Original article

Tibial & femoral tunnels parameters in arthroscopic ACL reconstruction by transtibial & transportal technique with capture of ACL femoral footprint

[1]DR. Manocha RK, [2]DR. Bhoumik ID, [3]DR. Modi V

[1]Additional Chief Health Director-Orthopaedic Surgeon/NRCH

[2]DNB – Orthopedics, Northern Railway Central Hospital New Delhi Name of the Institute/college:

[3]DNB – Orthopedics, Northern Railway Central Hospital New Delhi NORTHERN RAILWAY CENTRAL HOSPITAL, Department Of Orthopaedics, Northern Railway Central Hospital, Basant Lane, New Delhi-110055

Corresponding author : DR MANOCHA RK

ABSTRACT

Objective: To study tibial & femoral tunnels parameters in arthroscopic ACL reconstruction by transtibial & transportal technique with capture of ACL femoral footprint.

Methods: 75 clinico-radiological cases of ACL tear with definitive clinical symptoms of knee instability, underwent arthroscopic ACL reconstruction. Inclusion parameter was positive capture of footprint with femoral tunnel mouth within the native foot print. 11 cases were excluded because either the native foot print was not delineated or surgeon failed to completely contain the mouth of femoral tunnel within the delineated foot print. 64 patients, 32 in each group were enrolled into the study.

Results: There were statistically significant differences in length of Femoral Tunnel, Obliquity of Femoral tunnel as well as Femoral Tunnel Placement in reference to Blumensaat line. Likewise Tibial Tunnel Angle in AP & Lateral View as well as Tibial tunnel placement anteroposterior is also statistically significant.

Conclusion: Results indicate that while it is positively possible to capture Femoral footprint by both Transtibial and Transportal methods, statistically significant differences in tunnels parameters indicate that tunnels follow different trajectories in the bones by two methods and a surgeon must understand these differences to achieve predictable Femoral footprint capture.

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Keywords: ACL Reconstruction; Transtibial & Transportal Technique; Capturing Femoral Foot Print; Tibial & Femoral Tunnels; X-ray Parameters

INTRODUCTION

Arthroscopic surgical technique by which to prepare Femoral sockets that respect the native ACL anatomy remains controversial. Significant differences exist between femoral and tibial sockets as prepared by Transtibial and Transportal ACL reconstructions and are evident on Xrays. However, despite obvious differences in tunnels, most studies show no statistically significant difference in clinical outcomes as assessed by Improvements in grades of clinical tests of Instability or Functonal Scores[1, 2,3,4]. Transtibial Techniques has several described advantages viz. technically less demanding, shorter operative time with less chances of blow out of posterior wall of femur and a long femoral tunnel length but continues to be vilified on account of leading

to improper insertion site and making reconstructed ACL vertically oriented which is thought to impart less rotational stability[5].

Technical modifications to transtibial technique have been described in an effort to improve femoral tunnel obliquity and capture of the native femoral ACL footprint. Howell et al[6] recommended creating a tibial tunnel at a coronal angle of 65 to 70 degree to achieve sufficient tibial and femoral tunnel obliquity. Chhabra et al[7] reported that a tibial starting point at the midpoint between the tibial tubercle and posteromedial corner achieved a coronal angle of approximately 70 degrees. Heming et al[8] remarked that a TT technique could produce tunnel centred in the both the tibial and femoral footprint but only if a starting point prohibitively close to the joint line with a correspondingly short tibial tunnel were used.Despite technical modifications, concerns persist about the ability to capture the femoral ACL footprint with a Transtibial technique.[9] This study is conducted on an belief that capture of Femoral ACL footprint requires different *Coronal Plane Angle, Sagittal Plane Angle and Sagittal Plane Placement* of both Tibial & femoral Tunnels when using Transtibial & Transportal techniques and an understanding as to how these parameters differ in all such cases where arthroscopist actually captured femoral footprint may help a predictable capture of footprint by either technique

METHODS

75 clinico-radiological cases of ACL tear with definitive clinical symptoms of knee instability, underwent arthroscopic ACL reconstruction between April 2016 to July 2018. Attempt was made to identify Native femoral footprint in all cases and boundaries were clearly delineated. Inclusion criteria was a femoral socket mouth opening lying within the native ACL foot print. The cases were randomised by simple random method in to two groups and ACL reconstructions were done by Transtibial or Transportal technique. Transportal patients were taken as control because tibial as well as femoral tunnels could be chosen independent of each other whereas Tibial Tunnel placement was required to be finetuned in Transtibial technique such that would allow placement of subsequent femoral tunnel mouth within Native foot print.

11 cases were excluded because either the native foot print was not delineated or surgeon failed to completely contain the mouth of femoral tunnel within the delineated foot print. 64 patients, 32 in each group were enrolled into the study. X-rays were evaluated at 6 months follow up and various measurements were made in reference to mid-diaphyseal axis in femur and articular surface (Joint line) in Tibia (as illustrated in Figure 1). Following measurements were made

- Femoral Tunnel Angle, Tibial Tunnel Angle, Tibial Tunnel Placement in AP view.
- Femoral Tunnel Placement, Tibial Tunnel Angle and Tibial Tunnel Placement In Lateral view

The variables were compared between Transportal and Transtibial groups.

RESULTS

Tibial Tunnel Angle in AP view was 67.34 in Transportal and 53.16 in Transtibial, difference being statistically significant($p<0.01$) implying that external starting point of Tibial tunnel needs be placed more medially in Transtibial technique. The mean femoral tunnel length for Transportal technique was 33.38 mm and Transtibial was 39.25 mm and the difference between the two was statistically significant ($p< 0.001$).

Femoral Tunnel Angle in AP view showed statistically significant difference($p<0.01$) between Transportal and Transtibial groups; 37.73 degree & 33.28 degree implying that Femoral tunnel attained by Transtibial technique tends to be more vertical by approx. 4.5 degrees

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On lateral view, the Tibial Tunnel Angle showed a significant difference between Transportal and Transtibial groups, 53.62 degree in Transportal and 63.13 degree in Transtibial ($p<0.01$).

The mean Tibial Tunnel Placement in lateral view from anterior edge was 33.52% in Transportal and 48.34 % in Transtibial ($p<0.01$) implying tibial tunnel mouth is placed significantly posteriorward in Transtibial Technique.

Femoral Tunnel Placement in lateral view in postoperative period showed a statistically significant difference between Transportal and Transtibial groups 20.96% and 28.40%($p<0.01$).

DISCUSSION

ACL reconstruction with the Transportal[4] technique is said to have several advantages such as; the independent preparation of femoral and tibial tunnels, which thus could be placed in the center of native insertions of ACL at both tibial and femoral sites; more horizontal placement of the graft thereby decreasing the possibility of graft impingement limiting the need of Notchplasty: allowing drilling of femoral tunnel without the need of specific instrument, and reducing the difficulties of revision surgeries[3,4]. Whether these advantages translate in better clinical and functional outcomes continues to remain controversial because while only a few studies suggest better results[10] many other studies show no statistically significant difference[1,,2,3,4].

The Transportal technique has some disadvantages too; learning curve and duration of surgery is prolonged, short femoral tunnel (25–30 mm) may occur if the knee is not flexed adequately, flexed position obstructs 'over the top view' besides obstructing flow of irrigation fluid, the cartilage of the medial femoral condyle may sometimes get damaged during reaming through anteromedial portal, posterior wall of the lateral femoral condyle may sometimes get fractured (blow-out), the posterolateral structures including the peroneal nerve may sometimes get damaged.[3,9]

Advantages of Transtibial Technique has been described in introduction but the most of criticism is on account of non-physiometric sites of attachment resulting from failure to capture the femoral footprint because of constraints imposed by an already drilled tibial tunnel. While it is positively possible to capture femoral footprint through an appropriately constructed tibial tunnel, construction of such tunnel is mostly guestimate and can potentially lead to inaccurate trajectory. So, guidelines to construct an appropriate tunnel are of critical importance. Existing guidelines refer only to coronal plane angle of drilling and no recommendations exist regarding sagittal plane trajectory of the suitable tunnel. Errors often therefore occur in its sagittal trajectory leading to an anterior or vertical placement of graft, exposing an otherwise a good surgical technique to an undeserved criticism.

In our study, we found that two technique do in fact lead to similar functional outcomes; and femoral insertion of reconstructed ACL can be placed within the native footprint of ACL by either technique. In this study we have included only those cases where femoral footprint was adequately identified and we were able to place the femoral tunnel mouth completely within the Footprint.

Primary objective of this study was evaluation of radiological parameters of tibial tunnels, to understand how exactly the two techniques differed in placement of Tibial tunnels, when only those cases were included wherein the arthroscopist was able to place the femoral tunnel within the native footprint. The goal was to deduce guidelines to the usual inclinations and placements of Tibial tunnels in both coronal and sagittal plane which would permit predictable Femoral Footprint capture. Considering that in Transportal technique the two tunnels are made independently, Transportal group acts as a control group.

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Heming et al[8] was apprehensive that a TT technique could produce tunnel centered in both tibial and femoral footprint only if a starting point prohibitively close to the joint line with a correspondingly short tibial tunnel were used. His assertion of "prohibitively close" was not explained but with the first 10-15 cases we quickly realised that a tunnel as per suggestion by Howell et al or Chhabra et al and attempting to capture the center of both tibial and femoral footprint placed the starting point so close to the joint line and so medially as to always violate MCL in at least its anterior half (Figure 2 Shows Tibial tunnel created following the existing recommendations). It was amply clear that this trajectory even though did allow an acceptable low attachment on femur being at around 2 ½ O' clock (in left knee: 9 ½ O' clock in right knee) but the tunnel still continued to remain shallow/Anterior with its posterior periphery remaining still variably quite anterior, and only occasionally behind resident ridge. This impression of ours is in agreement with Brophy et al[11] and Pearle AD et al[12] who reported that the traditional arthroscopic TT technique predisposes patient to a "mismatch graft position from the postero-lateral tibial footprint to the antero-medial femoral footprint.

Capturing centre (50% point in both anterior-posterior and superior-inferior directions) of native femoral foot print in Transportal technique is independent of any tibial tunnel trajectory/orientation for obvious reasons. In Transtibial Technique, when we followed the existing guidelines the centre used to lie at best between 20% to 30% mark (superiorly & anteriorly) and led to violation of the Superficial MCL. The tunnel after reaming often ends up partly outside the native foot print. While clinical significance of such partial violation of MCL needs to be studied with a separate study, a violation of a normal ligament is undesirable in any case, and particularly so when patient has been reported some sprain of MCL already in radiological studies.

In our control (transportal group), wherein we stuck to the centre of Tibial foot print, the internal centre of tibial tunnel lies at about 33.5% of anteroposterior depth of Tibial articular surface whereas in our Transtibial group where we modified the trajectory so as to avoid violation of MCL and positively captured the native femoral foot print between 30-50% (centre or off-centre by only so much as to allow the tunnel finally to still lie within the foot print) placed the internal centre of tibial tunnel at mean of 46% of anteroposterior depth of Tibial articular surface, a good 12.5% further back than the centre of tibial foot print. Figure 3 shows the trajectory of Tibial tunnel with sagittal placements as described to avoid violation of MCL. A Transportal Tunnel X ray (Figure 4) is also shown for ready reference.

During actual execution of this modification during surgery, we have noticed that posterior free margin of lateral meniscus was reliable and good guide for centre of native tibial foot print for Transportal Group but in Transtibial Group one needed to go further back to almost start abutting PCL with ACL Tibial Guide with estimated posterior margin of tunnel just anterior to the posterior meniscus root of Lateral Meniscus. This implies that the final chosen tibial tunnel trajectory in transtibial technique tends to place the internal tibial exit point further back (in posterior part of Tibial foot print and never in the center).

It was satisfying to note that despite this posterior placement, our mean tibial tunnel placement was still in accordance with recommendations by Pinczewski et al[15] being "not equal or more than 50%". Pinczewski cautioned that placement of tibial tunnel greater than and equal to 50% posterior to the anterior tibial plateau can lead to loss of knee flexion and rupture of graft. We believe that far posterior tunnel leads to impingement with PCL and if tunnel reaches nearer PCL it may be worthwhile to place the tunnel somewhat lateral in interspinous area nearer LM root than nearer PCL.

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This modification in the trajectory of tibial tunnel led to the reduction of coronal angle to about 53±10 Degree (as measure in reference to joint line) against the suggested 70 Degree and prevented the violation of MCL. Our analysis also suggested that a sagittal plane angle of 63±8 Degree may also be necessary to be adhered to, to place tibial tunnel mouth at appropriate place.

Similarly, the femoral tunnel placement in Transportal and Transtibial in X-ray in lateral view, a proxy to assess shallow-deep placement of Femoral tunnel showed a statistically significant difference among groups with mean values of 20.96% ± 2.66 in Transportal and 28.40% ± 6.25 in Transtibial. Transtibial values indicate that tunnels were anterior to what we chose to make in the control (Transportal) group by a mean of 8%. It is understanding of authors that Transportal definitely permits farther back (Deep) as well as much lower internal attachment compared to what can be achieved by Transtibial Technique. Despite relative anterior location of Transtibial femoral site, the values in both groups were well within limits suggested by Nema Sandeep et al[16] who suggested a desirable femoral tunnel placement at an average of 30.59% ± 10.77 % anterior from the posterior femoral cortex. Our values attained by either technique are remarkable much more favourable that suggested by Nema Sandeep et al.

A lesser Femoral Tunnel mean angle @ 33.28 degree in Transtibial group compared to Transportal controls: difference is statistically significant, indicates that despite all adjustments and positive capture of Femoral foot print in all cases, verticality of the femoral tunnel may be inevitable. Considering that, it is the internal point where the graft enters the femoral socket which is important for function and kinematics, this verticality may have been overly criticised. So far as the trajectory of intraarticular part of graft is from within Tibial foot print to within Femoral footprint, tunnel trajectory within the bones may be of no consequence.

In conclusion we submit as below

1. It is perfectly possible to so adjust the Tibial Tunnel Trajectory that the surgeon may capture ACL femoral footprint, while still remaining within tibial foot print, in a reliable and predictable manner even by Transtibial technique without coming “prohibitively” close to joint line or causing any MCL damage.
2. Capturing Femoral foot print requires the surgeon to make the trajectory more horizontal & medial (coronal angle of 53±10) in frontal plane and internal exit point located back in sagittal plane such that the Intraarticular Tibial exit point comes to be located at approximately 46% of the distance from anterior to posterior with sagittal plane angle of 63±8 degrees. It is the impression of the authors of this study that this tends to place the internal point almost always past the prominence of Medial Tibial Spine, with posterior periphery of tibial tunnel anterior to the Posterior Meniscus root of LM.

LIMITATIONS

Here it must be mentioned that our modification of Tibial Tunnel Dependent (Transtibial) Technique allows both internal attachments at tibia and femur to be within footprints but neither is dead center. During early part of this study, when we were attempting to be centre in both femoral and tibial foot prints, we were creating tibial tunnel with coronal angle of 70 degree. It was only after about 7-8 cases (in both techniques) when we started making our modification to prevent violation of MCL by placing the tibial tunnel at less acute angle in coronal plane and making adjustment in sagittal plane to still ensure femoral foot print capture while still remaining within tibial foot print. Measurement of these cases may have affected mean values to some extent.

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Table 1- RADIOLOGICAL PARAMETERS OF FEMORAL & TIBIAL TUNNELS

	TECHNIQUE	N	MEAN	STD. DEVIATION	T VALUE & P Value
FEMORAL TUNNEL ANGLE-AP	TRANSPORTAL	32	37.734	1.7523	-9.712 P<0.001
	TRANSTIBIAL	32	33.284	1.9098	
FEMORAL TUNNEL PLACEMENT (LATERAL)	TRANSPORTAL	32	20.9656	2.66925	-6.183 P<0.001
	TRANSTIBIAL	32	28.4031	6.25931	
TIBIAL TUNNEL PLACEMENT-LATERAL	TRANSPORTAL	32	33.5219	2.29723	-7.959 P<0.001
	TRANSTIBIAL	32	46.3406	10.27885	
TIBIAL TUNNEL ANGLE-AP	TRANSPORTAL	32	67.347	4.0937	7.561 P<0.001
	TRANSTIBIAL	32	53.166	9.7878	
TIBIAL TUNNEL ANGLE-LATERAL	TRANSPORTAL	32	53.6250	2.46838	-6.100 P<0.001
	TRANSTIBIAL	32	63.1375	8.46963	

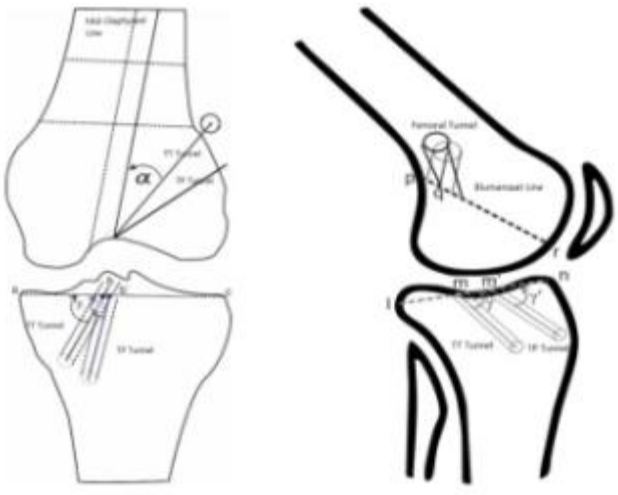

Figure 1- Outline diagram of knee joint AP and lateral view showing various radiological measurements. α = AP Femoral Tunnel Angle with Mid-diaphyseal Line β = AP Tibial Tunnel Angle pq/pr = Lateral Femoral Tunnel Placement mn/ln = Lateral Tibial Tunnel Placement γ = Lateral Tibial Tunnel Angle

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A


B


C

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