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Comparison of femoral foot prints in acute V/S chronic ACL injury

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Abstract
The aim of this study was to determine if there is a difference in the presence of the femoral footprints (lateral intercondylar ridge and the lateral bifurcate ridge) between patients with acute and chronic ACL injuries. Our study consisted of 83 patients with acute ACL injury and 17 patients with Chronic ACL injury. The femoral footprints (lateral intercondylar ridge and lateral bifurcate ridge) were scored as either present or absent. The femoral footprints were present in 93% of the acute patients and 47% of the chronic patients. We concluded that the femoral footprints were present less often in chronic ACL patients than in acute ACL patients.

Keywords: Arthroscopy, Acute and chronic ACL Injury, Femoral footprints

Introduction

Recently, there has been an increase in interest in anatomic anterior cruciate ligament (ACL) reconstruction. This means using the native ACL insertion sites to determine the tunnel positions. It is hypothesized that this method will more closely restore the native anatomy of the ACL and improve rotational instability of the knee on pivoting activities [1].

In acute patients, the remnants of the ACL can often be seen and used to determine the location of the insertion sites. However, in chronic patients, the remnants are often (partially) absent and the surgeon has to rely on other landmarks, such as osseous landmarks, to determine the tunnel positions. The lateral intercondylar ridge is an osseous land mark that was first described by Clancy [2], who called it the residents′ ridge. It is located on the medial wall of the lateral femoral condyle, and runs from anterior to posterior with the knee in 90 degrees of flexion (operating position). Since its discovery, the ridge has been described in several anatomical studies. Purnell *et al*. concluded that it clearly demarcates the anterior-most border of the origin of the ACL [3]. Farrow *et al*. studied the morphology of the intercondylar notch in 200 human femurs and found the lateral intercondylar ridge to be present in 194 of them. Ferretti *et al*. [4] recently described an additional ridge perpendicular to the lateral intercondylar ridge, separating the anteromedial (AM) and posterolateral (PL) bundle insertion of the ACL; the lateral bifurcate ridge. It is assumed that the lateral intercondylar ridge exists because of osseous remodeling in response to stress from the ligament fibers, in accordance with Wolff's law [5]. This may be there as on why the ridge is more clearly defined in young active people, as they put more strain on their ACL. If this is true, when there is no ACL (in case of chronic insufficiency), the ridge could gradually disappear. It has been suggested by surgeons that in chronic ACL patients the ridge is less visible or not visible at all. Our hypothesis is that both the lateral intercondylar ridge and the lateral bifurcate ridge are present less often in chronic ACL patients than in acute ACL patients.

Materials and methods

This is a prospective study. Between July 2015 and June 2016, all patients that underwent ACL reconstruction at Manipal Hospital, Bangalore, after an ACL injury were included. Chronic ACL injury was defined as the patient being ACL deficient for longer than 12 months before undergoing reconstructive surgery.

Acute was defined as a time shorter than 12 months between the ACL injury and there constructive surgery. Patients with previous injury to or surgery on the ipsilateral knee were excluded. Five orthopaedic surgeons trained in sports medicine, independently reviewed the arthroscopic footage of all patients and scored the presence of the lateral intercondylar ridge and lateral bifurcate ridge as either present or absent. Patient age, gender and the surgical delay were recorded.

Results

Table 1: Demographics

n=100	mean/proportion		standard deviation	min	max
age	30.66		8.72	17	59
sex	male	83			
	female	17			
group	acute	83			
	chronic	17			
time in days	322.65		729.29	15	4680

Table 2: Fisher's exact test comparing the intra-operative appearance of femoral footprint between the two groups categorized based on time from injury to surgery (acute and chronic).

Group	Footprint		Total
	Absent	Present	
Chronic	9	8	17
Acute	2	81	83
Total	11	89	100

Pearson chi^2 (1) =36.8018 $p < 0.001$
Fisher's exact $p < 0.001$

Fisher's exact test showed a significantly higher (81/83; 97.6%) in proportion of patients in whom the femoral foot print was visualized intra-operatively amongst patients who had surgery within 12 months from injury (acute) compared to those who had surgery after 12 months of injury (chronic) (8/17). The p value for the fisher's test was < 0.001 (statistically significant).

Table 3: Logistic Regression model for comparing and predicting intra-operative visualization of femoral footprint.

Logistic regression
Number of obs = 100
LR chi^2 =27.85
Prob > chi^2 < 0.001
Log likelihood = -20.725048
Pseudo R^2 = 0.4019

Footprint	Odds ratio	Std. Err.	Z	P>|z|	[95% conf. Interval]	
Group	73.41706	82.18098	3.84	<0.001	8.184385	658.5791
Age	0.9932175	0.0399796	-0.17	0.866	0.9178702	1.07475
Sex	0.9932175	5.812603	0.97	0.334	0.2385487	68.08115
Cons	0.2708078	0.5348969	-0.66	0.508	0.0056413	13.00008

The dependent variable used was intra-operative appearance of femoral footprint as a categorical variable (yes/no). The independent/predictive variable used was a categorical variable derived from time elapsed from injury to surgery, which was categorized as acute injury (≤ 12 months) or chronic injury (> 12 months). Other covariates were baseline age and sex to adjust for potential differences in baseline characteristics. Based on the logistic regression model, the odds of finding a femoral footprint intra-operatively is about 73 times higher for the group which had surgery in ≤ 12 months (acute) compared to the group which had surgery after 12 months (chronic) and was statistically significant ($p < 0.001$) after adjusting for baseline age and sex. The overall model had good predictive power with a p value of < 0.001 (significant). The predictive power was good as shown by pseudo R squared of about 0.4019 (~ 40.19%).

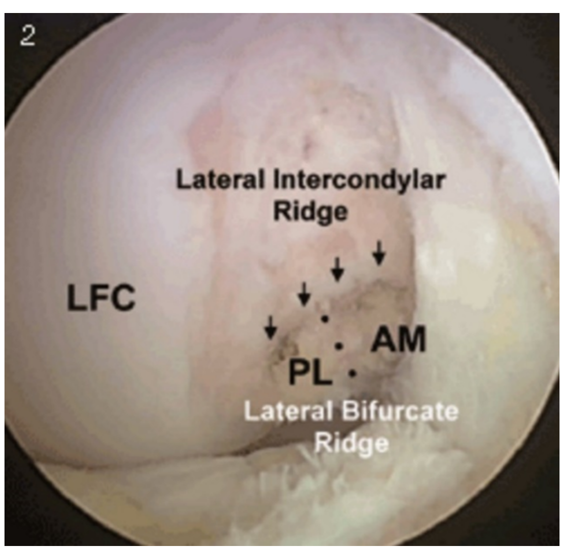

Fig 1: Intra-operative appearance of femoral footprint

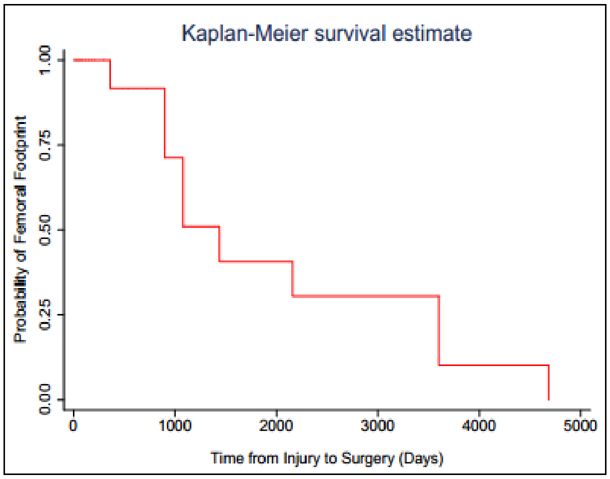

Fig 2: Kaplan Meier graph showing probability of femoral footprint with time

The Kaplan Meier estimates show that the probability of finding a femoral footprint intra-operatively reduces with increasing time from the time of injury.

Discussion

This study showed that the femoral footprint is present in 93% of acute ACL injuries and 47% of chronic ACL injuries. Farrow *et al*. [7] could identify the lateral intercondylar ridge in 97% of their specimens. However, these were femurs from a museum collection that had no soft tissue left and were studied in real time without the use of an arthroscope. It was not known if these subjects had ACL injuries.

A limitation of this study is that the presence of the footprints were determined from arthroscopic videos and five different surgeons. However, we did find good agreement for the lateral intercondylar ridge amongst the five observers. A possible explanation for this is that the observers found that this ridge was more difficult to visualize, resulting in the ridge often being scored as absent.

Another limitation of the current study is the small number of chronic patients. This is attributed to the demographics of the practice sampled in this study, which primarily consists of acute ACL injuries. On the basis of our results, we believe that the observed difference between acute and chronic patients is clinically relevant.

A strong point of this study was that it was a progressive study with no influence of gender or age on the results of this study. An explanation for the inability of the current study to find a difference in the presence of the lateral intercondylar ridge and lateral bifurcate ridge between patients with chronic and acute ACL injuries, could be that the presence of the ridges is influenced by other factors. One factor can be age. It is possible that more pronounced ridges may result as people age, due to the sustained force of the ACL on the femur for a longer period of time. Another fact or can be an individual's activity level. More active people have more force on the ACL, possibly resulting in greater ridge formation in young active people [6]. These factors were not recorded in the present study.

Surgeons who suggest that the ridge disappears may be biased by knowing the patient's history before starting the procedure. When the ACL remnants are no longer visible, it is more difficult to locate the ridges. Sometimes the ridge cannot be seen, but only felt when the wall of the notch is carefully probed [5].

The ridges are an important landmark for determining the native ACL insertion site8. In chronic injuries, when the femoral remnant has disappeared, the ridges can still be used to locate the ACL footprint. Even during ACL revision surgery, if the previous tunnel is drilled outside the native insertion site, the ridges can inform the surgeon where to place the new tunnels [9].

The ridges can also be very useful during navigation-assisted reconstruction10-13. They can even be used to locate the native ACL insertion site in an uninjured knee, using 3-dimensionally reconstructed computer tomography (CT) scans (Figure 3).

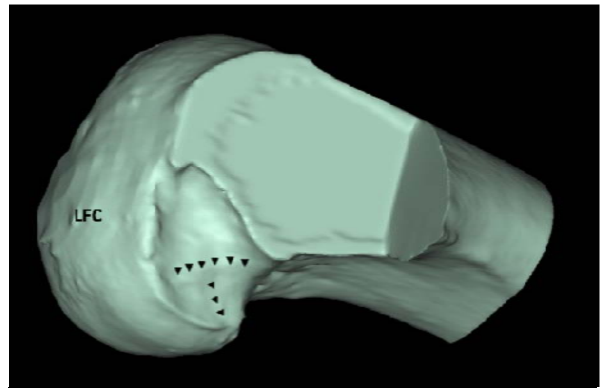

Fig 3: 3-Dimensionally reconstructed CT-scan of the right femur of a subject without ACL injury. Both the lateral intercondylar ridge and the lateral bifurcate ridge can be identified.

Conclusions

We concluded that femoral footprints (lateral intercondylar ridge and the lateral bifurcate ridge) are present less often in chronic ACL patients than in acute ACL patients. We found that the femoral footprints were present in 93% of the acute patients and 47% of the chronic patients. We believe that this difference would probably be clinically significant. This study should be expanded in the future to include patient activity level, gender differences and morphological characters. However as a general guide, it would be preferable to do an anatomical ACL reconstruction during first 12 months following injury to improve accuracy of femoral placement.

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