

CORRELATION OF TIBIAL MENISCUS WITH TIBIAL PLATEAU AND ITS CLINICAL SIGNIFICANCE: A CADAVERIC STUDY

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ABSTRACT

Background: The condyles of femur and tibia are not having the perfect congruent articular surfaces to adapt each other. To overcome this incongruity there exist tibial menisci over the tibial plateau. Loss of tibial menisci would result in devastating effect on the normal functioning of knee joint. Meniscal allograft or synthetic implants are the alternatives suggested to restore the contact pressure following the meniscectomy operations.

Size of menisci required for this allograft or synthetic implant procedures following meniscectomy can be determined. Present study done emphasizes on calculation of meniscal dimension by measuring the tibial plateau dimensions, using various analytical procedures and deriving the relevant formulae.

Study Design: In the present study different parameters of tibial meniscus were measured after exposure of knee joint. These measurements were done with digital Vernier calliper and a measuring scale.

Results: Mean MML, MMW, MMC were 42.28±3.71mm, 31.67±3.40mm, 101.46± 6.89mm. Mean LML, LMW, LMC were 32.73±3.08mm, 33.22±3.37mm, 97.61± 7.32mm respectively. Some of the linear equations derived from the study are as follows. $y = 0.71 * x + 9.01$ mm, here y=medial meniscal length and x= length of medial tibial plateau; $y = 0.48 * x + 16.55$ mm here y=medial meniscal width and x= width of medial tibial plateau; $y = 0.84 * x + 5.61$ mm here y= Lateral meniscal width and x= lateral tibial plateau width etc.

Conclusion: It can be easily judged that a graft which is too small in the size to fit the desired knee joint can be trapped beneath the condyles of femur. This might result in early damage to it due to disproportionate pressure acting on small meniscus. Whereas a large meniscus to a knee joint which is loose in fitting could also turn out to be ineffective due to disproportionate pressure distribution. Present Anthropometric study provides quantitative formulae to determine the meniscal dimensions, which may help to design artificial meniscus prostheses.

KEY WORDS: Tibial menisci, tibial plateau, dimensions, correlation, meniscal replacement, transplant.

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BACKGROUND

The knee joint is a condyloid joint with two articular surfaces between the two respective condyles of femur and tibia. Besides, there is also a joint between the patella and the femur. The condyles of femur and tibia are not having the perfect congruent articular surfaces to adapt

each other. To overcome this incongruity there exist tibial menisci over the tibial plateau. With the help of these menisci the articular surfaces between the tibia and femur maintain the congruity and hence carry out the smooth gliding movement.

Thus, the menisci are the vital structures of knee joint which bears the important functions such as weight bearing, act as mechanical shock absorbers, they provide the stability to joint and lubricating the joint for its smooth function[1].

Many studies done earlier suggest that loss of tibial menisci would result in devastating effect on the normal functioning of knee joint [2]. One of the reasons for development of osteoarthritis of knee is loss of meniscal cartilages. This process of osteoarthritis is also influenced by many local factors like mechanical stress and strain, systemic factors like age, obesity etc. Meniscectomy, a surgical process, is often accompanied by osteoarthritis of knee joint. Many studies done in past, on post meniscectomy subjects had shown the importance of loss of meniscal function in development of osteoarthritis of knee. The reasons suggested are increased local pressure on articular cartilages and subchondral bone damage due to loss of meniscal cushion support [3].

Thus, whenever it is possible, tibial meniscal repair is always suggested for preservation of this normal function [4]. Meniscal allograft or synthetic implants are the alternatives suggested to restore the contact pressured following the meniscectomy operations.

Size of menisci required for this allograft or synthetic implant procedures following meniscectomy can be easily determined by calculating the dimensions of tibial plateau. Previous studies done suggest that these dimensions were accurately calculated by the MRI of tibial plateau of knee joint [5]. Present study done emphasizes on calculation of meniscal dimension by measuring the tibial plateau dimensions. Tibial plateau dimensions are correlated with the tibial meniscal dimensions. By using the proper analytical procedures, the relevant formulae have been derived to calculate the required meniscal dimension. These formulae that have been derived in this study can be of much help in deciding the size of graft material required in the replacement or the transplant procedures.

MATERIALS AND METHODS

The present study was carried out at anatomy

department of T N Medical College, Mumbai. The permission of the Head of Department of Anatomy was taken prior to beginning of the study. Consent was not required being a cadaveric study.

50 skeletally mature cadaveric knee joints of either sex were included in the study. 25 knee joints were of right side and the rest 25 knee joints used in the study were of the left side of body. Exclusion criteria used was as follows:

- a) Knee joint with meniscal tear
- b) Fractured tibial plateau
- c) Evidence of previous surgery on knee joint.

50 cadaveric knee joints were made available from the dissection hall of anatomy department. Overlying skin and the muscles of knee joint were dissected. Horizontal incision was given to the collateral ligament and the ligamentum patellae. Vertical incision was given on each side of the joint capsule so as to open the joint on anterior side. Joint capsule was removed and various ligaments were cut so as to expose the menisci. Further fine dissection of soft tissues around the knee joint was done to expose the tibial plateau. All 50 cadaveric knee joint were dissected in the similar fashion, measurements were recorded and entered on a standardized data collection sheet. The data was tabulated & analyzed for various parameters described subsequently. SPSS 15 and Windows Excel software was used to process and analyse the data and produce the results.

The measurements of following parameters were taken with the help of digital vernier calliper and a measuring scale. As shown in figure 1 and figure 2 following are the methods used to measure the various dimensions of tibial plateau and menisci.

- 1) Medial meniscal length (**MML**) and Lateral Meniscal Length (**LML**) were measured from the most anterior part to the most posterior part of menisci.
- 2) Medial Meniscal Width (**MMW**) and Lateral Meniscal Width (**LMW**) were measured from the attachment of posterior horn of the respective meniscus to the peripheral most edge of respective menisci.

- 3) Medial Meniscal Circumference (**MMC**) and Lateral Meniscal Circumference (**LMC**) were measured with the help of a non elastic cotton thread. The thread was placed around the peripheral margin of the meniscus and was fixed to the ends of the menisci with the help of metallic pins. This length of the non elastic thread between the two end of pins was measured with the help of a measuring scale and was termed as circumference of respective meniscus.
- 4) Medial Plateau Width (**MW**) and Lateral Plateau Width (**LW**) was measured from the tibial eminences of the respective side till the medial and lateral edge of the respective tibial plateau.
- 5) Medial Plateau Length (**ML**) and Lateral Plateau Length (**LL**) were measured from the anterior most part of tibial plateau till the posterior most part of the tibial plateau on each side.
- 6) Total Plateau Width (**TPW**) is measured from the peripheral most part of medial margin till the peripheral most part of lateral margin of the tibial plateau.

RESULTS

Fig. 1: Showing the measurement of tibial meniscal length and width and circumference.

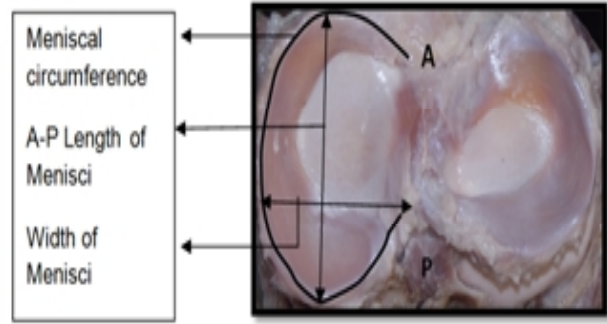


Fig. 2: Showing measurements of tibial plateau dimensions.

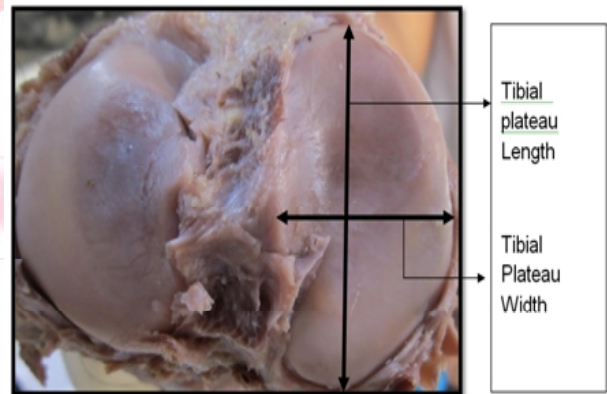


Fig. 3: Scatter diagram showing Correlation between medial meniscal length and length of medial tibial plateau.

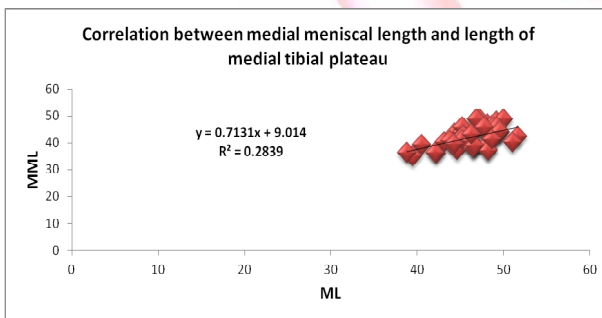


Fig. 5: Scatter diagram showing Correlation between lateral meniscal length and length of lateral tibial plateau.

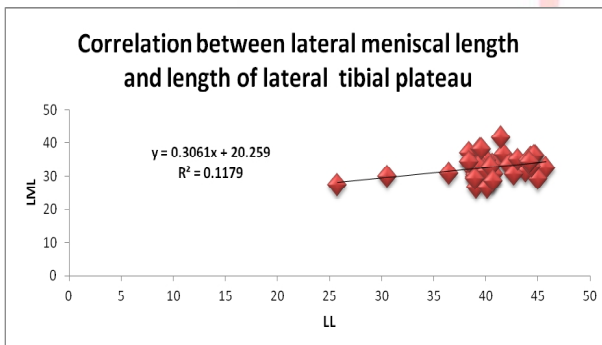


Fig. 4: Scatter diagram showing Correlation between medial meniscal width and width of medial tibial plateau.

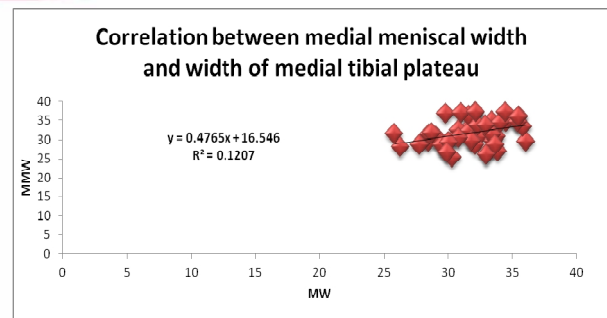


Fig. 6: Scatter diagram showing Correlation between lateral meniscal width and width of lateral tibial plateau.

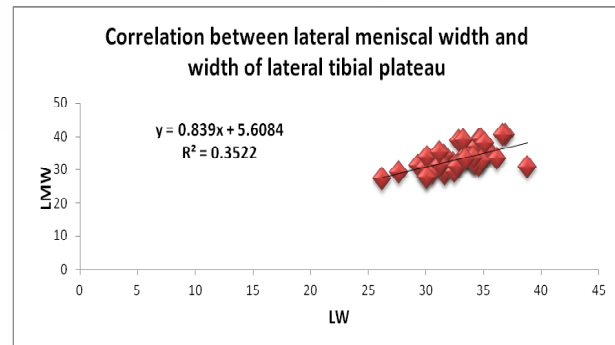


Fig. 7: Scatter diagram showing Correlation between Medial meniscal circumference and total plateau width.

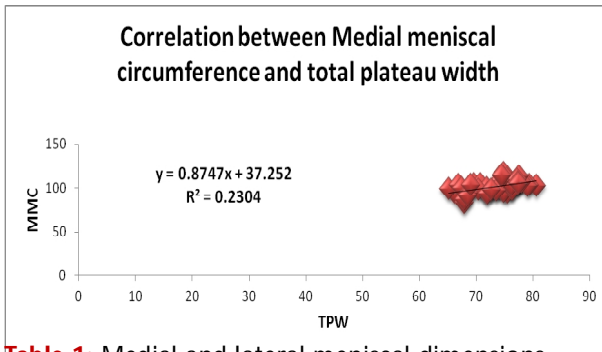


Table 1: Medial and lateral meniscal dimensions.

Variable	N	Mean (mm)	Std Dev (mm)	Minimum (mm)	Maximum (mm)
MML	50	42.28	3.71	35.1	48.8
MMW	50	31.67	3.4	25.44	37.25
MMC	50	101.46	6.89	82.74	117.48
LML	50	32.73	3.08	26.6	41.7
LMW	50	33.22	3.37	27.3	40.67
LMC	50	97.61	7.32	80.3	115.61

Fig. 8: Scatter diagram showing Correlation between lateral meniscal circumference and total plateau width.

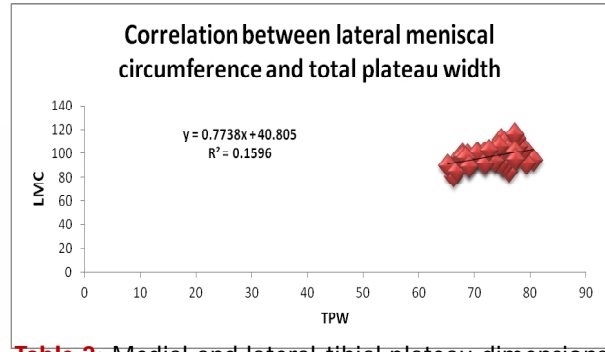


Table 2: Medial and lateral tibial plateau dimensions.

Variable	N	Mean (mm)	Std Dev (mm)	Minimum (mm)	Maximum (mm)
ML	50	46.64	2.77	38.81	51.67
MW	50	31.73	2.48	25.8	36.05
LL	50	40.72	3.47	25.77	45.77
LW	50	32.91	2.39	26.22	38.8
TPW	50	73.41	3.77	65.2	80.61

Table 3: Correlation between different variables tibial menisci and tibial plateau.

Medial meniscal length and length of medial tibial plateau	0.53	Significant Positive correlation	<0.001
Medial meniscal width and width of medial tibial plateau	0.34	Significant Positive correlation	0.013
lateral meniscal length and length of lateral tibial plateau	0.34	Significant Positive correlation	0.015
lateral meniscal width and width of lateral tibial plateau	0.6	Significant Positive correlation	<0.001
Medial meniscal circumference and total plateau width	0.48	Significant Positive correlation	<0.001
Lateral meniscal circumference and total plateau width	0.4	Significant Positive correlation	0.004

DISCUSSION

Tibial meniscal and tibial plateau dimensions:

As shown in table 1, Medial Meniscal Length, Width and Circumference were calculated as 42.28±5.0 mm, 31.67±3.4 mm and 101.46±6.89 mm respectively. Similarly Lateral Meniscal Length, Width and Circumference were calculated to be as 32.73±3.1mm, 33.22±3.38mm and 97.61±7.32mm respectively. In a cadaveric study done by I.D. McDermott et al (2004) on 44 cadaveric tibial menisci, the dimensions of medial meniscal length, width and circumference were calculated as 45.7±5mm, 27.4±2.5mm and 99.0±9.3mm respectively[6]. Similarly the lateral meniscal length, width and circumference were calculated as 35.7±3.7 mm, 29.3±3.0 mm and 91.7±9.6 mm respectively[6].

A cadaveric study done by B V Murlimanju et al (2012) on 23 cadavers, the medial meniscal circumference and the lateral meniscal circumference were calculated as 99.06 +/- 11.21mm and 90.25 +/- 9.36 mm respectively[7].

The difference in findings of the above mentioned study can be explained by the demographic variation as the I D Mc Dermott et al studied on European cadaveric subjects whereas the B V Murlimanju studied on the South Indian Cadaveric subjects[6,7]. Present study was carried out in Western part of India in Mumbai.

As shown in **table 2**, Medial Tibial plateau Length and Width were calculated as 46.64±2.77 mm and 31.73±2.48 mm respectively. Similarly the Lateral tibial Plateau Length and Width were

calculated as 40.72 ± 3.47 mm and 32.91 ± 2.39 mm respectively.

In a radiographic study done by I D Mc Dermott et al on 44 cadaveric tibial plateaus, the Length and width of medial tibial plateau were 50.4 ± 3.3 mm and 30.4 ± 2.4 mm respectively.[6] In the similar way they found the length and width of lateral tibial plateau to be 43.4 ± 3.4 mm and 31.3 ± 2.7 mm respectively.

Correlation between meniscal dimensions and tibial plateau dimensions: In the present study, cadaveric meniscal dimensions were correlated with respective cadaveric tibial plateau dimensions. Review of literature revealed that only one study was done to measure the tibial plateau and meniscal dimensions. It was done by McDermott et al, where they had shown direct radiographic measurements of tibial plateau and meniscal dimensions and correlation was established. In present study, meniscal length and width were correlated with the respective length and width of tibial plateau. Meniscal circumferences of both the medial and lateral menisci were correlated with total tibial plateau width.

On comparison of two studies, it was found that in the study done by McDermott et al on 44 menisci, there was poor correlation for medial meniscal length and length of medial plateau ($R^2=0.295$) and best fit equation derived was as follows Medial meniscal length= $0.83 \times$ medial tibial plateau length + 4.01 mm[6].

In present study as shown in figure 3, positive correlation was found for medial meniscal length and length of medial plateau which was statistically significant with p value of <0.001 , r (correlation coefficient)= 0.53 , $R^2=0.2839$, linear equation for correlation is as follows: $y = 0.71 \times x + 9.01$ mm, here y=medial meniscal length and x= length of medial tibial plateau.

McDermott et al also studied correlation of medial meniscus width and width of medial tibial plateau and found fair correlation[6]. Best fit equation for this was:

Medial meniscal width= $0.78 \times$ medial tibial plateau width + 3.57 mm.

In present study as shown in figure 4, medial meniscus width and width of medial tibial

plateau showed positive correlation which was statistically significant with p value of 0.013 , r(correlation coefficient)= 0.34 , $R^2=0.1207$, linear equation for this correlation is: $y = 0.48 \times x + 16.55$ mm here y=medial meniscal width and x= width of medial tibial plateau.

McDermott et al found good correlation for width of lateral meniscus and width of lateral tibial plateau ($R^2=0.752$), best fit equation derived was, Lateral meniscal width= $0.96 \times$ lateral tibial plateau width – 0.89 mm[6].

In present study, as shown in figure 6, positive correlation was seen for width of lateral meniscus and width of lateral tibial plateau which was statistically significant with p value of <0.001 and r(correlation coefficient)= 0.60 , $R^2=0.3522$. Linear equation for this correlation derived is as follows:

$y = 0.84 \times x + 5.61$ mm here y= Lateral meniscal width and x= lateral tibial plateau width.

In the study of McDermott et al there was positive correlation between total plateau width and medial meniscal circumference with equation:

Medial meniscal circumference= $1.15 \times$ total tibial plateau width+ 8.76 mm[6].

In the present study as shown in figure 7, medial meniscal circumference showed positive correlation with total tibial plateau width which was statistically significant with p value of <0.001 , $r=0.48$, $R^2=0.2304$, linear equation is as follows: $y = 0.87 \times x + 37.25$ mm, y= medial meniscal circumference and x= total plateau width.

McDermott et al also found fair correlation for lateral meniscal circumference and total bony plateau width with equation as:

Lateral meniscal circumference= $1.27 \times$ total bony plateau width – 7.70 mm[6].

In the present study as shown in figure 8, lateral meniscal circumference showed positive correlation with total tibial plateau width which was statistically significant with p value of 0.004 , $r=0.400$, $R^2=0.1596$, linear equation of this correlation is $y = 0.77 \times x + 40.81$ mm. y=lateral meniscal circumference and x= total tibial plateau width.

In the present study, as shown in figure 5, the lateral meniscal length showed positive significant correlation with lateral tibial plateau length which was statistically significant with p value of 0.015 $r=0.34$. $R^2=0.1179$. Linear equation of this correlation is $y = 0.3061 \times x + 20.259$ mm. y = lateral meniscal length and x =lateral tibial plateau length.

Different correlation values of two studies can be explained because of different modes of the two studies.

CONCLUSION

There are only few researches available to show the correlation of miss-match between the size of the tibial menisci graft and the tibial plateau. It can be easily judged that if the tibial menisci graft used after meniscectomy operation is smaller than the required size then it will malfunction as it will be trapped beneath the comparatively oversized femoral condyle. The disproportionate pressure distribution over the undersized meniscal graft will cause the graft failure. It can also be opined that an oversized tibial meniscal graft can also fail as fits loose around the femoral condyle and thus it is mechanically ineffective[6].

Thus, importance of geometrically matching the tibial meniscal graft to the host knee after meniscectomy operation in terms of size has been well established. Good understanding of these features of meniscal sizes in general population are very useful to avoid the graft failure due to mismatches in replacement surgeries[5]. Present Anthropometric study has provided a comprehensive set of quantitative measures of menisci and tibial plateau which may be of help for the design of artificial meniscal prostheses and for improvement of commonly used knee prostheses.

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Conflicts of Interests: None

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