TRANSTIBIAL VERSUS INDEPENDENT FEMORAL TUNNEL DRILLING TECHNIQUES FOR ARTHROSCOPIC ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION EVALUATION OF FEMORAL APERTURE POSITIONING

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ABSTRACT:

Background: *Although numerous clinical and cadaveric studies have compared transtibial (TT) versus tibial independent (TI) either anteromedial (AM) portal or Outside-in (OI) drilling techniques regarding anatomic femoral tunnel aperture placement in single bundle anterior cruciate ligament reconstruction (ACLR), there is no consensus on which technique offers the best anatomic position according to footprint position.*

Aim of the Work: *The aim of this study is to conduct a systematic review and meta-analysis for studies comparing the anatomical position of femoral tunnel aperture in single bundle ACLR using TI and TT techniques.*

Methods: *(PubMed, Cochrane library and Google Scholar) were searched for relative studies that evaluated femoral tunnel aperture position in patients and cadavers underwent arthroscopic single bundle ACLR. Meta-analyses were performed to pool 28 studies included in 15 outcomes measuring femoral tunnel aperture position by estimating the mean differences and their 95% confidence intervals from mean and standard deviation for each study.*

Results: *48 clinical and cadaveric studies compared femoral tunnel aperture position between TT and TI (AM and OI) techniques were obtained for final research. In these studies, 2384 clinical and cadaveric knees underwent arthroscopic single bundle ACLR, we qualitatively assessed the femoral aperture position in all 48 studies showing that the difference between TI and TT was non significant except in the direction perpendicular to Blumensaat's line (BL), but with low mean difference and anteroposterior (AP) anatomical axis.*

Conclusions: *There was non-significant difference between TI and TT technique regarding placing femoral aperture position closer to footprint position. There was non-significant difference in femoral aperture sagittal plane position along BL or along (proximal-distal) PD axis. Regarding femoral aperture coronal plane placement in the axis perpendicular to BL; modified TT technique improved the femoral aperture position in this axis. While regarding femoral aperture placement in the anteroposterior (AP) anatomical axis; TI technique placed femoral aperture significantly more posterior than TT technique, this was proper position regarding anatomic ACLR, while according to the recent concept of ACL femoral footprint, this might be improper position."*

INTRODUCTION:

Improper femoral aperture placement is the most common cause of anterior cruciate ligament reconstruction (ACLR) failure or unsatisfactory outcomes (long term joint degeneration and re-rupture, technical errors

have been noted in 50% of ACL failure cases[1]. The proportion of femoral, as opposed to tibial tunnel positioning errors is 3:1 because the knee's center of rotation is closer to the femoral insertion and preparation of this tunnel is considered to be one of the most complex procedures in ACLR[2].

With further anatomical and bio-mechanical studies, surgeons realized the two-bundle anatomy of the ACL and the specific role of its lower, shallower fibers posterolateral (PL) bundle in its rotatory stabilizing function, accordingly, surgeons attempted to restore the native footprint especially at the femoral side, This was the concept of the double bundle ACL reconstruction techniques "Anatomical double-bundle ACLR reconstruction"[3].

Recently, there are several modifications have been introduced on conventional transtibial (cTT) technique to target femoral aperture more anatomically to the femoral footprint such as altering the tibial position in relation to the femur during femoral aperture drilling, altering the starting point of the tibial tunnel, TT technique assisted by AM portal and posterior notchplasty at over the top position. In TT technique, femoral tunnel is drilled through tibial tunnel which results in a significantly more anterior and vertical position of the femoral tunnel, to overcome the problems of TT technique, surgeons began drilling the femoral tunnel through AM portal[4].

The proper positioning of the femoral tunnel is much easier in AM portal technique than TT technique because the position of the femoral tunnel is restricted by the angulation of the tibial tunnel in the frontal and sagittal planes in the TT technique[5] .

METHODOLOGY:

Search methods for identification of studies:

Electronic research: Databases searched (PubMed, Cochrane Library and Google Scholar). Searches in these databases were carried out in accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses)[6]. There were restrictions for electronic search for studies including English language only. **Searching other resources** e.g. Searching references lists of the included studies.

Criteria for considering studies for this review:

Characteristics of accepted studies:

Regarding design; clinical studies: randomized controlled trials (RCT), non randomized controlled clinical trials, cohort studies, and case-control studies, basic science (cadaveric) studies: controlled laboratory experimental studies. Context those that analyze femoral aperture placement with a direct comparison of TT versus independent (AM or OI) femoral drilling techniques. Full report femoral tunnel aperture position including a suitable statistic describing average and distribution, and sample numbers. Publications in the form of an abstract, letter, or review article were not included.

Characteristics of the included Participants:

Human or cadaveric subjects (basic science), following single bundle ACL recons-truction, skeletally mature patients.

Comparisons and interventions:

Direct comparisons of TT and TI (AM portal or OI) techniques. Adequate statistical methods to compare quantified femoral aperture location resulting from TT and TI (AM portal or OI) methods of ACLR.

Outcome:

Assessment of femoral aperture position by direct measurement or by postoperative imaging: plain X-ray (PXR) and/or computerized tomography (CT) and/or

Magnetic reasonance imaging (MRI). Femoral aperture tunnel location quantified by an appropriate method.

Data collection and analysis:

Study selection:

We reviewed the title and abstract of each publication and then performed a thorough reading of all potentially relevant articles

Data extraction and management:

Data from included studies were independently extracted into Spread sheets, including study characteristics, participants' characteristics; intervention characteristics; and outcomes of interest including femoral aperture posision with summary data of outcome in each intervention group. In case of any missing data in any study, we tried to contact the corresponding author.

Statistical analysis:

For analysis of categorical outcomes (e.g., proportion of femoral aperture inside a reference anatomical range), the effect of treatment was quantified by calculating the risk ratio (RR) and associated 95% confidence interval (CI).We provided a qualitative synthesis of the findings from the included studies, structured according to the imaging technique and measurement method. If enough comparative studies are provided (at least 2) using the same measurement tool on the same imaging modality, a meta-analysis was performed.

The random-effects estimate was presented with its 95% CI, as well as the estimates of T^2 and I^2. We performed these analyses using Rev Man software (version 5.3.5; Nordic Cochrane Centre, Copenhagen, Denmark).

RESULTS:

Literature search Electronic search yielded 2434 studies from three databases (PubMed, Cochrane Library and Google Scholar). After screening title/abstract, 2361 studies were excluded irrelevant to our included studies, resulting in 73 studies were screened in full text screening for inclusion criteria, and 27 studies were excluded because they included double bundle ACLR, non anatomical studies, femoral tunnel orientation, and non comparative studies. So, 46 studies are remaining from electronic search, then by manual search 2 studies were added, so 48 studies were suitable and eligible for qualitative and quantitative synthesis, out of these 48 studies there were 28 studies encountered in quantitative meta-analysis. *Fig (1)*

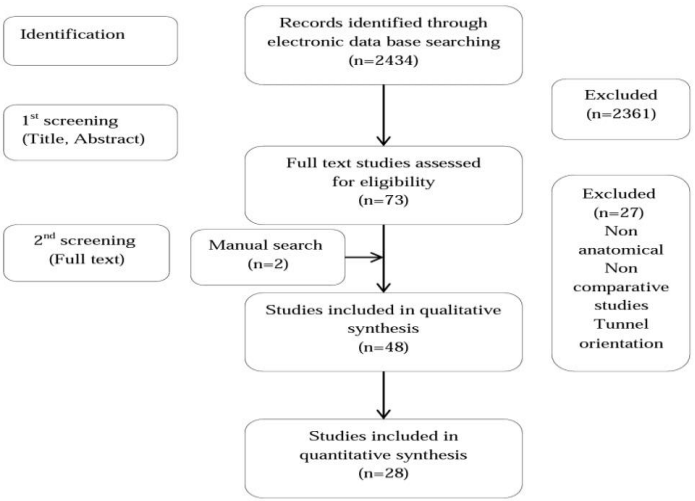

Figure (1): PRISMA flow diagram of the identification and selection of the studies included in systematic review and meta-analysis.

Studies and participants characteristics *(Table 1)*

Table (1): Characteristics table for patients in the included.

No	Study ID	Imaging Modality	Study groups	Research type	Number of knees assessed	Year
1	Abebe etal, 2009 [7]	MRI & Direct	mTT vs OI	Clinical	16 (8 TT 8 OI)	2009
2	Ahn et al,2013[8]	CT	TT vs OI	Clinical	69 (34 TT, 35 OI)	2013
3	Albuquerque et al, 2007 [9]	Direct	TT vs AM	Basic science	20 (AM,TT)	2007
4	Arno et al,2016 [10]	MRI	TT vs AM	Clinical	20(10 TT ,10 AM)	2016
5	Bedi et al, 2011 [11]	Direct	TT vs AM	Basic science	10 (5 AM, 5 TT)	2011
6	Bowers et al, 2011 [12]	MRI	TT vs AM	Clinical	30 (15 TT, 15 AM)	2011
7	Chang et al, 2013 [13]	Radiograph	mTT vs AAM	Clinical	105 (55 TT, 50 AM)	2013
8	Cho et al, 2012 [14]	Radiograph	mTT vs AAM	Clinical	30 (15 TT, 15 AM)	2012
9	Clockaert et al, 2016[15]	CT	TT vs AM	Clinical	32(16 TT, 16 AM)	2016
10	De Abreu Silva, 2014[16]	CT	TT vs AAM	Clinical	23 (9 TT, 14 AM)	2014
11	Francesci et al, 2013[17]	Radiograph	TT vs AAM	Clinical	88 (46 TT, 42 AM)	2013
12	Gadikota et al, 2012[18]	Direct	TT vs AM vs OI	Basic science	8 (AM, TT, OI)	2012
13	Gavriilidis et al, 2008[19]	Direct	TT vs AAM	Basic dcience	10(AM, TT)	2008
14	Geng et al , 2018 [20]	CT	TT vs AM	Clinical	104 (TT 48, AM 56)	2018
15	Guler et al, 2016 [21]	MRI	TT vs AAM	Clinical	48 (25 TT, 23 AM)	2016
16	Hart et al, 2018 [22]	MRI	mTT vs AM vs AM,	Clinical	AM 21 (1^{st} : 11, 2^{nd} :10) TT 20 (3rd: 9, 4th:11)	2018
17	Hensler et al, 2013 [23]	CT	TT vs AM	Clinical	47 (27 TT, 20 TI)	2013
18	Hussin et al, 2018 [24]	Radiograph	mTT vs AAM	Clinical	60 (30 TT, 30 AM)	2018
19	ILllingworth, 2011 [25]	MRI, radiograph, CT	TT vs TI	Clinical	50 (34 TT, 16 TI)	2011
20	Inderhaug et al, 2016 [26]	CT	TT vs AAM	Clinical	139 (TT: 41, AM1: 58, AM2: 40)	2016
21	Jennings et al, 2017 [27]	Direct	mTT vs AM vs TT	Basic science	12 (TT 16, TT 28 AM 28)	2017
22	Jaecker etal,2017 [28]	CT	TT vs AM	Clinical	101 (64 TT), (37 AM)	2017
23	Kaseta et al, 2008 [29]	Direct	TT vs OI	Basic science	12(TT, OI)	2008
24	Larson, et, al,2012 [30]	CT	TT vs AM vs OI	Basic science	20 (5 for TT, 5 AM rigid reamer (rr), AM flexible reamer (fr),5 OI)	2012
25	Lee D.W et al,2018 [31]	CT	OI vs mTT	Clinical	100 (50 mTT,50 OI)	2018
26	Lee J,K,et al,2014 [32]	CT	mTT vs AM	Clinical	104 (52 mTT, 52 AM)	2014
27	Matassi et al, 2015 [33]	CT	TT vs OI	Clinical	40 (20 TT,20 OI)	2015
28	Miller et al, 2011[34]	CT	TT vs AM	Basic science	20 (10 TT, 10 AM)	2011
29	Mirzatolooei et al, 2012[35]	Radiograph	TT vs AM	Clinical	105 (47 TT 58 AM)	2012
30	Noh et al, 2013 [36]	MRI	TT vs AM	Clinical	61 (30 TT, 31 AM)	2013
31	Osti et al, 2015 [37]	CT	TT vs AAM vs OI	Clinical	100 (36 TT, (32 AM, 32 OI)	2015
32	Pascual et al, 2013 [38]	Radiograph	TT vs AAM	Clinical	40 (23 AM 17 TT)	2013
33	Robert et al, 2013 [39]	CT	TT vs OI vs AAM	Basic science	13 (Am, TT, OI)	2013
34	Seo et al, 2013 [40]	CT	TT vs OI	Clinical	42 (17 TT, 25 OI)	2013
35	Shin et al, 2013 [41]	CT	TT vs AAM vs OI	Clinical	153 (42 TT: 73 AM, 38 OI)	2013
36	Silva et al, 2012 [42]	CT	AAM vs TT	Clinical	40 (20 TT, 20 AAM)	2012
37	Song et al, 2014 [43]	CT	TT vs AM	Clinical	60 (30 TT, 30 AM)	2014
38	Steiner et al,2009 [44]	Direct	TT vs AM	Basic science	20 (AM 10, TT 10)	2009

39	Tasdemir et al, 2015[45]	MRI	TT vs AM	Clinical	39 (15 TT, 24 AM)	2015
40	Tompkis2012[46]	CT	TT vs AAM	Basic science	20 (10 TT, 10 AM)	2012
41	Tompkins, 2013 [47]	CT	TT vs AAM	Basic science	20 (10 TT,10 AM)	2013
42	Tudsico, 2012 ([48]	Radiograph,Direct	TT vs AM	Basic science	12 (6 TT, 6 AM)	2012
43	Venosa et al, 2017 ([49]	CT	TT vs AAM	Clinical	52 (TT 26, AM 26)	2017
44	Wolf et al, 2014 [50]	CT	OI vs AM vs TT	Basic science	67 (23 TT, 23 AM, 21 OI)	2014
45	Xu, eta al,2011 [51]	Radiograph	TT vs AM	Clinical	72 (53 TT, 19 AM)	2011
46	Yanasse et al, 2016 [52]	Radiograph	TT vs OI	Clinical	32 (14 TT, 18 OI)	2016
47	Yau et al, 2013 [53]	MRI	TT vs AM	Clinical	39(20 TT, 19 AM)	2013
48	Youm et al, 2014 [54]	CT	mTT vs AM	Clinical	40 (20 mTT, 20 AM)	2014

Outcome:

Assessment of femoral aperture position in the included 48 studies, there were 28 studies included in meta-analysis.

Effects of interventions (Qualitative synthesis and meta-analysis):

Femoral aperture position could be defined by one of 2 approaches

1) **Absolute definition (indirect methods**: (The femoral aperture position of each technique in the lateral femoral condyle or inter condylar notch irrelevant to footprint position).

A. Coronal plane position as Percentage ratio of an overall scaling dimension from the lateral femoral condyle or the inter condylar notch.

a) Coronal plane position perpendicular to Blumensaat's line (BL):

- Using quadrant method measured on 3DCT scan; 14 studies assessed this outcome and their results were pooled in a meta-analysis {1}.
- Using quadrant method measured on radiograph (Xu et al,[51] found that TI technique placed femoral aperture at a significantly lower position than TT technique in the axis perpendicular to BL. Regarding Franceschi et al,[17] found that femoral aperture position percentage perpendicular to BL in AM group was lower than TT group; 55% vs 22%, respectively. However, no statistical comparison was performed.

b) Coronal plane position along AP anatomical axis:

- Measured using ACA method on CT scan Lee, JK , Shin, and Illingworth[32,41&25] were pooled in meta-analysis{2}
- Measured by Clock face method on axial MRI. (Gueler, Tasdemir and Yau)[21,10&53] discussed in meta-analysis {3}.
- Measured by Clock face method directly on specimen Alburquque et al,[9] found that there was no statistically significant difference between both group.
- Measured by method proposed by Heming[55] on axial CT view, Larson et al, [30] found that OI aperture position was significantly lower than TT technique. Also demonstrated that femoral tunnel position with AM rr (rigid reamer) technique placed femoral aperture at significantly higher position than OI technique

B. Coronal plane position as distance in mm from fixed anatomic land mark:

a) On profile 3D CT view of the medial wall of the lateral femoral condyle:

- Femoral aperture inferior edge (distal anatomically) to inferior articular surface (posterior anatomically) on CT scan. we found 2 cadaveric studies Tompkins, 2013,[47] and In Larson et al,[30] (including 30 specimen) that measured this outcome ,but the results couldn't be

pooled, the results were inconsistent, Tompkins, found non significant difference, while Larson, found that OI was significantly closer than TT and AM rr (OI was lower).

- Femoral aperture inferior edge (posterior anatomically) to inferior edge of articular cartilage (posterior anatomically) In Miller et al[34] distance was significantly lesser in AM group than in TT group (i.e. TI was lower).

b) On Coronal MRI; the distance from femoral aperture position to "over the top" in AP axis Noh, et al [36] found that AM was significantly nearer to "over the top" than TT technique (AM was lower).

C. Sagittal plane position as Percentage ratio of an overall scaling dimension from the lateral femoral condyle or the intercondylar notch:

a) Sagittal plane position along BL

- Using quadrant method measured on 3DCT scan; 14 studies assessed this outcome and their results were pooled in meta-analysis. {4}
- Femoral aperture position percentage from whole BL length (Harner method) measured on radiograph (Hussinet al and Yanasse et al) [24&52] discussed in meta-analysis {5}
- Measured by quadrant method on sagittal MRI Guler and Yau [21][53] studies were pooled in meta-analysis {6}

b) Sagittal plane position along to PD axis

- Measured using ACA method on CT scan Lee, JK , Shin, and Illingworth[32, 41&25] were pooled in meta-analysis {7}
- Measured by method proposed by Heming [55] on Coronal CT view, Osti, et al,[37] found that both AM and OI aperture position were significantly more distal along PD axis than TT techniques.

D. Sagittal plane position as distance in mm from fixed anatomic land mark along PD axis:

a) Measured directly on specimen:

- Femoral aperture center to posterior articular border of the lateral intercondylar notch. Gravidiliis et al,[19] TI aperture was significantly closer to deep articular border of lateral notch than TT technique (TI more proximal).
- Distance between femoral aperture posterior margin to posterior articular cartilage measured on cadaveric specimens (posterior wall thickness). Alburquque,[9] proved that there was no significant difference between both groups in post wall thickness.

b) Measured on profile 3D CT view of medial wall of lateral femoral condyle.

- Distance from femoral aperture center to posterior wall on CT scan. Miller et al,[34] found that the distance was significantly lesser in AM group than in TT group (i.e.AM was more proximal).
- Femoral aperture anterior edge to anterior articular surface (distal anatomically). Tompkins, 2013,[47] found that the the distance was significantly closer for AM than TT technique (i.e. AM more distal).

2) Definition relative to femoral footprint (Direct measurement):

A. Own study footprint position:

a) Footprint of the same knee:

- On Photographed on arthroscopic image: Distance of femoral aperture center to margin of femoral ACL footprint measured on photographed arthroscopic image. Gavrillidis et, al,[19] found that AM was significantly closer to footprint than TT technique with mean difference of 3.4 mm

- On 3D model of specimen created by digitizing stylus Distance from femoral aperture center to footprint center
- Along AP and PD axes. In Gadicota, et al,[18] and Kaseta, et al,[29] their results were analyzed in meta-analysis {8}, {9}. While in greatest distance. In Gadicota, et al,[18] and Kaseta, their results were analyzed in meta-analysis {10}.
- On 3D CT scan.
- Distance from center of femoral aperture to center of footprint on CT scan. We found 2 cadaveric studies Tompkins, 2012[46] and Robert [39] (including 33specimens) that measured this outcome , we decided not to pool their results together because of different methodology in defining the femoral footprint during analysis of femoral aperture site on the same knee specimen.

b) Footprint of the contralateral knee on MRI reconstructed knee model mirrored and its osseous geometry aligned with contralateral intact knee model:

- Difference in AP and PD position percentage between femoral aperture and femoral footprint where AP and PD position in each group was measured by a method that could be translated to anatomical coordinate axis method on MRI. Arno et al,[10] found that in the AP position percentage difference was equivalent between the TT and AM groups but regarding the PD % , TT group was more proximal than the intact ACL.
- Distance in anatomic coordinate axes (in AP and PD axes). Abebe and Bowers [7&12] data results were analyzed in meta-analysis {11 and 12}
- Femoral aperture distance to femoral footprint center in greatest (hypotenuse) distance. Abebe, Bower and Hart [7,12&22] their results were analyzed in meta-analysis {13}

Reference anatomical footprint position:

a) Proportion of femoral aperture outside a referenced anatomic range formed by Forsythe et al,[56] measured by anatomic coordinate axis method. Hensler et al.,[23] and Illingworth et al,[25] were included in meta-analysis {14}.

b) Proportion of outliers from an anatomical femoral aperture height measured by clock face method (≤ 11 o'clock for a right knee (or ≥1 o'clock for a left knee which was equivalent to ≤ 330^o for a right knee (or ≥30^o for a left knee (No reference cited). Tasdemir et al.,[45] and Yau et al,[53] found significantly less outliers in AM than TT group. These 2 studies were included in meta-analysis {15}.

Effect of intervention (Meta-analysis): 28 studies were included in meta-analysis analyzed for 15 outcomes as following:

1) Femoral aperture coronal plane position perpendicular to (BL) using quadrant method on CT scan. 14 studies fulfilled the criteria for review of this outcome. ***(Fig 2)***

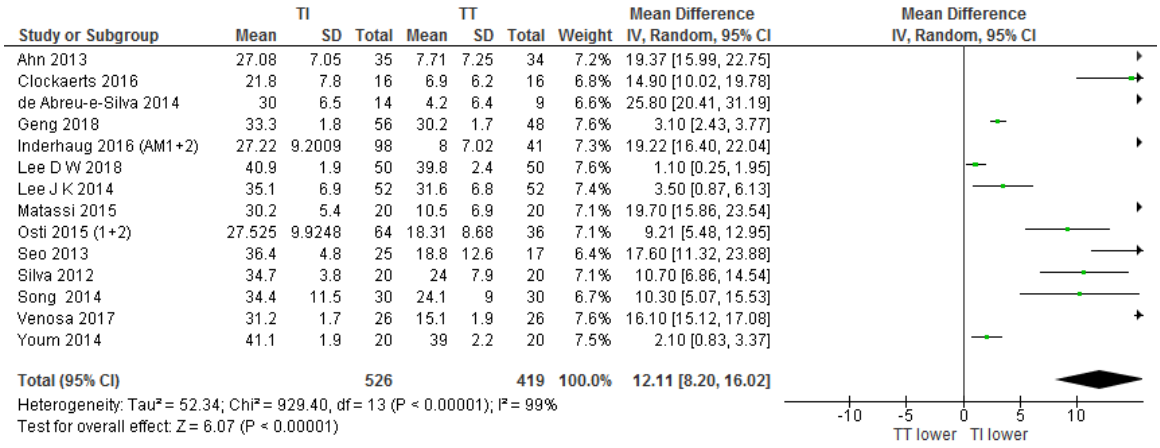

Figure (2): Forest plot of comparison: femoral tunnel aperture height on CT scan.

TI technique placed femoral aperture 12.11 % lower than TT technique, (95% CI) was (8.2% lower to 16.02 % lower). The difference was statistically significant (P<0.00001).There was sever heterogeneity (I^2) =99%.

2) Femoral aperture coronal plane position along AP axis measured using ACA method on CT scan. In 3 studies[25, 32& 41], TI technique placed femoral aperture 13.95 % more posterior than TT technique, 95% CI was (1.86 % more posterior to 25.98 % more posterior).The difference was statistically significant (P=0.02).

3) Femoral aperture coronal plane position along AP anatomical axis using Clock face method measured on axial cut MRI. In 3 studies[21,45&53], TI technique placed femoral aperture19.15 ˚ more posterior angle than TT technique, 95% CI (24.13˚ more posterior to 14.18 ˚ more posterior).The difference was statistically significant (P<0.00001).

4) Femoral aperture sagittal plane position along (BL) using quadrant method on CT scan: 14 studies fulfilled the criteria for review of this outcome ***(Fig 3)***

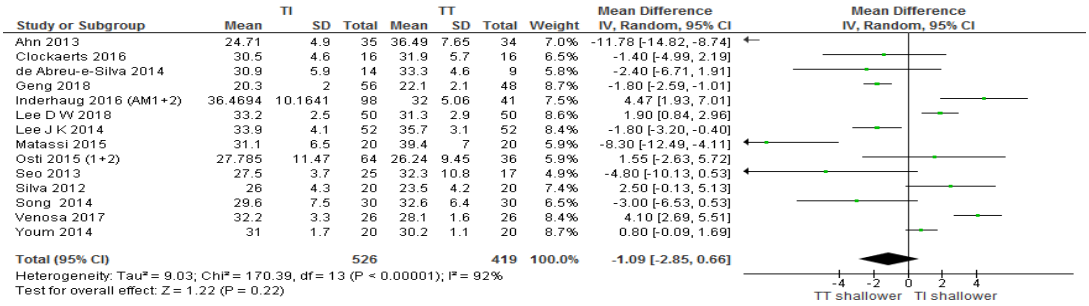

Figure (3): Forest plot of comparison: (Quadrant method for femoral aperture depth on CT scan).

TI technique placed femoral aperture 1.09 % deeper than TT technique (95% CI) was (2.85 % deeper to 0.66 % shallower), however the difference was statistically non significant.

5) Femoral aperture sagittal plane position % from whole BL using Harner method measured on radiograph. In 2 studies [24&,52]TI technique placed femoral aperture 12.5 % shallower than TT technique, CI 95% (9.92 % shallower to 15.08 % shallower). The difference was statistically significant (P<.00001). There was no heterogeneity (I^2=0%).

6) Femoral aperture sagittal plane position along BL by quadrant method measured

on MRI. In 2 studies[21& 53], TI technique placed femoral aperture 2.89 % deeper than TT technique, 95% CI (5.86 % deeper to 0.08 % shallower), however this difference was statistically insignificant (P=0.6).

7) Femoral aperture sagittal position along proximal to distal axis using anatomic coordinate axis on CT scan. In 3 studies[25,32&,41], TI technique placed femoral aperture 0.58 % more distal than TT technique, 95% CI (1.46 % more proximal to 2.62 % more distal), however; the difference was statistically non significant (P=0.58).

8) Distance from femoral aperture center to the same knee footprint center along AP axis, on digitized 3D model of specimen. In 2 studies[18&29] ,TI technique placed femoral at 3.27 mm more posterior distance from footprint than TT technique, 95% CI (6.2 mm more posterior to 0.33mm more posterior. The difference was statistically significant (P=0.03).

9) Distance from femoral aperture center to the same knee footprint center in PD axis on digitized 3D model of specimen. In 2 studies[18& 29], TI technique placed femoral aperture at 2.88 mm more distal distance from footprint than TT technique, 95% CI was (6.06 mm more distal to 0.3 mm more proximal). However difference was non significant (P=0.08).

10) Greatest distance from femoral aperture center to the same knee footprint center on digitized 3D model of specimen. In 2 studies[18& 29] fulfilled the criteria for review of this outcome. TI technique placed femoral aperture at 3.95 mm distance closer to footprint than TT technique, 95% CI (8.29 mm closer to 1.12 mm farther), however this difference was statistically non significant (P=0.14).

11) Femoral aperture distance to contralateral femoral footprint center along AP plane on MRI. in 2 studies [7&12], TI technique placed femoral aperture at 3.49 mm more posterior distance from footprint than TT technique, 95% CI (8.21 mm more posterior to 1.24 mm more anterior), however this difference was statistically non significant (P=0.15).

12) Femoral aperture distance to contralateral femoral footprint center in (Proximal to distal) plane using MRI. in 2 studies [7&12] TI technique placed femoral aperture at 1.56 mm more distal distance from footprint than TT technique, 95% CI (6.01 mm more distal to 2.89 mm more proximal), however; this difference was statistically non significant (P=0.49).

13) Femoral aperture center to contralateral femoral footprint center greatest distance (hypotenuse) measures on MRI. In 3 studies[7,12&22] TI technique placed femoral aperture at 1.38 mm closer to footprint than TT technique, 95% CI (5.65 mm closer to 2.88 mm farther), however; the difference was statistically non significant (P=0.52).

14) Proportion of femoral aperture outside reference anatomic range according to (Forsythe et al)[56] In 2 studies[25&23],TI technique significantly lowered the risk of apertures outside the referenced anatomic range by 80% than TT technique, 95% CI (92 % low risk to 53% low risk), the difference was statistically significant (P=0.0003).

15) Proportion of outliers from referenced anatomical femoral aperture height measured by clock face method. In 2 studies[53& 45] TI technique lowered the risk of femoral apertures outside the referenced anatomical range by 93 %. 95% CI (99% low risk to 51 % low risk). This difference was statistically significant (P=0.007).

DISCUSSION:

Regarding the ability of each technique to achieve the footprint center position; Directly comparing the distance of aperture center placed by each technique to footprint center of the same knee on digitized 3d model showed non significant difference in 48 specimens of 2 studies [18&29] On 87 patients of 3 studies[7, 12& 22] assessing the ability of each technique to recreate the footprint position of the contralateral knee on MRI, there was non significant difference in distance of aperture center to footprint center. Contradictory to the pervious findings, aperture placed by TI technique was significantly closer, albeit by small difference of 2.4mm and 4 mm, in two studies using CT scan and including 59 specimens[39& 46].

Regarding the ability of each technique to achieve the proper footprint coronal plane position along AP anatomical axis on digitized 3D model of 48 specimens of 2 studies [18& 29] showed that TI technique placed aperture at less anterior distance from footprint than TT technique, albeit with a small difference of 3.3 mm. Contradictory to the pervious findings, there was non significant difference between both techniques in recreating the AP footprint position of the contralateral knee in two studies using MRI and including 46 participants[7& 12].

Regarding the axis perpendicular to BL, assessing the spatial position In footprint referenced to BL, the apertures placed by TI and TT techniques were in lower deep quadrant in 70% and 50% of specimens, respectively, in one study including 20 specimens and using CT scan [46].

Regarding the ability of each technique to achieve the proper footprint sagittal plane position, regarding PD anatomical axis, there was non significant difference between both techniques in recreating the PD footprint position of the same knee assessed on digitized 3D model in two studies including 48 specimens[18&29].

Regarding the direction along BL, Comparing the ability of each technique to achieve a reference anatomical position, one study[8] used Frosythe's reference anatomical position[56] along BL (28.4%) in a clinical study on 69 patients and found that TI technique placed the aperture center 11.7% deeper and closer to the referenced position than TT technique.

Regarding the difference in coronal position of femoral aperture placed by each technique in the axis perpendicular to BL, in 14 studies including 990 patients, TI technique significantly lowered the position of the placed aperture by 11.3% (95% CI 7.9% lower to 14.7% lower) than the TT technique as measured by quadrant method on 3D CT. A consistent finding as demonstrated on 52 patients of 1 study[51] where TI technique significantly lowered the position of the placed aperture than the TT technique as measured by Quadrant method on radiography.

While along AP anatomical axis, in 3 studies [25,32&41] including 307 patients, TI technique placed femoral aperture in significantly more posterior position than TT technique with mean difference of 13.9% (95% CI of 1.9% to 29%) as measured by anatomic coordinate axis method on 3D CT. A radiological study[36] using MRI performed on 61 participants demonstrated that the posterior margin of aperture placed by TI technique was significantly at more posterior distance from the over-the-top point than TT technique with mean difference of 7 mm. Contradictory to these findings, there were inconsistent results of qualitative synthesis of results of 2 studies [30&47] assessing the distance of aperture inferior edge to inferior articular surface on profile 3D CT view of medial wall of LFC of 40 specimens.

Regarding the difference in sagittal position of femoral aperture placed by each technique, in the axis along BL. On 990 patients (14 studies), there was non significant difference between both techniques in the position of placed aperture along BL as measured by quadrant method on 3D CT. Using the same measurement method on radiography and MRI, a consistent result was demonstrated on 72 patients 1 study,[51] and 87 patients (2 studies; [21&53] respectively.

While in the axis along PD anatomical axis, on 307 patients (3 studies [25, 32& 41] there was non significant difference between both techniques in the PD position of placed aperture as measured by anatomic coordinate axis method on 3D CT. Contradictory to that, on 100 patients included in 1 study[37], TI technique placed femoral aperture at a significantly more distal position than the TT technique as measured by clock face method on CT coronal view. Non significant difference was demonstrated in 3 studies; [9, 30&36] Contradictory to that a significant difference between both techniques was demonstrated. The direction of that intervention effect was diverse among studies.

Conclusion:

There was non-significant difference between TI and TT techniques in the distance from femoral aperture center to footprint center. Regarding placement in the direction perpendicular of BL, TI technique placed femoral aperture in lower deep quadrant a little bit more than TT technique and significantly lowered the position of the placed aperture than TT technique, but the mean difference looked clinically insignificant. Regarding placement along AP anatomical axis, TI technique placed Femoral aperture at less anterior distance from footprint than TT technique with a small difference and placed femoral aperture in a more posterior position than TT technique and the difference looked clinically significant. Regarding sagittal plane placement of femoral aperture along AP anatomical axis and along BL, there was non-significant difference between both techniques.

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مراجعة منهجية وتحليل بعدى لما تم نشره من أبحاث مقارنة حفر النفق الفخذي عن طريق القصبة مقابل الحفر المستقل عن القصبة في علاج الرباط الصليبي الامامي :تقييم مكان فتحة النفق الفخذي

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المقدمة: بالرغم من أن هناك العديد من الدراسات العملية والمعملية التي قارنت بين حفر النفق الفخذي عن طريق القصبة مقابل الحفر المستقل عن القصبة (الحفر الامامي الداخلي والحفر الخارجي الداخلي) في ايجاد فتحة النفق الفخذي اثناء عملية اعادة بناء الرباط الصليبي الأمامي أحادي الحزمة ، الا انه ليس هناك اجماع علي افضل مكان تشريحي لها حسب مكان أثار الرباط الصليبي الأمامي.

الهدف من البحث: مراجعة منهجية وتحليل بعدى لما تم نشرة من أبحاث في مقارنة حفر النفق الفخذي عن طريق القصبة مقابل الحفر المستقل عن القصبة في ايجاد فتحة النفق الفخذي أثناء عملية اعادة بناء الرباط الصليبي الامامي أحادي الحزمة.

طرق البحث: لقد قمنا بعمل بحث الكتروني في المواقع الاتية (PubMed , Cochrane Library, Google Scholar) للدراسات التي تقيم مكان فتحة النفق الفخذي في الاشخاص والجثث التي تعرضت الي عملية اعادة بناء الرباط الصليبي الامامي احادي الحزمة بالمنظار.

النتائج: تم ايجاد ٤٨ بحث عملي ومعملي قارنت بين الحفر عن طريق القصبة والحفر المستقل عن القصبة في ايجاد فتحة النفق الفخذي و هذه الدراسات كانت تشتمل علي ٢٣٨٤ ركبة تعرضت الي عملبية اعادة بناء الرباط الصليبي الامامي احادي الحزمة بالمنظار، لقد قمنا بتقييم مكان فتحة النفق الفخذي في تلك الدراسات والتي اوضحت أن الفرق بين الحفر عن طريق القصبة والحفر المستقل عن القصبة كان غير ملحوظ سوي في الاتجاه العمودي علي خط البلومنسات ولكن بمتوسط اختلاف طفيف وأيضا في الاتجاه الأمامي الخلفي التشريحي.

الاستنتاج: كان هناك اختلاف غير ملحوظ بين الحفر عن طريق القصبة والحفر المستقل عن القصبة بخصوص ايجاد فتحة النفق الفخذي الأقرب إلي مكان أثار الرباط الصليبي الأمامي. كان هناك اختلاف غير ملحوظ في الاتجاه السهمي (في اتجاه خط البلومنسات والاتجاه القريب البعيد). وبخصوص مكان فتحة النفق الفخذي في الاتجاه التاجي (الاتجاه العمودي علي خط البلومنسات) فالحفر المعدل عن طريق القصبة قام بتحسين مكان فتحة النفق الفخذي علي هذا الاتجاه. وبخصوص الاتجاه الأمامي الخلفي التشريحي فالحفر المستقل عن القصبة قام بوضع مكان فتحة النفق الفخذي اكثر للخلف باختلاف ملحوظ عن الحفر عن طريق القصبة وهذا يعتبر مكان أفضل علي حسب الوضع التشريحي لاعادة بناء الرباط الصليبي الأمامي ولكن علي حسب المفهوم الحديث لأثار الرباط الصليبي الأمامي فإن هذا المكان يعتبر غير مناسب.