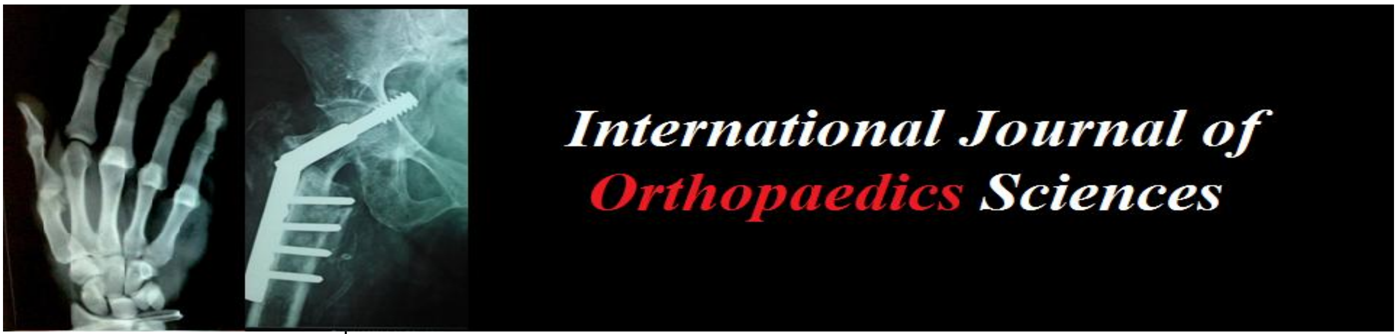
International Journal of Orthopaedics Sciences 2018; 4(1): 160-163



ISSN: 2395-1958
IJOS 2018; 4(1): 160-163

www.orthopaper.com
Received: 24-11-2017
Accepted: 25-12-2017

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Bone tunnel widening following arthroscopic reconstruction of anterior cruciate ligament (Acl) using hamstring tendon autograft and its functional consequssences

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DOI: https://doi.org/10.22271/ortho.2018.v4.i1c.24

Abstract
Background: To evaluate the correlation between bone tunnel diameter following Anterior cruciate ligament (ACL) reconstruction measured by computed tomography (CT) using multiplanar reconstruction (MPR) and functional outcome.
Materials and methods: This study is a prospective study. Fifteen patients (14 men and 1 women, with mean age 30.27 years) who had undergone ACL reconstruction with hamstring tendon auto graft had subsequent CT scan during their follow up (mean follow up is 11.27 months) were included in this study. The diameter of both tunnels (femoral and tibial) were measured using MPR (multiplanar reconstruction) technique. Functional outcome was evaluated with International Knee Documentation Committee grade. Statistical analysis of the correlation between the diameter of the tunnels and IKDC grade were investigated.
Results: The tibial and femoral bone tunnels were found to be significantly widened. There was no significant correlation between the diameter of bone tunnels and functional outcome (IKDC grade).
Conclusion: Neither the diameter nor its widening during interval follow-up is correlated with functional outcome (IKDC Grade).

Keywords: ACL reconstruction, Hamstring tendon autograft, Tibial tunnel, femoral tunnel, Bone tunnel widening

Introduction
Although the incidence is unknown and variable occurrence has been documented in the literature, bone tunnel widening after anterior cruciate ligament (ACL) reconstruction is well established [1, 2, 3, 4, 5, 6]. It occurs predominantly during the first six months after surgery and has been documented up to two years postoperatively [1, 3, 7, 8, 9, 10]. Some authors report a decrease in tunnel diameter three years after surgery [3].
Although many studies showed no effects of bone tunnel widening on clinical outcomes or objective laxity [3, 5, 8, 9, 11, 12, 13, 14], a few investigations demonstrated that it might be associated with anterior knee laxity and an early sign of graft failure [15, 16]. Thus, the clinical significance of bone tunnel widening has not yet been fully established and is still unclear.
Bone tunnel widening has usually been assessed with plain radiographs [17] but it is not enough to evaluate bone tunnels exactly with plain radiographs. Although a number of studies used cross-sectional imaging tools such as computed tomography (CT) or magnetic resonance imaging (MRI) to evaluate bone tunnel widening [12, 13, 17], they could not measure the tunnel diameters exactly because they used only conventional orthogonal planes, which could not be parallel or perpendicular to the axes of the bone tunnels. As such, we decided to conduct this study using CT with multiplanar reconstruction (MPR) along the axis of each tunnel in patients who underwent ACL reconstruction with hamstring tendon autograft. The aim of the study was to evaluate the correlation between the bone tunnel diameters in patients who had undergone ACL reconstruction with hamstring tendon autograft measured by CT using MPR, and their functional outcome (IKDC grade).

Materials and methods

This study is a prospective cohort study. 15 patients who had undergone primary arthroscopic ACL reconstruction using hamstring tendon autograft between July 2015 and September 2016 were included in this study. In a total of 15 patients, eleven were males and one was female. The mean age of the patients was 30.27 years (range: 21-47) at the time of surgery. The patients received a CT during their post-operative follow up. CT images were evaluated for the location and angle of bone tunnel in addition to evaluating the postoperative complications.

Arthroscopic procedure

All ACL reconstructions were performed by a trained arthroscopic orthopaedic surgeon. Preparation and arthroscopic examination were performed in the usual manner. From anteromedial and anterolateral portal arthroscopic view, the femoral footprints of the ACL were carefully defined by the ACL remnant or bony anatomy, and the centers of each footprint were marked with a microfracture awl. After arthroscopic examination, the semitendinosus tendon graft was harvested, and prepared as a graft. The drill diameters of the femoral and tibial tunnels were decided based on the diameter of the prepared graft. The ACL was reconstructed using trans portal technique and graft was fixed by an endobutton for the femoral side and titanium interference screws for the tibial side.

CT Imaging and Evaluation

CT assessments were performed with the help of radiologists. The reconstructed CT data were loaded into a workstation. MPR and measurements were accomplished simultaneously with dedicated software. At first, reformatted images were displayed in the axial, coronal, and sagittal planes automatically on the viewer. Radiologists made dedicated longitudinal planes according to each bone tunnel (femoral and tibial) using MPR tools. The diameters of tibial tunnel were recorded at five points and their mean value was considered as the diameter of tibial bone tunnel and the diameters of femoral tunnel (maximal diameter) were recorded at three points and their mean value was considered as the diameter of femoral bone tunnel (Image1: tibial tunnel measurement, Image 2: femoral tunnel measurement).

Image 1: Tibial tunnel measurement

Image 2: Femoral tunnel measurement

Clinical Assesment

To evaluate functional outcome, bilateral knee joints were examined and scoring was done with International Knee Documentation Committee evaluation form. The functional outcome of Arthroscopic reconstruction of ACL using variables were analysed which include Knee effusion, Passive motion deficit, Ligament examination, Compartment findings, harvest site pathology, X-ray findings and Functional tests. Based on the above variables, the final grade of the injured knee was obtained. (Grade A – normal, Grade B – Nearly normal, Grade C – Abnormal, Grade D – Severely abnormal)

Statistical analysis

The statistical analysis was done with Independent samples test after adjustment for patient sex, age, side (right/left), and follow up month at which CT was taken. Corrected p values [sig. (2- tailed)] less than 0.05 were regarded as statistically significant. Using independent T-test there is no statistically significant difference between the functional outcome and mean femoral diameter and mean tibial diameter at $p>0.05$.

Results

Table 1 shows the mean diameters of each bone tunnel and month at which postoperative CT was taken (range: 6-14 months. Mean: 11.27 months, SD: 1.870). IKDC grading was done to each patient and 11 patients had Grade A (normal knee) and 4 patients had Grade B (nearly normal knee). There were no patients with grade C (abnormal knee) and Grade D (severely abnormal). The association between the femoral and tibial bone tunnel diameter and IKDC final grade which were analysed using t- test revealed no significant relationship, Corrected p values [sig. (2- tailed) values are 0.502 and 0.119] were more than 0.05.

Table 1: Mean femoral and tibial bone tunnel diameters at follow up and their functional outcome (IKDC Grade)

Patient	Age	Sex	Side	Ct At Follow Up Month	Diameter of Femoral And Tibial Bone Tunnels While Reaming(Cm)	Mean Femoral Diameter (Cm)	Mean Tibial Diameter (Cm)	Functional Outcome (Final Grade With Ikdc Score)
Patient no 1	27	M	Left	14 months	0.8	1.201	1.0468	A
Patient no 2	26	M	Right	12 months	0.9	1.220	1.1444	A
Patient no 3	21	M	Right	11 months	0.8	1.216	0.9368	A
Patient no 4	36	M	Right	10 months	0.8	1.166	0.9148	B
Patient no 5	29	F	Left	12 months	0.8	1.264	1.0351	A
Patient no 6	23	M	Left	12 months	0.8	1.440	0.9246	A
Patient no 7	24	M	Right	11 months	0.9	1.376	1.0034	A
Patient no 8	26	M	Left	14 months	0.8	1.291	0.9931	A
Patient no 9	41	M	Left	11 months	0.8	1.245	0.9861	B
Patient no 10	47	M	Left	11 months	0.8	1.362	0.9796	A
Patient no 11	34	M	Right	6 months	0.8	1.408	1.0006	B
Patient no 12	26	M	Right	12 months	0.9	1.204	0.9962	A
Patient no 13	41	M	Right	10 months	0.9	1.279	1.0922	A
Patient no 14	29	M	Left	12 months	0.8	1.178	0.9714	B
Patient no 15	24	M	Right	11 months	0.8	1.275	1.0087	A

Discussion

The principal findings of this study were that the femoral and the tibial bone tunnel were significantly widened on follow-up CT and that the diameters of the bone tunnels on follow-up CT were not correlated with functional outcome (IKDC grade).

Bone tunnel widening is well established after ACL reconstruction; however, its etiology is still unknown, and a multifactorial process including biological and mechanical theories has been proposed as an explanation [2, 3, 4, 5, 6, 18]. Biologic factors include increased cytokine levels caused by the immune response or inflammatory response caused by synovial fluid leakage within the bone tunnel [1, 2, 19]. Mechanical factors include the types of graft and devices, the location of the graft, and the presence and degree of stress shielding proximal to the interference screw that results in bone resorption [2, 3, 4, 18]. Although bone tunnel widening with fibrotic tissue proliferation has been known to be a clinically significant finding that may complicate revision surgery, many clinical studies failed to demonstrate an association between bone tunnel widening and instability or prevalence of post-traumatic osteoarthritis after ACL reconstruction [1, 2, 3, 18, 20]. In terms of imaging modality, conventional radiographs and CT have been studied [1, 12, 13, 17]. In daily practice, measuring bone tunnel diameter has been subjective with the use of conventional radiographs. They are widely used as the primary modality, but they cannot show the bone tunnel consistently because they only provide two-dimensional images [2, 21]. Although CT imaging has been regarded as a reliable imaging modality for evaluating ACL bone tunnels, MPR for the axis of each bone tunnel is mandatory for exact measurement [22]. To the best of our knowledge, there have been only a few studies attempt to evaluate bone tunnel widening using MPR with CT images. The current study showed no statistically significant correlations between diameters of the bone tunnels on follow-up CT images and functional outcome (IKDC grade) with a mean follow-up of 11.27 months (range: 6-14 months); these results are similar to those from previous studies.

This study has a number of limitations. First, variable follow-up periods could have resulted in low correlations between measurements and clinical scores. Second, only 15 cases were included because of the limitations of patients with ACL insufficiency demanding surgery. Third, the lack of a long-term follow-up is also a limitation. Fourth, we could not evaluate the nature of bone tunnel widening such as bone tunnel cyst formation or fibrosis. Finally, we could not evaluate the status of ACL grafts and other structures such as cartilage, meniscus, and other ligaments that could influence clinical outcome.

Conclusion

Neither the diameter nor widening of bone tunnel during the interval follow-up is correlated with functional outcome following arthroscopic reconstruction of anterior cruciate ligament using hamstring tendon autograft.

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