International Journal of Research in Orthopaedics
Athar AMA et al. Int J Res Orthop. 2018 Mar;4(2):266-270
http://www.ijoro.org

Original Research Article

DOI: http://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20180510

Comparison of tunnel widening between interference screw and suture disc fixation after ACL reconstruction using CT scan

Athar Ahemad M. A.[1]*, Anand B. Anerao[2]

[1]Department of Orthopaedics, Indian Institute of Medical Sciences and Research, Warudi, Jalna, Maharashtra, India
[2]Sahyadri Hospital, Vishnunagar, Maharashtra, India

Received: 26 January 2018
Revised: 14 February 2018
Accepted: 15 February 2018

***Correspondence:**
Dr. Athar Ahemad M. A.,
E-mail: dratharahmed@gmail.com

ABSTRACT

Background: It is important to study the cause of tunnel widening which occurs after anterior cruciate ligament (ACL) reconstruction as it may affect tendon to bone healing. Amount of tunnel enlargement that happens after different fixation methods like interference screw or suture discs needs to be compared. The objective of the study was to test the hypothesis that aperture fixation (interference screw) reduces tunnel enlargement compared to suspensory fixation (suture disc) due to reduced graft tunnel motion.
Methods: 24 bone tunnel diameters in 12 patients were evaluated by CT scan postoperatively after ACL reconstruction to measure tunnel widening. Two groups were formed, one consisting of 14 tunnels fixed by interference screws (IFS) and other consisting of 10 tunnels fixed with suture disc (SD). The difference between the two groups was compared by unpaired student's t test.
Results: The mean tunnel widening in IFS group was 0.414mm while that in the SD group was 1.23mm. The difference between the means of the two groups was statistically significant ($p<0.001$).
Conclusions: Tunnel widening phenomenon was significantly less with anatomic IFS fixation as compared to suture disc fixation probably due to reduced motion of graft within the walls of bony tunnel and consequently better graft healing.

Keywords: Tunnel widening, ACL reconstruction, CT scan

INTRODUCTION

Bone tunnel enlargement after anterior cruciate ligament (ACL) reconstruction is a widely reported complication seen with both bone-patellar tendon-bone and hamstring autografts as well as allografts.[1-5] The mechanism of tunnel enlargement is not yet fully understood. Various causes have been suggested including discrepancy between size of graft and bone tunnel, graft-tunnel motion (Wind-shield wiper effect and bungee effect), thermal necrosis of bone during drilling, early aggressive rehabilitation etc.[6-9] Tunnel enlargement is known to occur in first 6 months after ACL reconstruction and declines thereafter.[10,11] It is not seen 2 years after ACL reconstruction. No study has yet identified any effect on clinical stability or arthrometer measurements due to tunnel enlargement.[11-14] Nevertheless, long-term implications and difficulty in revision surgery are matters of concern.[14,16] With autologous hamstring grafts, extra-cortical or periosteal fixation devices like suture disc or endobutton are very popular, but they are far away from the articular surface and are associated with graft tunnel motion, and suture-stretch out leading to concerns of delayed biological incorporation, tunnel enlargement and secondary rotational and anterior instability.[5,15,17,18] Aperture fixation devices like interference screws which are close to the articular surface can allay these concerns.[19] Tunnel enlargement cannot be correctly evaluated using radiographs as they are only two-dimensional (Figure 1) and they cannot show bone tunnels in axial or oblique sections.[12,20] This is important as femoral and tibial tunnels are oblique both in sagittal and coronal planes. So, we have used CT scan to measure tunnel diameter following ACL reconstruction and compare them with intraoperative tunnel diameters. In this study, we aim to test the hypothesis that anatomic aperture fixation by interference screws will reduce the amount of tunnel enlargement when compared to suspensory extra-cortical fixations like suture disc, presumably due to reduced graft tunnel motion.

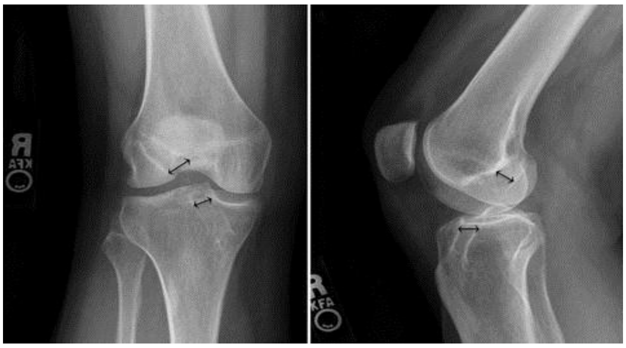

Figure 1: Radiographs depicting tunnel widening after ACL reconstruction.

METHODS

In our retrospective study, 12 patients are included who underwent an arthroscopic ACL Reconstruction with tripled semitendinousus autograft and fixed with either interference screw or suspensory extra-cortical fixations like endobutton or suture disc. The study was conducted from July 2016 to December 2017 at a rural medical college (mentioned above). The intraoperative tunnel diameter was taken from previous operative record i.e. the final reaming diameters for tibial or femoral tunnel. The bone tunnels were evaluated at follow-up with a CT scan study and tunnel diameter was measured. The difference between two measurements gives the amount of bone tunnel enlargement. A total of 24 tunnels were evaluated by CT scan and were divided into two groups. In Group A tunnels, graft was fixed with interference screw near the joint line and in Group B tunnels; graft was fixed with a suspensory fixation (endobutton or suture disc) at a distance from the articular surface. Group A had 14 tunnels and Group B included 10 tunnels. Topography films were taken with femur in anteroposterior and tibia in lateral view. Cut sections were taken perpendicular to axis of tunnel in tibia (gantry vertical) and along the axis of tunnel in femur (gantry tilted).[21,22] As the tunnels in tibia are angulated both in sagittal and coronal planes by about 50° and 30° respectively, leg was placed in internal rotation and axis of cut was placed perpendicular to that of the tunnel seen in topo CT. A circular tunnel was visualized and a cut section was taken (Figure 2). In femur, the cut was taken along the axis of femoral tunnel by angulating the CT gantry to 30 degrees in coronal plane (Figure 3). A coronal cut was taken to visualize the whole tunnel with similar diameters throughout the course of the tunnel. A mean of three measurements was taken and compared to intra-operative tunnel measurements. The part of the femoral or tibial tunnel where interference screw (IFS) is located was excluded from measurements because here, it is difficult to define the borders of tunnel and spurious enlargement can be seen due to compression of cancellous bone by IFS. Standard deviation was calculated in both groups and statistical significance was measured by *unpaired student's t-test*. All patients were operated by the same surgeon (first author) using same fixation devices and same surgical technique. Post-operative management; all patients followed an aggressive, brace-less mobilisation protocol. They were made to walk full weight-bearing on second day with aid of a walker. 'Range of motion' exercises were started immediate post-operatively. After 3 weeks, active strengthening exercises for quadriceps and hamstrings along with closed chain kinetic exercises were advised. After 3 months, agility training is introduced and return to sports allowed at 5-6 months.

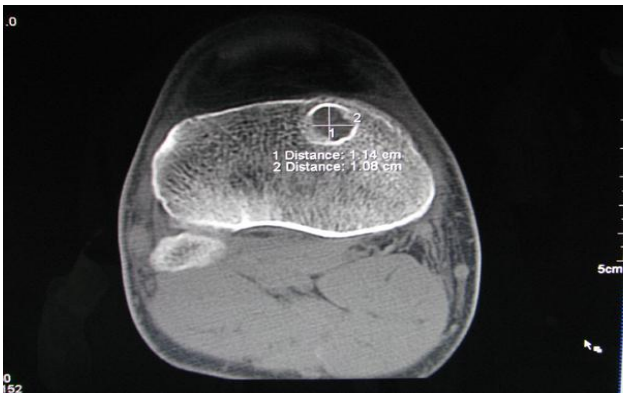

Figure 2: CT scan image showing measurement of tibial tunnel diameter to detect tunnel widening.

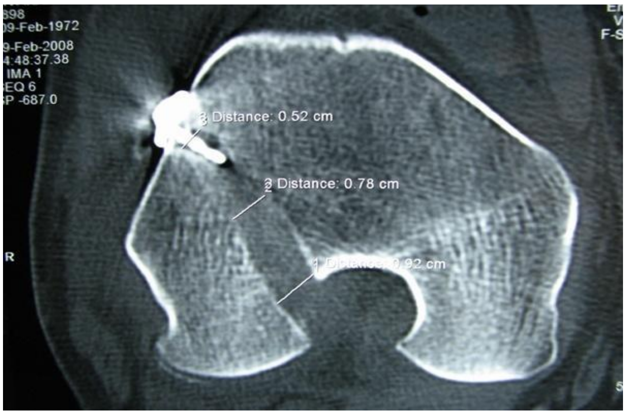

Figure 3: CT scan image showing measurement of femoral tunnel diameter.

RESULTS

Out of 12 patients in the study, a majority (8) were in the 20-30 year age group. There were 9 males and 3 females in the study (Table 1).

Table 1: Age and gender wise distribution of cases.

Particulars	No. of cases
Gender	
Male	10
Female	2
Age (in years)	
20 - 24	1
25 - 29	7
30 - 34	3
35 - 39	1

Table 2: Distribution of patients based on the side of injury.

Side	No. of cases	Percentage (%)
Left	5	41.67
Right	7	58.33

We have used a tripled semitendinosus graft for all patients. Grafts were randomly fixed either with interference screw or suture disc. In 6 cases, graft was fixed in tibial side with a suture disc and femoral side by IFS. In 4 cases, graft was fixed on both sides with IFS. In 2 cases, suture disc was used on either side of graft (Table 3). The average tunnel enlargement regardless of fixation was 0.758 mm on the tibial side and 0.508 mm on the femoral side. Reamed diameters of tibial tunnel ranged from 7.5 to 10.5 mm and femoral tunnel ranged from 6.5 to 10.0 mm.

Table 3: Distribution of patients based on fixation.

Fixation (Tibia-Femur)	No. of cases	Percentage (%)
IFS-SD	2	16.67
IFS-IFS	4	33.33
SD-SD	2	16.67
SD-IFS	4	33.33

Table 4: Distribution of patients based on surgery-CT scan duration in weeks.

Duration (in weeks)	No. of cases	Percentage (%)
2	3	25
3	5	41.67
8	2	16.67
24	2	16.67

Minimum follow-up was 2 weeks and maximum follow-up was 6 months (Table 4).

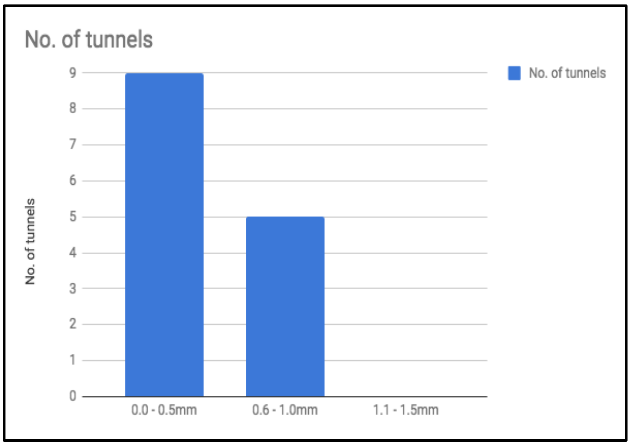

Figure 1: Tunnel enlargement with interference screw.

With interference screw fixation, out of 14 tunnels, 9 tunnels had a tunnel widening of 0 to 0.5 mm and 5 tunnels had 0.6 to 1.0 mm enlargement. Average tunnel widening with IFS was 0.414 mm (Figure 4).

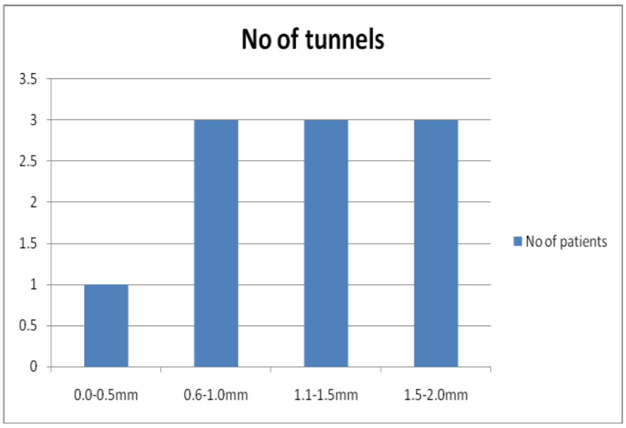

Figure 2: Tunnel enlargement with suture disc.

With suture disc fixation, (Figure 5) one patient had 0 to 0.5 mm, 3 patients had 0.6 to 1.0 mm, 3 patients had 1.1 to 1.5 mm and 3 patients had 1.5 to 2.0 mm tunnel widening. Average tunnel enlargement was 1.23 mm in this group.

The difference of tunnel enlargement between the anatomic and extra-cortical fixation groups was statistically significant (p-value<0.05) in favour of the former (Table 5). The two groups were compared by unpaired t test and the p value is less than 0.0001 ($t=5.0277$, $df=22$, std. error$=0.162$). So, greater tunnel widening was observed with suture disc fixation than with interference screw.

Table 5: Mean tunnel widening.

Group	Mean	No. of tunnels	SD	P value (Unpaired t test)
Group IFS	0.414	14	0.296	p<0.0001 (Statistically highly significant)
Group SD	1.23	10	0.499	

DISCUSSION

Tunnel enlargement is a consequence of impaired graft healing and graft healing depends on a secure fixation technique that will not allow graft to move within the bone tunnel during everyday activities.[16] Thus, graft healing, fixation technique and tunnel enlargement are inter-related. Graft fixation is the weak link of the construct until histological anchoring of the graft in the bone tunnel occurs.[23,24] In animal models, it appears that grafts with bone plugs (6 weeks) achieve histological incorporation earlier than soft tissue grafts (4 months).[25] Wieler et al showed in animal studies that reducing the relative motion between tendon and wall of the tunnel promotes the ingrowth of an intervening fibrous layer and bony trabeculae.[26] They used biodegradable IFS to reduce shear forces on the tendon within the tunnel. In a biomechanical study, Ishibashi et al demonstrated that graft fixation at the aperture reduces anterior tibial translation compared with extra-articular fixation techniques. [27] This improved stability can be attributed to an overall shortening of the fixation construct leading to reduced elastic deformation. The total length of a fixation button-graft construct is much longer than the normal ACL. This leads to longitudinal motion of the graft in the tunnel or the ‘bungee effect’.[15] Buelow, Fauno, Iorio have all concluded that there was a significant reduction of tunnel widening using fixation points close to the joint compared to the system where the distance between fixation points is long.[11,14,28] In our study also, there was significantly less tunnel enlargement (p-value) with the use of interference screw as compared to suture disc. We have observed tunnel enlargement in the early post-operative period (2 weeks) probably because we have used extraction drilling.[29,30] A possible solution to this problem may be to drill 1 mm smaller than measured graft diameter and then enlarge to appropriate diameter with a tunnel dilator.[29] Another possible cause for early tunnel enlargement may be the early aggressive, brace-less rehabilitation protocol that we have followed. Several studies have shown that non-aggressive rehabilitation can reduce micro-motion of the graft in the bone tunnel and thereby reducing synovial bathing effect which may result in tunnel enlargement.[5,14,31,32] Measuring bone tunnels by radiographs can underestimate the size of bone tunnels. CT scan accurately images the boundaries of the intra-osseous tunnels and can give axial cross-sections. CT scans are not influenced by factors of magnification and knee positioning.[14] Fink et al and Harris et al reported that enlargement occurs particularly within first 6 weeks after operation and no further increase is observed 2 years after operation.[12,33] We have also noted maximum tunnel enlargement during first 2 months after surgery.

To conclude, interference screw fixation shows lesser tunnel widening and better biological incorporation than suture disc fixation presumably due to reduction in relative motion between graft and tunnel wall.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the institutional ethics committee

REFERENCES

1. Fahey M, Indeliceto PA. Bone tunnel enlargement after anterior cruciate ligament replacement. Am J Sports Med 1994;3:410-4.
2. Hersekli MA, Akpinar S, Ozalay M, Ozkoc G, Cesur N, Uysal M, et al. Tunnel enlargement after arthroscopic anterior cruciate ligament reconstruction:comparison of bone-patellar tendon – bone and hamstring autografts. Adv Ther. 2004;21(2):123-31.
3. Otsuka H, Ishibashi Y, Tsuda E, Sasaki K. Comparison of three techniques of anterior cruciate ligament reconstruction with bone-patellar tendon-bone graft:differences in anterior tibial translation and tunnel enlargement with each technique. Am J Sports Med. 2003;31(2):282-8.
4. Zijl JA, Kleipool AE, Williams WJ. Comparison of tibial tunnel enlargement after anterior cruciate ligament reconstruction using patellar tendon autograft or allograft. Am J Sports Med. 2000;28(4):547-51.
5. L’ Inslata JC, Klatt B, Fu FH, Harner CD. Tunnel expansion following anterior cruciate ligament reconstruction:comparison of hamstring and patellar tendon autografts. Knee Surg Sports Traumatol Arthrosc. 1997;5(4):234-8.
6. Hantes ME, Mastrokalos DS, Yu J, Paesler HH. The effect of early motion on tibial tunnel widening after anterior cruciate ligament replacement using hamstring tendon grafts. Arthroscopy. 2004;20(6):572-80.
7. Hogervorst T, Van der Hart CP, Pels Rijcken TH, Toconis WK. Abnormal bone scans of the tibial tunnel 2 years after patellar ligament anterior cruciate ligament reconstruction:correlation with tunnel enlargement and tibial graft length. Knee Surg Sports Traumatol Arthrosc. 2000;8(6):322-38.
8. Nobelung W, Becker R, Merkel M, Röpke M.. Bone tunnel enlargement after anterior cruciate ligament reconstruction with semitendinosus tendon using endobutton fixation on the femoral side. Arthroscopy 1998;14(8);810-5.
9. Romano VM, Graf BK, Keene JS. Anterior cruciate ligament reconstruction:the effect of tibial tunnel

placement on the range of motion. Am J Sports Med. 1993;21(3):415-8.
10. Peyrache MD, Dijian P, Christel P, Witvoet J. Tibial tunnel enlargement after anterior cruciate ligament reconstruction by autogenous bone-patellar tendon-bone graft. Knee Surg Sports Traumatol Arthrosc. 1996;4(1):2-8.
11. Beulow JU, Siebold R, Ellerman A. A prospective evaluation of tunnel enlargement in anterior cruciate ligament reconstruction with hamstrings, extra-cortical versus anatomic fixation. Knee Surg Sports Traumatol Arthrosc. 2002;10(2):8-5.
12. Fink C, Zapp M, Benedettok P. Tibial tunnel enlargement following anterior cruciate ligament reconstruction with patellar tendon autograft. Arthroscopy. 2001;17(2):138-43.
13. Segawa H, Omori G, Tomita S, Koga Y. Bone tunnel enlargement after anterior cruciate ligament reconstruction using hamstring tendons. Knee Surg Sports Traumatol Arthrosc. 2001;9(4):206-10.
14. Iorio R, Vadala, Argento G, Di Sanco V, Ferreti A. Bone tunnel enlargement after anterior cruciate ligament reconstruction using hamstring tendons:a CT study. Int Orthop. 2007;31(1):49-55.
15. Hober J, Moller HD, Fu FH. Bone tunnel enlargement after anterior cruciate ligament reconstruction:facts or fiction? Knee Surg Sports Traumatol Arthrosc. 1998;6(4):231-40.
16. Strobel MJ. Anterior cruciate ligament. In: Manual of Arthroscopic Surgery.
17. Brucker PU, Lorenz S, Imhoff AB. Aperture fixation in arthroscopic anterior cruciate ligament double-bundle reconstruction. Arthroscopy. 2006;22(11):1250.
18. Jansson KA, Harilainen A, Sandelin J, Karjalainen PT, Aronen HJ, Tallroth K. Bone tunnel enlargement after anterior cruciate ligament reconstruction with the hamstring autograft and endobutton fixation technique:a clinical, radiographic and magnetic resonance imaging study with two years follow-up. Knee Surg Sports Traumatol Arthrosc. 1999;7(5):290-5.
19. Brown CH, Ferretti A, Conteduca F, Morelli F. Biomechanics of the swing-bridge technique for anterior cruciate ligament reconstruction. Eur J Sports Trauma Rel Res. 2001;23(2):69-73.
20. Webster KE, Feller JA, Hameister KA. Bone tunnel enlargement after anterior cruciate ligament reconstruction:a randomized comparison of hamstring and patellar tendon grafts with 2 years follow-up. Knee Surg Sports Traumatol Arthrosc. 2001;9(2):86-91.
21. Asparakhov A, Fandi G, Sumeonov I. Radiological control and assessment in arthroscopic anterior cruciate ligament reconstruction. Roentgenologia Radiologica. 1998;37:3.
22. Hoser C, Tecklenburg K, Kuenzal KH, Fink C. Post-operative evaluation of femoral tunnel position in anterior cruciate ligament reconstruction: plain radiography vs computed tomography. Knee Surg Sports Traumatol Arthrosc. 2005;13(4):256-62.
23. Scranton PE, Lanzer WL, Ferguson MS, Kirkman TR, Pflaster DS. Mechanism of anterior cruciate ligament neovascularisation and ligamentisation. Arthroscopy. 1998;14:702-16.
24. Papageorgiou CD, Ma CB, Abramowitch SD, Clineff TD, Woo SL. A multidisciplinary study of the healing of an intra-articular anterior cruciate ligament graft in a goat model. Am J Sports Med. 2001;29:620-6.
25. Tomita F, Yasuda K, Mikami S, Sakai T, Yamazaki S, Tohyama H. Comparisons of intraosseous graft healing between the doubled flexor tendon graft and the bone-patellar tendon-bone graft in anterior cruciate ligament reconstruction. Arthroscopy. 2001;17:461-476.
26. Weiler A, Hoffman RFG, Stahelin AC, Bail HJ, Siepe CJ. Hamstring tendon fixation using interference screws- A biomechanical study in calf tibial bone. Arthroscopy 1998;14:29-37.
27. Ishibashi Y, Rudy TW, Liveay GA, Stone JD, Fu FH, Woo SL. The effect of anterior cruciate ligament graft fixation site at the tibia or knee stability: Evaluation using a robotic testing system. Arthroscopy. 1997;13:177-82.
28. Fauno P, Kaalund S. Tunnel widening after hamstring anterior cruciate ligament reconstruction is influenced by type of graft fixation used;A prospective randomized study. Arthroscopy. 2005;21(11):1337-41.
29. Ugutman E, Ozkan K, Gruven M, sener N, Altintas F. Early tunnel enlargement after arthroscopic anterior cruciate ligament reconstructions. Acta Orthop Belg. 2007;73(5):625-9.
30. Gokce A, Beyzadeogle T, Ozyer F. Does bone impaction technique reduce tunnel enlargement in anterior cruciate ligament reconstruction. Int Orthop 2008.
31. Clatworthy MG, Annear P, Bulow JU, Bartlett RJ. Tunnel widening in anterior cruciate ligament reconstruction:A prospective evaluation of hamstring and patellar-tendon grafts. Knee Surg Sports Traumatol Arthrosc. 1999;7(3):138-45.
32. Yu JK, Paessler HH. Relationship between tunnel widening and different rehabilitation procedure after anterior cruciate ligament reconstruction with quadrupled hamstring tendons. Chin Med J (Engl). 2005;118(4):320-6.
33. Harris NL, Indelicato PA, Bloomberg MS. Radiologic and histologic analysis of tibial tunnel after allograft anterior cruciate ligament reconstruction in goats. Am J Sports Med. 2002;30(3):368-73.

Cite this article as: Athar AMA, Anerao AB. Comparison of tunnel widening between interference screw and suture disc fixation after ACL reconstruction using CT scan. Int J Res Orthop 2018;4:266-70.