APPENDIX

List of Research papers and poster presented at conferences and CME

Name of conferences and CME	Titles	Months and year
International Virtual Anatomy Conference	Os Fabella of knee: A Cadaveric study (Oral Presentation)	February, 2021
International Virtual Anatomy Conference	A cadaveric study on plantaris muscle with its clinical significance (Oral Presentation)	February, 2021
AVEOCON Anatomy Conference	Anatomy study of patellar ligament of knee joint with its clinical significance (Paper Presentation)	July, 2021
2nd International e-conference on "Exploring the Newer modalities in Teaching- Learning and Research in Basic Medical Science during COVID era"	An Unusual Accessory Band of Semitendinosus Muscle In Human Cadaver: A Rare Case Report" (Poster Presentation)	November, 2021
2nd International e-conference on "Exploring the Newer modalities in Teaching- Learning and Research in Basic Medical Science during COVID era"	Morphological Variation In Menisci Of knee With Its Clinical Significance: A Human Cadaveric Study (Oral Presentation)	November, 2021

List of Publications in Journals

Name of Journals	Title	ISSN Number	Vol. Numbers, Month and Years	Indexed in
MedPulse International Journal of Anatomy	Morphometric study of patella and patellar ligament of knee with its clinical significance.	Print ISSN: 2550-7621 Online ISSN: 2636-4557	Vol. 20(1) October 2021	Index Copernicus international
Journal of anatomical society of India	Anatomical and Morphological variations in the structures constituting in the insertion of Pes Anserinus of knee with its clinical significance: Human Cadaveric study	-	Volume 72(Issue 2) April-June 2023	Scopus & UGC care listed

Appendix-I

IVACON 2021

INTERNATIONAL VIRTUAL ANATOMY CONFERENCE

ANATOMICAL SOCIETY

of

KING GEORGE'S MEDICAL UNIVERSITY, U.P., LUCKNOW

Certificate of Participation

Dr. Meghana Joshi

gave an oral presentation during International Virtual Anatomy Conference, organized by the Anatomical Society, King George's Medical University UP, Lucknow, from 20-22 February 2021 entitled Os Fabella of knee: A Cadaveric study

9 UPMCI CREDIT HOURS

Dr. Punita Manik	Dr. Anita Rani	Dr. A. K. Pankaj
ORGANISING CHAIRPERSON	ORGANISING SECRETARY	ORGANISING SECRETARY

Appendix-2

IVACON 2021

INTERNATIONAL VIRTUAL ANATOMY CONFERENCE

ANATOMICAL SOCIETY
of
KING GEORGE'S MEDICAL UNIVERSITY, U.P., LUCKNOW

Award Certificate

Dr. MEGHANA JOSHI

gave an oral presentation which was adjudged as the "best oral presentation of the session" during International Virtual Anatomy Conference, organized by the Anatomical Society, King George's Medical University UP, Lucknow, from 20-22 February 2021, entitled – A cadaveric study on plantaris muscle with its clinical significance.

9 UPMCI CREDIT HOURS

Dr. Punita Manik	Dr. Anita Rani	Dr. A. K. Pankaj
ORGANISING CHAIRPERSON	ORGANISING SECRETARY	ORGANISING SECRETARY

Appendix-3

ANATOMY CONFERENCE

AVEOCON-2021

CERTIFICATE OF PARTICIPATION

This is to certify that Dr./ Mr./MS

Meghana Joshi

6 HOURS ACCREDITED BY UP MCI

Gave a Paper Presentation during E – National Conference AVEOCON - 2021

Organized by

Department of Anatomy, Teerthanker Mahaveer Medical College & Research Centre, Moradabad Uttar Pradesh

under aegis of Anatomical Society of India (UP Chapter) from 9-10th July 2021, entitled

"Anatomical study of patellar ligament of knee joint with its clinical significance"

Dr. S. K. Jain
Organizing Chairman
Vice Principal / HOD Anatomy
TMMC&RC, Moradabad

Dr. Shyamoli Dutta
Principal
TMMC&RC, Moradabad

Dr. Nidhi Sharma
Organizing Secretary
Professor of Anatomy
TMMC&RC, Moradabad

Appendix-4

VINAYAKA MISSION'S RESEARCH FOUNDATION
(Deemed to be University under section 3 of the UGC Act 1956)

AVMC
AARUPADAI VEEDU MEDICAL COLLEGE

BMSeCON 2021

Tamil Nadu Medical Council 6 Credit Hours*

2nd International e-conference on

"Exploring the Newer modalities in Teaching – Learning and Research in Basic Medical Sciences during COVID era"

Certificate of Proficiency

This certificate is presented to

Dr. Meghana Joshi,

*for making an e Poster Presentation - (UG Category) for his/her paper titled "**An Unusual Accessory Band of Semitendinosus Muscle In Human Cadaver: A Rare Case Report**" in **BMS e-CON**, organized by the Departments of Anatomy, Biochemistry, Physiology and Center for Biomedical Research, AVMCH, Puducherry, India held from 25th to 27th November, 2021.*

Dr. T. Rajan	**Dr. Lakshmi Jatiya**	**Dr. M. Manju**	**Dr. P.F. Kotur**
Organizing Secretary	Organizing Chairperson	Scientific Committee Head	Dean, AVMC

Appendix-5

VINAYAKA MISSION'S RESEARCH FOUNDATION
(Deemed to be University under section 3 of the UGC Act 1956)

AVMC
AARUPADAI VEEDU MEDICAL COLLEGE

BMSeCON 2021

Tamil Nadu Medical Council 6 Credit Hours*

2nd International e-conference on

"Exploring the Newer modalities in Teaching – Learning and Research in Basic Medical Sciences during COVID era"

Certificate of Appreciation

This certificate is presented to

Dr. Meghana Joshi,

*for making an oral paper Presentation - (PhD Category) for his/her paper titled "**Morphological Variations In Menisci Of Knee With Its Clinical Significance: A Human Cadaveric Study**" in **BMS e-CON,** organized by the Departments of Anatomy, Biochemistry, Physiology and Center for Biomedical Research, AVMCH, Puducherry, India held from 25th to 27th November, 2021.*

Dr. T. Rajan	**Dr. Lakshmi Jatiya**	**Dr. M. Manju**	**Dr. P.F. Kotur**
Organizing Secretary	Organizing Chairperson	Scientific Committee Head	Dean, AVMC

Original Research Article

Morphometric study of patella and patellar ligament of knee with its clinical significance

Meghana H Joshi[1], Vasant H Vaniya[2*]

[1]Department of Anatomy, Parul Institute of Medical Sciences and Research, Parul University, Vadodara, Gujarat, INDIA.
[2]Department of Anatomy, Government Medical College Baroda, The Maharaja Sayajirao University of Baroda, Gujarat, INDIA.
Email: mhjoshi67@gmail.com

Abstract

Background: Patella is largest sesamoid bone in humans. It forms component of knee joint and embedded in tendon of quadriceps femoris. Morphometric parameters of patella and patellar ligament reported important in designing patellar implant for the success of functionality of knee arthroplasty procedure and in various other surgical procedures of knee. **Aims and objectives:** To observe morphometric linear measurements of patella and patellar ligament of knee joint and to evaluate bilateral and sexual dimorphism in cadavers. **Materials and methods:** Total ninety lower limb including both sexes dissected for morphometric analysis of patella and patellar ligament. Mean length, width, thickness of patella and patellar ligament, width of medial and lateral articular facet of patella were measured by digital vernier calliper and analyzed statistically. **Results:** Mean length, width, thickness of patella measured 38.37, 48.95, 18.68mm on right sided and 37.40, 47.40, 18.40mm on left sided respectively. Mean Length, width and thickness of patellar ligament in proximal and distal part measured 59.82, 28.33, 4.044, 4.222mm on right sided respectively and 61.93, 28.95, 4.400, 3.977 on left sided respectively. Mean width of lateral and medial articular facet on right and left sided measured 27.00, 22.57, 27.00, 26.00mm respectively. **Conclusion:** The morphometric knowledge of patella, patellar ligament and their interrelationship can help to orthopaedic surgeons for knee arthroplasty procedure. Patellar ligament morphometric knowledge can be of great significant to the surgeons, as patellar tendon graft is choice of graft in anterior and posterior cruciate ligament reconstruction procedure using "Bone-patellar tendon-bone" autograft harvest.

Key Words: ACL reconstruction, knee Arthroplasty, Knee Joint, Morphometry, Patella, Patellar tendon.

***Address for Correspondence:**
Dr. Vasant H Vaniya, Department of Anatomy, Government Medical College Baroda, The Maharaja Sayajirao University of Baroda, Gujarat.
Email: mhjoshi67@gmail.com
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INTRODUCTION

The patella (knee cap) is flattened and triangular shaped bone, embedded within the tendon of quadriceps femoris muscle. It forms part of the knee joint situated in front of the lower end of the femur approximately one cm above the knee joint. It has a thick superior border and distally converging medial and lateral borders[1]. It has a rough anterior surface and posterior surface has upper three fourth (smooth and articulating) and lower one fourth (rough and non-articulating). Upper posterior surface is divided into medial and lateral articular facets separated by a vertical ridge. Each facet is further divided by faint horizontal lines into equal thirds. Between narrow strips along the medial border of the patella presents a seventh odd facet[1]. The patellar ligament is tendinous insertion of quadriceps femoris muscle, attached above to the margins and rough posterior surface of apex of patella and below to the smooth upper part of tibial tuberosity [1]. The morphometric knowledge of patella, patellar ligament and their interrelationship in different population group and gender is often utilized for the functionality of implant design. A disproportional patellofemoral joint implant would result in an ineffective lever support, limitation of range of motion, excessive wear of the patella with associated knee pain. Furthermore, knowledge is crucial in various other surgical procedures of knee such as the

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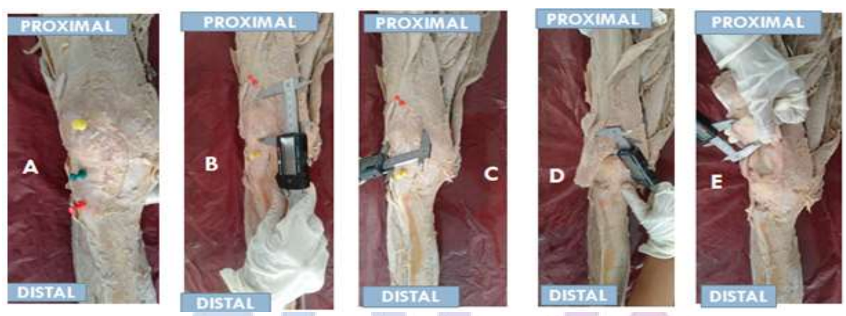
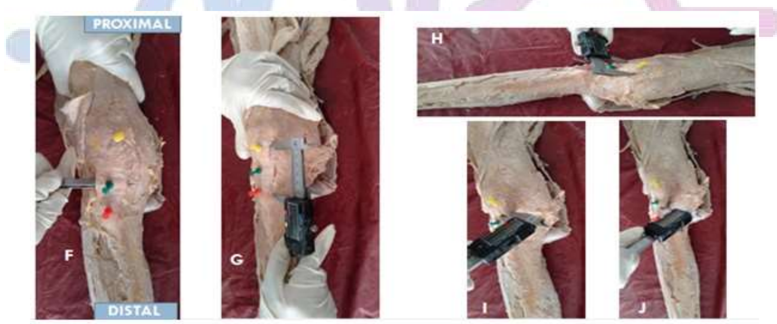
harvesting technique of patellar ligament grafts during the reconstruction of the anterior cruciate ligament and posterior cruciate ligament[1]. Patella is involved in various sitting and squatting positions and hence shows cultural and gender variables.[2,3,4] Therefore, present study was aimed to measure morphometric linear measurements of patella and patellar ligament of knee joint and to evaluate bilateral and sexual dimorphism in cadavers.

METHODOLOGY

This was an observational study carried out after obtaining approval from Institutional Ethics Committee for Human Research, Medical College and S.S.G. Hospital Baroda, Gujarat. Ninety properly embalmed and formalin fixed lower limb of adult cadavers (62 males and 28 females) were selected for the study. All the available specimens, did not have any visible external abnormalities in their lower limb were included. Any cadavers with previously operated in lower limb knee region, established osteoarthritis related changes to knee, signs of patellofemoral disease, physical signs of deformity of patella which may prevent the morphometric analysis of patella and patellar ligament were excluded from the study. Observations were made after dissecting the cadavers. An incision was made on the medial aspect of knee. Initially skin, overlying fascia and fat surrounding the knee joint was removed. The quadriceps femoris muscle and patellar tendon were freed from the surrounding structures. The patellar bone was exposed. The infrapatellar pad of fat was removed. Patellar tendon was cleaned and exposed after removal of parapatellar sheath.



Picture 1: Showing morphometric measurements of patella of knee in cadavers– present study.
A- Anterior aspect of dissected knee. B- Length of patella. C- Width of patella. D- Thickness of patella. E- Width of lateral articular facet.



Picture 2: Showing morphometric measurements of patellar ligament of knee in cadavers– present study.
F- Patellar ligament in dissected knee. G- Length of patellar ligament. H- Width of patellar ligament. I and J- Thickness of patellar ligament in proximal and distal part.

Table 1: Shows description of various measurements of patella and patellar ligament of knee

Measurements	Description
Length of patella	Linear distance between superior border and apex of patella.
Width of patella	Linear distance between medial border and lateral border of patella.
Thickness of patella	Linear distance between anterior surface and median ridge on posterior surface of patella.
Width of lateral articular facet	Maximum width from lateral border to median ridge of patella.
Width of medial articular facet	Maximum width from medial border to median ridge of patella.
Patellar Ligament Length	Linear distance between apex (non-articular posterior surface) of patella and tibial tuberosity.
Patellar Ligament Width	Linear distance between two margins/borders of patellar ligament.
Patellar Ligament Thickness	Linear distance between anterior and posterior surface of patellar ligament at proximal and distal part.

Statistical analysis: The data was measured by using digital vernier calliper in millimetres (mm). It shows mean, standard deviation (SD), Standard error of mean (SEM), t-value and p-value of all parameters of both male and female sexes and right and left side. Data was statistically analyzed by Statistical product and Service Solution (SPSS) in Microsoft Excel.
Ethical Issues: No ethical issues were involved.

RESULT

Total ninety cadaveric knee joints were dissected (Right = 45, Left = 45) with known gender. All measurements were taken in the Department of Anatomy from various colleges, and data was measured by digital vernier callipers. Data is enlisted in table 2 and 3 in detail.

TABLE 2: Statistical data of different parameters of patella and patellar ligament of knee right sided and left sided.

MEASUREMENTS	RIGHT SIDED (N=45)		LEFT SIDED (N=45)			
	Mean ±SD (in mm)	SEM	Mean ±SD (in mm)	SEM	t- value	P-value
Length of patella	38.37±0.554	0.083	37.40±0.542	0.081	1.197	0.230
Width of patella	48.95±0.724	0.109	47.40±0.485	0.073	1.115	0.260
Thickness of patella	18.68±0.171	0.025	18.40±0.170	0.172	0.913	0.360
Width of lateral articular facet	27.00±0.194	0.028	27.00±0.178	0.026	<0.001	0.500
Width of medial articular facet	22.57±0.224	0.033	26.00±0.168	0.025	1.488	0.070
patellar ligament Length	59.82±0.712	0.106	61.93±0.638	0.116	0.196	0.422
patellar ligament Width	28.33±0.535	0.079	28.95±0.436	0.065	0.647	0.259
patellar ligament Thickness (Proximal Part)	4.044±0.928	0.138	4.400±0.687	0.102	2.064	0.020
Patellar ligament Thickness (Distal Part)	4.222±1.412	0.210	3.977±1.177	0.175	0.891	0.187

TABLE 3: Statistical data of different parameters of patella and patellar ligament of knee in males and females.

MEASUREMENTS	MALE (N= 62)		FEMALE (N= 28)			
	Mean ±SD (in mm)	SEM	Mean ±SD (in mm)	SEM	t- value	P-value
Length of patella	39.54±0.506	0.064	33.82±0.427	0.080	5.199	0.001
Width of patella	48.00±0.687	0.087	48.22±0.407	0.055	0.299	0.382
Thickness of patella	18.62±0.175	0.222	18.35±0.168	0.031	0.688	0.246
Width of lateral articular facet	22.69±0.188	0.023	23.32±0.219	0.041	1.388	0.084
Width of medial articular facet	16.69±0.187	0.023	16.96±0.181	0.034	0.639	0.262
patellar ligament Length	60.24±0.625	0.079	59.96±0.614	0.116	0.196	0.422
patellar ligament Width	29.06±0.455	0.057	27.75±0.549	0.103	1.186	0.119
patellar ligament Thickness (Proximal Part)	4.177±0.820	0.104	4.321±0.862	0.163	0.758	0.225
Patellar ligament Thickness (Distal Part)	4.338±1.447	0.183	3.571±0.634	0.119	2.683	0.004

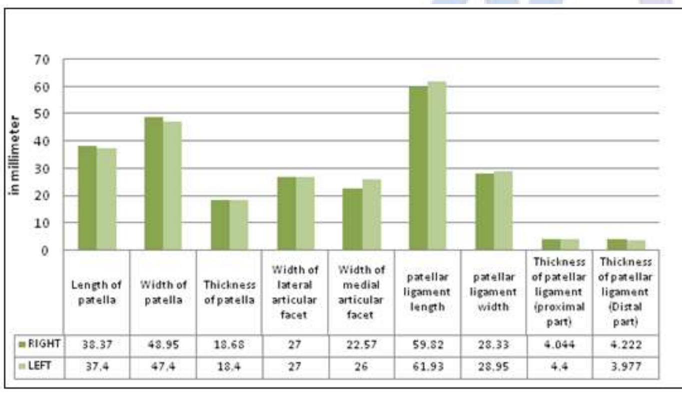
DISCUSSION

In the treatment of knee joint degenerative diseases, knee joint arthroplasty procedure has become popular. The proper use of morphometric matched prosthesis is the key to success for knee arthroplasty procedure. It is therefore very important to have knowledge of reliable morphometric data for designing and selection of implant size of prosthesis. The morphometric knowledge on patellar ligament can be of great significant to surgeon, as patellar tendon graft is the choice of graft in anterior cruciate ligament reconstruction procedures using “Bone-patellar tendon-bone” autograft harvest. For present study data was recorded from cadaveric study by direct observation. Morphometric study on patella and patellar ligament was usually done by dry bone study, CT-scan study or intra-operative study as per the author’s record. The present study results were compared with the studies done by other authors and it is elicited in Table no.4 below.

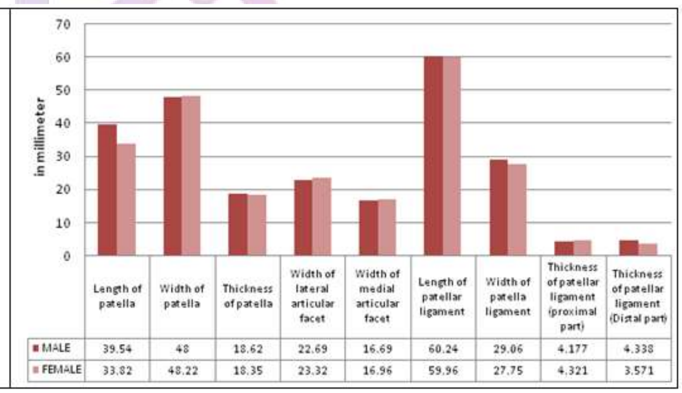
Table 4: Shows comparison of morphometric measurements of patella among various authors.

Measurements	Peng shang *et al.*[5] (2014)	I. Kayalvizhi *et al.*[6] (2015)	Rupa Chhaparwal *et al.*[7] (2018)	Sudipa Biswas *et al.*[8] (2019)	Shaifuzain Ab Rahman *et al.*[9] (2020)	Present study
Length of patella (in mm)	R- 39.98	R- 42.90	R- 36.61	R- 39.45	R- 31.41	R-38.37
	L- 39.90	L- 41.70	L- 36.72	L- 40.53	L- 31.24	L-37.40
Width of Patella (in mm)	R-44.12	R- 42.10	R- 38.80	R- 40.54	R- 40.67	R-48.95
	L-44.15	L- 41.30	L- 38.53	L- 41.21	L- 40.85	L-47.40
Thickness of patella (in mm)	R-22.65	R- 19.70	R- 19.21	R- 19.39	R- 20.82	R-18.62
	L-22.79	L- 20.70	L- 19.31	L- 19.79	L- 20.65	L-18.35
Width of lateral articular facet (in mm)	R-25.21	R- 30.50	R- 22.73	R- 19.75	R- 21.30	R-27.00
	L-25.06	L- 26.40	L- 23.97	L- 20.16	L- 21.30	L-27.00
Width of medial articular facet (in mm)	R-18.92	R- 22.10	R- 20.94	R- 14.78	R- 19.22	R-22.57
	L-19.15	L- 22.40	L- 20.44	L- 15.60	L- 19.55	L-26.00

Result found in study by poonam vohra *et al.*[3] was little smaller as compared to present study. Present study results for morphometric measurements of patella were almost similar to the study conducted by Peng Shang *et al*.[5]., I. Kayalvizhi *et al.*[6] In present study results observed for width of patella measured highest in comparison with other authors and results observed in mean values of right and left sided patella were to be similar. Although the right patellar width showed somewhat larger values than the left patella, but it was not statistically significant. In the present study, the mean value of patellar ligament length was measured on the right side 59.82±0.712 and on the left side 61.93±0.638 respectively. The result was much higher than found in Jae Ho Yoo *et al.*[11], Oladiran Olateju OI *et al.*[12] and less than the result found in Zooker Chad *et al.*[13] Mean value of width of patellar ligament was measured 28.33±0.535 on right side and 28.95±0.436 on left side, the data was measured similar in other studies by authors Jae HO Yoo *et al.*[11], Oladiran Olateju OI *et al.*[12] and Zooker, Chad *et al.*[13] Mean value for thickness of patella was measured in proximal and distal parts and found similar as by Jae HO Yoo *et al.*[11] Furthermore mean values of male and female specimen for sex dimorphism was also found to be similar. Although the length of patella and patellar ligament were insignificantly observed higher in males than females. The difference in results may be due to the difference in build and stature of females.



Graph 1



Graph 2

Graph 1: Morphometric linear measurements of patella & patellar ligament of knee right sided vs. left sided; **Graph 2:** Morphometric linear measurements of patella & patellar ligament of knee in males vs. females

CONCLUSION

The present study aids morphometric knowledge in patellar bone and patellar ligament and established data with sex and right and left pattern. Knowledge can be utilized for implant design in replacement and reconstructive surgeries of knee and various other surgical procedures involving knee. The data can significantly help in orthopaedic surgery, Forensic evaluation, anthropology, comparative anatomy, and evolutionary biology of humans.

Acknowledgement: Authors are thankful to the teaching and non-teaching staff of department of Anatomy, especially Medical College Baroda, GMERS Medical College Vadodara, J. S. Ayurveda Mahavidhyalaya, Dr.N.D.Desai Faculty of Medical Sciences and Research for their full co-operation and support as and when required.

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Conflict of Interest: None Declared

Anatomical and Morphological Variations in the tendons Constituting the Pes Anserinus of Knee with its Clinical Significance: A Human Cadaveric Study

Meghana Harshadbahi Joshi, Minal K Ravat[1], Vasant H Vaniya[2]

Department of Anatomy, Dr. Kiran C. Patel Medical College and Research Institute, VNSGU, Bharuch, Surat, [1]Department of Anatomy, GMERS Gotri Medical College, [2]Department of Anatomy, Government Medical College, Baroda, The M. S. University, Vadodara, Gujarat, India

Abstract

Context: Pes anserinus (PA) includes conjoined tendinous insertion of the sartorius, gracilis, and semitendinosus muscles. Each tendon can have individual insertions attached nearly in a linear arrangement. The presence of accessory tendons, bands, and structures constituting in forming PA shows high variability and has been reported clinical importance in harvesting PA graft and tendon reconstruction procedure. **Aim:** The present study aimed to macroscopically observe anatomical and morphological variations in the structures constituting in the insertion of the PA tendon and establish its clinical significance. **Subjects and Methods:** A total of ninety cadaveric lower limbs including both sexes dissected to observe variations in the structures forming PA at the anteromedial surface of the upper part of the tibia. **Statistical Analysis Used:** The descriptive statistical analysis was done. **Results:** PA was constituted of sartorius, gracilis, and semitendinosus tendons in all the specimens. The most common pattern observed was monotendinous-sartorius, gracilis, and semitendinosus in 67 (74.44%) limbs. The semimembranosus and tibial collateral ligament participation was observed in 5 (5.55%) and 2 (2.22%) limbs, respectively. The accessory band of sartorius and semitendinosus was observed in 2 (2.22%) and 14 (15.55%) limbs, respectively. **Conclusions:** PA in the medial side of the knee is a common injury site. The presence of any accessory structures or bands within can handicap graft harvesting since the gracilis and semitendinosus tendons are routinely harvested for the reconstruction procedure. Furthermore, present anatomical knowledge can be helpful to surgeons for preoperative radiological examination and to avoid complications during transplant graft surgeries of the knee.

Keywords: *Anserine bursitis, anterior cruciate ligament reconstruction, gracilis tendon, guy ropes, hamstring graft, knee joint, pes anserinus, sartorius tendon, semitendinosus tendon*

Introduction

Pes anserinus (PA) in Latin means "goose foot." The PA is formed by the tendinous insertion of sartorius (S), gracilis (G), and semitendinosus (ST) muscles in the anterior to posterior aspect on the anteromedial surface of the upper part of the tibia, lying superficial to the tibial collateral ligament.[1] The radiating arrangement of insertion pattern of tendons of PA resembles to the goosefoot, hence the name PA. It is also known as guy ropes. The muscles of PA arise from the three different compartments of thigh and have a common tendinous insertion on the anteromedial aspect of tibia separated by a complicated anserine bursa.[2]

- Sartorius is a long, narrow, and ribbon-like muscle of anterior compartment of thigh. It runs obliquely extending from the hip bone to the leg on tibia below the knee. It arises from the anterior superior iliac spine and upper half of the notch below the spine and is inserted on the anteromedial aspect of the tibia, forming a most superficial component of PA
- Gracilis is a long, slender, and most superficial muscle of medial (adductor) compartment of the thigh. The muscle lies on the medial aspect of the thigh and extends from the hip bone above to the tibia bone below the knee. It arises from the anterior surface of the body of pubis from its lower half, inferior pubic ramus and ramus of ischium and it inserts on the anteromedial aspect of the tibia; where it lies between sartorius and semitendinosus muscle and forming a component of PA

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Address for correspondence:
Dr. Meghana Harshadbahi Joshi, Department of Anatomy, Dr. Kiran C. Patel Medical College and Research Institute, VNSGU, Bharuch, Gujarat, India.
E-mail: mhjoshi67@gmail.com

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Website: https://journals.lww.com/joai

DOI: 10.4103/jasi.jasi_41_22

Quick Response Code:

- Semitendinosus is a fusiform muscle of the posterior compartment of thigh. It arises from the posteromedial impression of ischial tuberosity and inserts on the anteromedial aspect of the tibia, forming a component of PA.[1]

The anatomical knowledge and relationship of the structures in the medial aspect of the knee and the tendons forming PA is essential for the accurate diagnosis and for the development of improved surgical and operative procedures in the various pathologies related to the knee.[3] The lack of morphological and anatomical knowledge of the PA tendon can lead to damage to the infrapatellar branch of the saphenous nerve, tibial collateral ligament, and difficulty in identifying their insertion pattern in knee surgeries.[4] Overuse, acute trauma, iatrogenic disorders, and tumors are all common causes of PA damage. An incorrect incision can result in complications such as cutting the main tendon, insufficient graft length, tibial nerve injury, decreased normal glide, and muscle stiffness.[5] Currently, steroid injection in the anserine bursa is a method to treat bursitis that can provide pain relief. The accuracy of anserine bursa injection with ultrasound guidance is markedly higher compared to the blind injection.[6] However, in clinical practice, surgeons are frequently confronted with situations that necessitate blind injections, despite the fact that ultrasound-guided injections are highly preferred. Understanding and identifying morphological variations of the PA based on anatomical knowledge would be very useful in the case of a blind injection.[7,8] Hence, understanding the tendon constituent of PA and the arrangement of the accessory bands is a prerequisite for a favorable clinical outcome. As a result, the goal of this study is to macroscopically review and focus on the anatomical and morphological variants of the structures constituting the insertion of PA, and to compare them to previously documented studies in an attempt to provide baseline anatomical information for PA.

Subjects and Methods

This was an observational study carried out in 90 (62 males and 28 females) properly embalmed and formalin-fixed lower limbs of adult cadavers dissected from the cadaveric laboratory of the Anatomy Department. The study was done after obtaining approval from the Institutional Ethics Committee for Human Research. All the available specimens were included in the study that did not have any visible external abnormalities in their lower limb. The specimens previously operated in the lower limb knee region, which may prevent the cadaveric analysis of knee, were excluded from this study. While doing the dissection in the various specimens in knee region, we observed different variations in the insertion pattern of tendons on the anteromedial aspect of the knee including sartorius (S), gracilis (G), and semitendinosus (ST). Various patterns of PA formation including monotendinous-sartorius, gracilis, semitendinosus (S/G/ST pattern), monotendinous-sartorius, Gracilis, semitendinosus, semimembranosus (S/G/ ST/SM pattern), sartorius, gracilis, semitendinosus, semimembranosus, tibial collateral ligament (S/G/ST/SM/ TCL pattern), S/G/ST/ aST pattern, S/G/ST/aS pattern, S/G/ ST/aS/aST pattern, S/G/ST/aST/abST pattern were observed. Therefore, the aim was made to evaluate the tendinous insertion of PA, in detail showing total number of specimens with parentage of individual pattern involved in constituent of PA and various individual structures in numbers and percentage contributing in forming PA. For this, an incision was made on the skin at the anteromedial aspect of the knee. Initially, the skin was reflected, and fat and superficial fascia along the medial aspect of the knee was cleaned carefully. Upon dissection, PA tendons including sartorius, gracilis, and semitendinosus muscle were exposed carefully to identify for any anatomical and morphological variations. The insertion site of all the specimens was macroscopically observed by the principal investigator. The data were analyzed for several variations in the disposition of the tendons of muscles, ligaments, and accessory band taking participation in the constitution of each PA, and considered for the computation. The findings were documented, recorded, and photographed. The obtained data were analyzed using descriptive statistics analysis.

Results

Several variations were observed for PA. In the present study, no muscle of PA was found to be absent in any specimen of lower limb. Various structures were observed involving in forming PA and thus forming various patterns of PA. The data are enlisted in detail in Table 1 showing total number of specimens with parentage of various patterns involved in constituent of PA. Furthermore, the data is also presented in graph showing various individual structures in numbers and percentage contributing in forming PA.

Various patterns involved in constituent of pes anserinus

The most common and most constituent in PA was observed with S/G/ST pattern.

The other variant was observed as participation from the semimembranosus muscle S/G/ST/SM pattern, tibial

Table 1: Various pattern involved in constituent of insertion of pes anserinus in total number of specimens and parentage

Pes anserinus pattern formed by	Pattern present in total number of specimens	Percentage (%)
Monotendinous S/G/ST pattern	67	74.44
Monotendinous S/G/ST/SM pattern	5	5.55
S/G/ST/SM/TCL pattern	2	2.22
S/G/ST/aST pattern	12	13.33
S/G/ST/aS pattern	2	2.22
S/G/ST/aS/aST pattern	1	1.11
S/G/ST/aST/abST pattern	1	1.11

S: Sartorius, G: Gracilis, ST: Semitendinosus, SM: Semimembranosus, TCL: Tibial collateral ligament, aS: Accessory band of S, aST: Accessory band of ST, abST: Another band of ST collateral ligament (S/G/ST/SM/TCL pattern), accessory band of sartorius S/G/ST/aS pattern, and various accessory bands of semitendinosus muscle S/G/ST/aST pattern or S/G/ST/aST/abST pattern.

The participation of accessory band of semitendinosus as S/G/ST/aST pattern was observed as a most frequent variation. Figure 1 and Table 1 shows different patterns involved in constituent of insertion of PA in total number of specimens and in parentage.

Individual structures contributing in the formation of pes anserinus

In the present study, sartorius, gracilis, and semitendinosus were observed to take participation in forming the PA in all the specimens (n = 90, 100%). The other variant was observed as participation from the semimembranosus muscle (n = 7, 7.77%), tibial collateral ligament (n = 2, 2.22%), accessory band of sartorius (n = 2, 2.22%), accessory bands of semitendinosus muscle (n = 2, 2.22%), and another (ab) accessory bands of semitendinosus muscle (n = 1, 1.11%), as depicted in Graph 1.

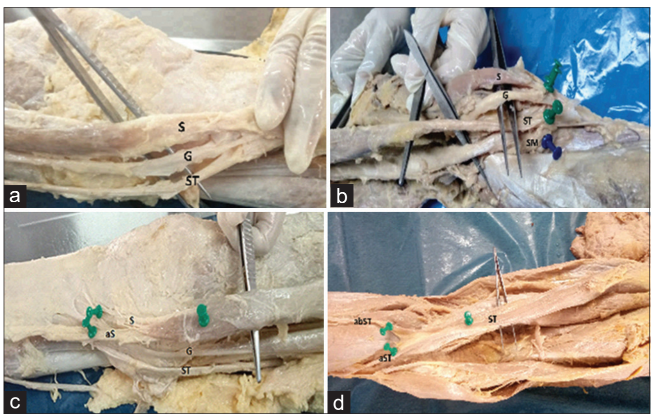
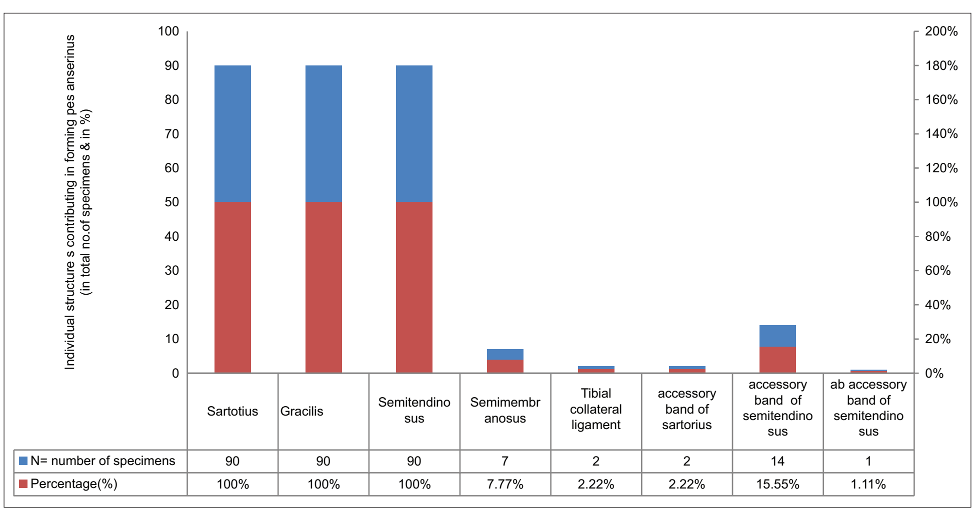


Figure 1: (a) Most frequent constituent of pes anserinus with monotendinous tendons of sartorius (S), gracilis (G), and semitendinosus (ST), muscle forming (S/G/ST) pattern. (b) Tendon of semimembranosus muscle (SM) taking participation in the constituent of pes anserinus forming S/G/ST/SM pattern. (c) Accessory band of sartorius tendon taking participation in the constituent of pes anserinus forming S/G/ST/Sa pattern. (d) Accessory bands of semitendinosus taking participation in the constituent of pes anserinus forming S/G/ST/aST/abST pattern

Discussion

Studies on the anatomical variation of PA are rare in the literature. It serves as an additional secondary valgus constraint, strengthening the medial knee supporting structures. In the present scenario, the arthroscopic ACL reconstruction using semitendinosus and gracilis tendons is a popular technique for the treatment of ACL-deficient knees. Ten embalmed adult human cadaveric limbs were dissected for the gracilis and semitendinosus tendons by Candal-Couto JJ.[3] Bands were seen between tendons, connecting them to the popliteal fascia, sartorius, gastrocnemius, pretibial, and superficial fascia, as the author noted that the accessory bands of the PA exhibit a high degree of diversity. Similarly, Mochizuki *et al*.[5] dissected nine legs of five adult cadavers and observed a superficial longitudinal fibrous bundle on the superficial surface of the sartorius and a deep longitudinal fibrous bundle on the aponeurotic membrane covering the tendon of the gracilis muscle. The fascia covering the medial head of the gastrocnemius and fascia cruris, and a minor tendinous extension from the semimembranosus muscle, were joined with aponeurotic membrane from the semitendinosus tendon and tibial collateral ligament. In the study done by Kijkunasathian *et al*.,[6] The proximal site of PA insertion in the Thai population was determined by measuring the distance between the tibial tuberosity and the PA tendon insertion in 85 cadavers. When performing reconstructive surgery on tendons or administering steroid injections to treat anserine bursitis, these structures are crucial from a clinical standpoint. 46.8% of individuals with knee osteoarthritis have a clinical diagnosis of anserine bursitis. In contrast, radiographic evidence of knee osteoarthritis was seen in 83.3% of individuals with anserine bursitis or tendinitis.[9] Patients with pes anserine bursitis will typically appear with



Graph 1: Various individual structures contributing in forming pes anserinus in total number of specimens and in percentage

pain and swelling in the medial aspect of the knee, which may cause the clinician to accurately diagnose them as having differential knee pathology.[10] Furthermore, the diagnostic imaging and minimally invasive surgical approaches of PA are significantly variable.[11,12] The literature suggests that investigation evaluation for the boundary of anserine bursa with the recommended injection site and shape on the insertion area of PA, with the aim of improving clinical practice in uncommon problems like snapping pes syndrome, is highly significant.[12] The ligament restoration and reconstruction surgeries are also used to treat a variety of traumatic injuries, most frequently to the knee and ankle joints. The hamstring tendons are one of the most commonly used grafts in anterior cruciate ligament (ACL) reconstruction of the knee, either as an autograft or allograft. For tendocalcaneus repair, repair of a ruptured patellar tendon, and restoration of the ACL, orthopedic surgeons frequently use knee flexor tendons like the semitendinosus and gracilis.[13,14] The hamstring tendon grafts when compared to patellar-bone-tendon-bone grafts allow harvesting through a minimal skin incision, minimal donor site morbidity, and less extensor mechanism dysfunction or functional deficits. However, during a surgical procedure, concrete landmarks are required to navigate the incision site and identify the appropriate tendons for grafting. The knowledge of surface landmark and anatomical and morphological variants of pes anserine is a prerequisite for orthopedic surgeons while harvesting the anserine graft to minimize various complications like extra care must be taken with the use of the tendon stripper if one is to avoid cutting the main tendon.[12-14] Therefore, the goal of the current study was to provide the most significant information regarding the proper recognition of the numerous variations in tendons and structures that constitute the PA in terms of their insertion type. This similar type of study was carried by various other authors and their results compared with the result of the present study elicited in Table 2.

In order to determine the shape of the PA, Lee *et al*.[12] dissected 86 limbs. They found that the sartorius was placed into the superficial layer, the gracilis was inserted into the deep layer on the medial surface of the tibia, and the semitendinosus was inserted into the deep layer. Ashaolu *et al*.[14] evaluated morphological framework of the PA in Nigerian cadavers and observed the insertion was also joined to the part of tibia close to the tibia tuberosity (90%) and to the fascia cruris (10%). Additionally, the author noted that accessory bands of the sartorius, gracilis, or semitendinosus were a part of the PA in 95% of cases, but the combined occurrence of the monotendinous sartorius, gracilis, and semitendinosus tendons was only reported in 5% of cases. Cidambi *et al*.[15] performed an MRI study to identify the frequency and characteristics of anomalous PA tendon morphology in an adolescent population undergoing knee ACL reconstruction surgery. The author concluded that the accessory muscle and tendon could be an aberrant strip of the semimembranosus tendon, an anomalous tendon and muscle belly of the gracilis, or a thickening and separation of the sartorius tendon.

In the study done by Lukasz *et al*.,[16] the PA was present and composed of the sartorius, gracilis, and semitendinosus tendons. The existence of accessory bands allowed the author for the differentiation of six different types of PA. Further, the author observed the commonest pattern involving in PA formation was monotendinous sartorius, gracilis and semitendinosus (S/G/ST pattern) in 54 limbs (52.9%). Additionally, three types of insertion were noted (short, band-shaped, and fan-shaped). The mean length between the insertion and the origin of the accessory bands to the fascia of the gastrocnemius muscle was 63.5 mm.

In the study conducted by Murlimanju *et al*.,[18] it was found that 48 lower limbs (90.6%) had PA formed by the gracilis, semitendinosus, and sartorius tendons. It was found that 5 lower limbs (9.4%) had a divergent pattern of PA morphology, whereas 7 (13.2%) had early convergence and 41 (77.4%) had convergent type. Semimembranosus muscle was taking in the formation of PA in 3 lower limbs (5.7%). The PA was inserting into the fascia cruris and not tibia in 8 specimens (15.1%). However, the insertion occurred at both the tibia and fascia cruris in 10 cases (18.9%). In 15.1% of cases, the insertion was limited to the fascia cruris and not the tibia. The semitendinosus was giving an extra slip, which was attaching to the medial condyle of tibia in 7 cases (13.2%). It was giving slip to medial collateral ligament in 2 cases (3.8%) and ligamentum patellae in 1 case (1.9%). The PA formed by the combination of monotendinous sartorius, gracilis, and semitendinosus (S/G/ST pattern) was reported to be the most commonly observed pattern forming PA in the current study. However, such pattern was observed highest in Cidambi *et al*.[16] The present study results were similar to the results observed by the authors Cidambi *et al*.[16] and Murlimanju *et al*.[18] In the present

Table 2: Author-wise comparison of morphological variants of tendons of pes anserinus

Author's name	Year of study	Number of samples	Pes anserinus formed by S/G/ST (%)	Pes anserinus formed by S/G/ST/SM (%)	Other variants (%)
Ashaolu *et al*.[14]	2015	20	1 (5)	25%	70%
Cidambi *et al*.[15]	2016	123	97.60	-	2.40%
Olewnik *et al*.[16]	2019	102	54 (52.9)	-	47.10%
Munhoz *et al*.[17]	2018	7	-	-	-
Murlimanju *et al*.[18]	2019	53	48 (90.60)	3 (5.70)	3.70%
Present study	2021	90	67 (74.44)	5 (5.55)	18 (19.99)

S: Sartorius, G: Gracilis, ST: Semitendinosus, SM: Semimembranosus study, the author observed that the PA was also formed with combined occurrence of monotendinous sartorius, gracilis, semitendinosus, and semimembranosus tendon (S/G/ST/SM pattern) in 5 (5.55%) specimens, the data were measured almost similar with Murlimanju *et al*.[18] but the value was very less compared to the study done by Ashaolu *et al*.[14]

Further, various study showed a greater distance for the vincula of the gracilis compared to the semitendinosus for the insertion of PA.[19,20] The variations observed in the present study that the tibial collateral ligament, accessory band of sartorius and accessory bands of semitendinosus, and accessory band of gracilis were taking participation in the formation of the PA. The participation of accessory band of semitendinosus (S/G/ST/aST pattern) was observed as a most frequent variation in 12 (13.33%) specimens, and the tibial collateral ligament was in 2 (2.22%). The sartorius, gracilis, semitendinosus, and accessory band of sartorius was observed in 2 (2.22%) specimens.

The sartorius, gracilis, semitendinosus, accessory band of sartorius, and accessory band of semitendinosus (S, G, ST, aS, aST pattern) was observed in 1 (1.11%) specimen. The sartorius, gracilis, semitendinosus, accessory band of sartorius, accessory band of semitendinosus, and another accessory band of semitendinosus (S/G/ST/aS/aST/abST Pattern) was observed in 1 (1.11%); these types of variations were not commonly seen. In addition, no accessory band of gracilis was observed in the present study and no classification of the PA has been drawn up.

Conclusions

The present study confirms and highlights the several variants of the PA. Based on these findings, it can be concluded that PA was formed by sartorius, gracilis, semitendinosus, semimembranosus tendons, their accessory tendon bands, and tibial collateral ligament. The knowledge of such anatomical variants is significant in planning and performing various surgical procedures by orthopedic surgeons and plastic surgeons. Furthermore, the improved preoperative radiological investigations of PA may aid operating surgeons in avoiding iatrogenic injuries, premature tendon grafts, and subsequent difficulties during the graft harvesting procedure and reconstructive knee surgeries.

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Conflicts of interest

There are no conflicts of interest.

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