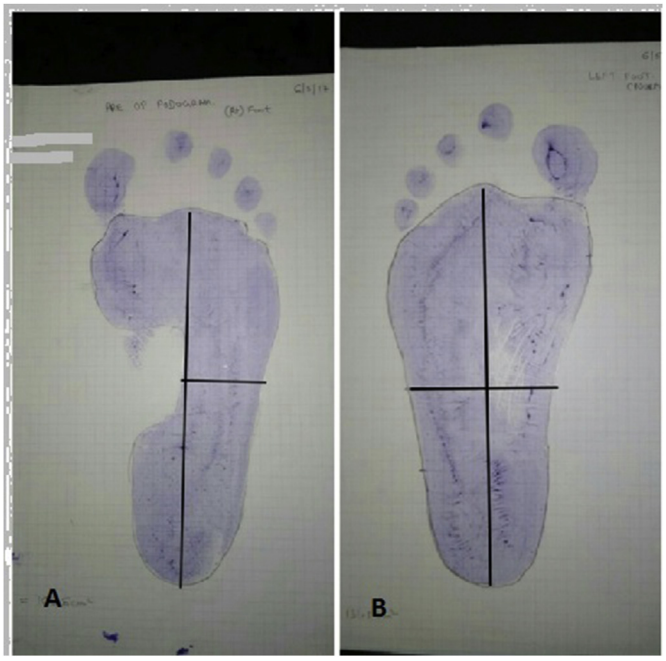

Fig. 2. 2 A-podogram of the unaffected limb measuring 106.5 cm^2 2 B- podogram of the affected limb measuring 131.5 cm^2.

In a study of 23 cases of ACl injury, after statistically analyzing data by PSPP software after using appropriate statistical test we found mean of area occupied by affected leg is 115.26 cm^2 (SD = 18.92) compared to 102.36 cm^2 (SD = 13.57) on non affected leg which comes out to be statistically significant after applying paired *t*-test (Fig. 3). Standard error of mean is 4.855 with 95% confidence interval of 3.1156 (lower) and 22.6844 (upper). P value came 0.0109, as it is < 0.05, it is statistically significant (Table 2).

4. Discussion

Several theories and anatomical variation have been described to explain pes planus like posterior tibial tendon dysfunction, tarsal coalition, inflammatory arthropathy, tarsometatarsal osteoarthritis, neuromuscular disease or traumatic dysfunction of mid foot, but after vast literature search, none of the studies has thrown light on flat foot acquired in ACL deficient knee. ACL being a common injury nowadays with increased sports injuries and road traffic accidents, it can be a measure cause of adult acquired flat foot.

Study by Paulo Cesar de Cesar[6] concluded that people having high medial longitudinal arch are more prone for ACL injury, but their study doesn't comment upon what changes occur in foot arch after ACl rupture.

Podogram has been used to assess the flat foot in many studies.[7,8] Yifang Fan[9] conducted a study using 3D foot scanning system to obtain static footprints from subjects adopting a half-weight-bearing stance.

We found only one research, conducted by Engin Cetin,[10] evaluating distribution of plantar pressure in patients who have ACL deficiency, comparing preoperative and postoperative changes. Using pedobarography they found out reduced hind foot pressure and increased mid foot pressure in ACL deficient knee. They concluded ACL-deficient patients have altered plantar pressure distributions and ACL reconstructions restore these changes to normal. They attributed this to quadriceps weakening and quadriceps avoidance gait. This increased mid foot pressure can be the cause of flat foot which we recorded in the form of increased area in

Table 1
Showing podogram area on affected and non affected side along with difference.

S. no.	Age (years)	Sex	Affected side	Pre op podogram area on affected side (cm^2)	Pre op podogram area on non affected side (cm^2)	difference	%Difference (as compared to non affected side)
1.	27	M	RT	130	125	5	4
2.	49	F	RT	88.5	78	10.5	13.46
3.	25	M	LT	109.25	107.75	1.5	1.37
4.	35	M	LT	131.5	106.5	25	23.47
5.	20	M	LT	115.4	111.5	4	3.56
6.	27	M	RT	100	96.5	3.5	3.62
7.	39	M	RT	112.5	111	1.5	1.35
8.	47	M	RT	125	117	8	6.83
9.	19	M	LT	110.5	110.5	0	0
10.	33	M	RT	145	117.5	27.5	23.4
11.	17	F	LT	89.25	85	4.25	4.7
12.	40	F	LT	85	75	10	11.76
13.	25	M	LT	115	99.75	15.25	13.26
14.	37	M	RT	142.5	122.5	20	16.32
15.	28	M	RT	117.5	109	8.5	7.79
16.	44	M	LT	131.25	99	32.25	24.571
17.	29	M	RT	122.5	110	12.5	11.36
18.	30	M	RT	150	106.25	43.75	41.27
19.	41	F	LT	91.25	82.5	8.75	10.60
20.	26	M	RT	135	101.25	33.75	33.33
21.	46	F	RT	103.375	91.75	11.62	11.24
22.	23	M	RT	99	94.37	4.63	4.92
23.	34	M	RT	101.87	96.75	5.12	5.29

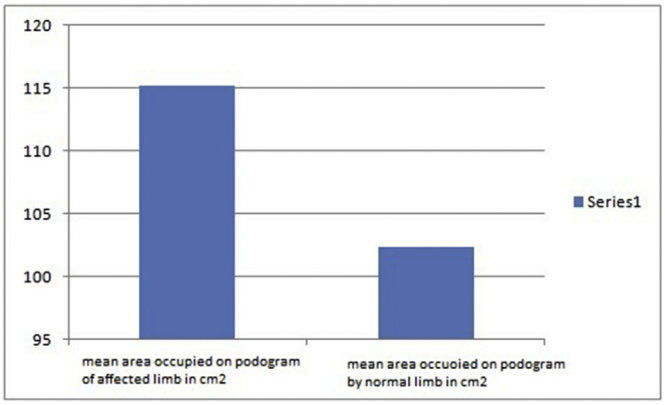

Fig. 3. Bar diagram showing mean area occupied by affected and normal limb on podogram in cm^2.

Table 2
Mean podogram area in cm^2 with Standard deviation and p value of affected and non affected foot.

	Mean (cm^2)	Sd	P value
Preoperative affected	115.26	18.92	
Preoperative non affected	102.36	13.57	0.0109

the respective podogram.

Shabani[11] et al. conducted a 3D kinematic assessment of 30 ACL deficient knee and compared them to 15 normal healthy knees. They noticed significant lower extension of the knee joint during stance phase and significant difference in tibial rotation angle. The patients with ACLD rotated the tibia more internally during the mid-stance phase. In another study done by Xiaobing Yu[12] et al. using 3D motor analysis system, results showed that flexion extension rotation angle (FERA), internal and external rotation angle (IERA) and varus eversion rotation angle (VERA) were significantly different between the ACL injury group and the healthy control group. In the swing phase of a gait cycle, knee flexion angle, tibial external rotation and varus reached maximum. In the stance phase of a gait cycle, the extension, tibial internal rotation, varus angles reached maximum. In the healthy control group, FERA, IERA and VERA varied within a narrow range, while in the ACL injury group, FERA, IERA and VERA varied at a significantly larger range.

Guoan Li[13] and co workers in their study focused more on mediolateral translation and varus-valgus rotation of knees in ACL deficient people where ACL deficiency alter both the mediolateral tibial translation and valgus –varus rotation under various loding condition, the increased medial tibial translation shifts the contact in the medial compartment towards medial tibial spine. So in our study we assumed that to compensate the knee valgus foot tries to accumulate more space and goes in flat foot position. We took podogrm before surgery so hamstring deficiency post ACL reconstruction is not contributing to additional valgus. Due to loss of ACL, instability occurs causing loss of secondary restrain to knee varus–valgus movements, which is compensated by flat foot position, or due to loss of proprioception feedback mechanism, foot require more space on ground for better stability, which is seen as a flat foot.

There are many studies on flat foot showing flat foot people are more prone for ACL injury during normal landing and deceleration. In a meta analysis Tong[14] concluded that increased lower extremity injuries are associated with both high arch and flat foot. Flat foot leading to ACL injury can be distinguished with ACL injury leading to flat foot by unilateral nature of the flat foot, difference in the area occupied by the affected and non affected on the podogram and finally by the reversal of the flat foot after ACL reconstruction.

In a long term study comparing gait and initial impact loading between healthy cohort and ACL reconstructed group, results suggest that there continues to be unresolved gait adaptations that lead to greater impact loading even after rehabilitation has been completed.[15] In another study comparing gait pattern post reconstruction states that the gait parameters shift towards the normal pattern.[16] So a long term follow up is required post ACL reconstruction to find out effect of ACL reconstruction on this type of acquired flat foot.

As with other studies, this study also has limitations. A large

sample size can add more information to this topic. As isolated chronic ACL tears are rare, a longer duration is required for study to increase the sample size. Sample size involving different demographic areas can be more beneficial. Another parameter for evaluation of flat foot can be added in the form of weight bearing radiographs. This will help in more accurate evaluation of affected and non affected limbs. Further studies with long term follow up after ACL reconstruction can throw light on whether this kind of adult acquired flat foot is reversible or irreversible after proper physiotherapy.

5. Conclusion

The Podogram data of ACL ruptured limb and uninjured contralateral limb do not support our null hypothesis. There is significant difference between the area measured on podogram between ACL deficient knee and normal knee indicating that it is a kind of acquired flat foot due to ACL rupture which causes changes in gait pattern.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jajs.2019.06.002.

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