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EDITORIAL

The teaching of anatomy in the modern world – The role of human cadaveric dissection

The teaching of anatomy has long been the core of medical education throughout the world. A comprehensive knowledge of anatomy is crucial in better understanding of pathology and physiology. This results in safer and better clinical performance.

Human cadaveric dissection (dissection) is a traditional component of anatomy teaching. The dissection has been practiced as a key method of studying and teaching anatomy since the ancient days. Herophilus and Erasistratus practiced dissection for the first time in the 3rd century BC at the Greek school of medicine in Alexandria. Herophilus and Erasistratus performed the dissection on executed prisoners. But, following their deaths, the practice of dissection gradually diminished. After that there was a dark period for dissection because it was prohibited by the religion. However the church permitted dissection in the 13th century for the development of anatomy and science. Following that, the dissection was declared official in the 14th century (in 1340) in Montpellier, France (1). Since that time, dissection has been the foundation of human anatomy education.

Dissection has numerous benefits for students. The dissection promotes respect to the death and the living among the students. It also encourages interpersonal skills and teamwork. For the students, teamwork is a vital ability for their future careers. Dissection also teaches students to appreciate the tactile perception of tissues and increases three-dimensional perception. Furthermore, several studies conducted among medical students revealed that medical students regard dissection as a vital tool for learning and they like the dissection process. (2). Studies have also demonstrated that teaching using dissection produces better learning outcomes in students (3).

Traditional anatomy teaching was with dissection, lectures and tutorials. In Sri Lanka, dissection remains as the primary method of anatomy teaching. However there are problems associated with this type of traditional anatomy teaching. Trained personnel are required for dissection-based anatomy teaching. Some major issues with traditional anatomy teaching are a lack of anatomists, a lack of cadavers (in other parts of the world), and the number of teaching hours required.

However the method of teaching anatomy has changed overtime. The alternative teaching methods adopted in other parts of the world include; pre dissected cadaveric specimens (prosections), plastinated specimens, plastic models (4), computer based system learning (virtual dissection table) (5), etc. Furthermore, due to current curriculum revisions and the promotion of student-cantered learning, various teaching methods such as peer teaching, computer-based learning, learning through videos, and simulations have been introduced. (6).

The number of anatomy teaching hours and the amount of anatomy taught are rapidly decreasing globally due to the addition of additional specialties to the medical curriculum and the promotion of student-cantered learning approaches. (7), (8). In Sri Lanka the number of hours allocated to the teaching of anatomy varies between the faculties from 483 to 733 hours (9). The notable thing in this is that faculties which were established recently allocated more time for anatomy teaching. Another factor is that the amount of anatomy teaching hours is reducing with curriculum revisions (9). For example, after such a curriculum revision at one of Sri Lanka's universities, the anatomy curriculum was reduced by 25.5% (9).

There is also a global lack of anatomists. This reduces the number of medical schools that have dissection (10). Furthermore, according to a circular issued by the University Grants Commission in 2019, the approved norm for a faculty's student: teaching staff ratio is 7:1 (11). However, many faculties do not have enough staff to meet this ratio. (9). In various regions of the world, the availability of human cadavers is also a difficulty (10). However due to the culture, there are adequate cadaver donations to medical institutions in Sri Lanka. (12).

Anatomy teachers have expressed concern about the reduction of anatomy teaching hours and dissection hours, which has resulted in students having lesser knowledge of anatomy. They reported that new surgical trainees who studied the revised curriculum as medical students (reduced dissection time curriculum) required additional anatomy teaching. (13). Therefore we should continue the traditional dissection with explanations provided by a staff frequently. This combination is shown to improve the understanding of anatomy by the students (14). It has been shown that students also like the traditional way of dissection to learn anatomy.

Taking into account all of the factors. Dissection should be continued as a major component of anatomy education in the future. Because this forms the cornerstone of anatomy teaching. The teaching hours of anatomy should not be reduced significantly in the new curricula. Because the dissection teaches them the fundamentals of human structure, human pathology and physiology. This results in more effective application of their knowledge as doctors, particularly surgeons. As Robert Liston once said that “the foundation of the study of the art of operating must be laid in the dissecting room”.

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REVIEW ARTICLES

Incidence of "*Caterpillar hump*" of right hepatic artery in the "*Calot triangle*" among a selected population in Sri Lanka. A chart review

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Abstract

Introduction: "*Caterpillar hump*" of the right hepatic artery in the triangle of Calot, is a rare variation that increases the risk of vascular and biliary injuries during laparoscopic cholecystectomy. This study aims to determine the prevalence of right hepatic artery forming "*caterpillar hump*" in a selected cohort of patients who underwent laparoscopic cholecystectomy in a private hospital in Sri Lanka.

Methods: A retrospective chart review was conducted to determine the prevalence of "*Caterpillar hump*" of the right hepatic artery among patients who underwent laparoscopic cholecystectomy for symptomatic cholelithiasis in a private hospital in Colombo, Sri Lanka, from 2015 to 2022. Data were retrieved from the available records at hospitals from 2015 to 2022. There were 79 patients recode during the study period. These records consist of manually written bed head charts, discharge summaries and electronic medical records. Patient records which did not clearly mention the Calot triangle vasculature or illegible handwriting were excluded from the study. Out of that, only 75 [94.9%] patients' charts were eligible for the study. Data on demographic and Calot triangle vasculature was recorded during surgery and retrieved from the hospital records. Ethical approval for the study was obtained from the hospital's ethical committee.

Results: Among the patients who underwent laparoscopic cholecystectomy, 50 (66.7%) were female, and 25(33.3%) were male patients, with a mean (±SD) age of 57.4±4.8 years (range 18–81). The prevalence of the "caterpillar hump" right hepatic artery in the calot's triangle among the study sample was 4 % (3/75). Two were females and one male. In all cases, the vascular variation was reported in a single-loop fashion, and no double-loop configuration was noted.

Conclusions: This study showed that the right hepatic artery was subjected to this rare anatomical variation. This anomalous presentation increased the risk of vessel ligation or injury during laparoscopic Cholecystectomy. Thus, the awareness of caterpillar hump within Calot triangle, during surgical procedures is useful.

Keywords: Calot's triangle, Caterpillar hump, Cholecystectomy

Introduction

Laparoscopic cholecystectomy has been widely accepted as the gold standard for patients with symptomatic gallstone disease. [1] However, despite excellent surgical field visualisation, the laparoscopic approach is associated with a slightly increased risk of iatrogenic biliary injury and arterial haemorrhage. [1] The variations in biliary and related vascular anatomy of the gallbladder predispose to iatrogenic injuries during cholecystectomy. [2]

The reported incidence rate of conversion to open surgery due to vascular injuries is approximately 0%–1.9%,[10] with a mortality rate of 0.02%.[1,2] Although several variations in the origin and branching pattern of Calot triangle arteries have been reported,[1,3] the tortuous right hepatic artery configuring an insidious hump is one of the most dangerous anomalies. This configuration is known as caterpillar hump, or Moynihan's hump, [4]; the right hepatic artery runs very close to the gallbladder and cystic duct, forming a U-shaped loop, where the cystic artery is very short. [4,5] [Diagram 01] This misidentifies vascular structures with wrong clipping or uncontrollable bleeding. [5]

Therefore, detailed knowledge of arterial and biliary variants in the Calot triangle is essential to perform safe Cholecystectomy. [3,5] This study aims to assess the prevalence of the right hepatic artery forming caterpillar hump in patients who underwent laparoscopic cholecystectomy for symptomatic gallstone disease.

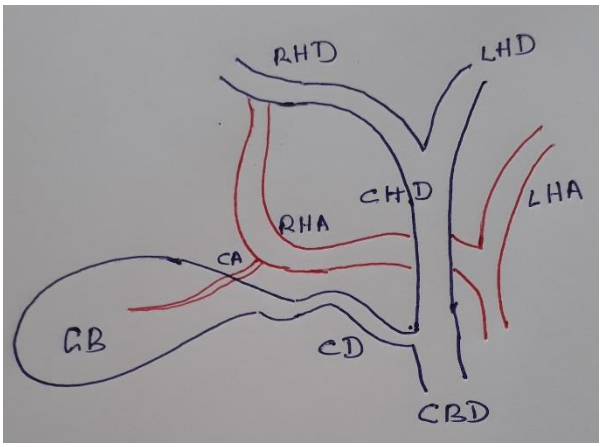

Diagram 01: Showing the tortuous right hepatic artery (RHA) forming a U-shaped loop configuring in the Calot triangle [bounded by the cystic duct (CD), Common Hepatic Duct (CHD) and lower border of the liver], known as caterpillar hump, or Moynihan's hump. The RHA runs very close to the gallbladder (GB) and cystic duct (CD), where the cystic artery (CA) is very short. LHA – Left Hepatic Artery; LHD – Left Hepatic Duct; RHD – Right Hepatic Duct.

Method

A retrospective chart review was conducted to determine the prevalence of "Caterpillar hump" of the right hepatic artery among patients who underwent laparoscopic Cholecystectomy for symptomatic cholelithiasis in a private hospital in Colombo, Sri Lanka, from 2015 to 2022. Data were retrieved from the available records at hospitals from 2015 to 2022. There were 79 patients recode during the study period. These records consist of manually written bed head charts, discharge summaries and electronic medical records. Patient records which did not clearly mention the Calot triangle vasculature

or illegible handwriting were excluded from the study. Out of that, only 75 [94.9%] patients' charts were eligible for the study. Data on demographic and Calot triangle vasculature was recorded during surgery and retrieved from the hospital records. Ethical approval for the study was obtained from the Hospital's ethical committee.

Statistical Analysis

The continuous, normally distributed variables are presented as the mean and SD, whereas categorical variables are presented as the portions. All analyses were performed using SPSS 17 software package (SPSS, Inc., Chicago, IL, USA)

Results

Among the patients who underwent laparoscopic Cholecystectomy, 50 (66.7%) were female, and 25(33.3%) were male patients, with a mean (±SD) age of 57.4±4.8 years (range 18–81). The prevalence of caterpillar hump right hepatic artery in the calot's triangle among the study sample was 4 % (3/75). Two were females and one male. For the patients who identified as having a "*caterpillar hump*", the right hepatic artery presented a tortuous configuration arising from the right hepatic artery and coursed behind the common hepatic duct. Inside the Calot's triangle, it made a characteristic unique loop with convexity facing upwards and to the right. The U-shaped loop configured an insidious hump running very close to the gallbladder and cystic duct, and the cystic artery resulted in exceptionally short. (Table 1)

Table 1: The observations of the study populations.

Variable	Right hepatic artery with a capillary hump (N=3)	Right hepatic artery without capillary hump (N=72)
Age (Mean±SD) in years	59±4.8	56±3.2
Age category (in years)		
Less than 40	0	6 (8.3%)
41 to 50	0	42 (58.3%)
51 to 60	2 (66.6%)	17 (23.6%)
More than 61	1 (33.4%)	7 (9.7%)
Gender		
Female	2 (66.6%)	48 (66.6%)
Male	1 (33.4%)	24 (33.4%)

Discussion

Well-versed knowledge of the anatomy of the Calot triangle is a must to perform a safe laparoscopic cholecystectomy. Anatomic variations in and around the Calot triangle are frequent [5], accounting for 20%–50% of the patients. The position and variations of the cystic artery are not only an anatomical dissertation but also play a crucial role in laparoscopic surgery, to avoid uncontrolled vascular lesions that usually lead to conversion. [5]

Furthermore, the route of the cystic artery is difficult to establish before surgery, and it can be recognized only after careful dissection of Calot triangle. [6] In previous reports, the incidence of caterpillar or Moynihan's hump of the right hepatic artery ranged between 3% and 13.3%. [4,5,6] Its incidence in the present study was 4%, which is more or less comparable to the literature data. The aetiology of the caterpillar hump is still not well known. The literature [2, 5] hypothesized that the elongation and the tortuosity of the artery could be attributed to architectural distortion with corkscrewing of intrahepatic branches of the hepatic artery. The incidence of caterpillar hump right hepatic artery in both the operative and cadaver groups (7% vs 6.9%, respectively) indicated that a significant vascular anomaly is unlikely due to surgical manoeuvres [2-5]. According to another hypothesis based on embryology, [2, 4, 5, 6], the embryonic liver is supplied by three segmental arteries arising from the dorsal aorta. The branch from the middle segmental artery develops into a proper hepatic artery arising from the common hepatic artery. The other two become accessory hepatic arteries arising from the left gastric and superior mesenteric arteries. Since the artery arising from the left gastric artery can persist in 25% of cases and the other persists in 18.3%, it could be postulated that the partial or complete persistence of the arterial supply of foetal liver could remain as the caterpillar hump of the right hepatic artery.

The tortuous artery may route anteriorly or posteriorly to the common hepatic duct, [7] representing the posterior presentation of the more common anatomical variation with 60% of incidence. [8] Accordingly, in the current study's three patients with caterpillar hump, the arterial trunk passed dorsally to the common hepatic duct. Due to its tortuous course and closeness to the gallbladder and common hepatic duct, this variant of the right hepatic artery may be injured with catastrophic consequences unless carefully dissected during Cholecystectomy.[9] Furthermore, it may be mistaken for the cystic artery and inadvertently ligated during surgery.[8,9,10] It must be highlighted that an atypically large cystic artery requires careful exploration of the hepatobiliary triangle as it may represent a Moynihan's hump right hepatic artery.[11,12] Vascular variation is reported more commonly in a single-loop fashion (55% of cases), and in the present study, all vascular humps were noted in a single-loop configuration.

The available literature stated that the double-looped hump, the cystic artery usually arises from the distal loop in a very short length, but when it origins from the proximal loop, it is reported that, the long cystic artery crossing the tortuous right hepatic artery reaching the

gallbladder. [13] In the present study, the cystic artery arose from the convexity single-looped right hepatic artery resulting in an exceptionally short in length. A very short cystic artery could lead to vascular injuries during Cholecystectomy [12,13] such as an accidental avulsion from the right hepatic artery due to excessive traction applied to the gallbladder and for right hepatic artery injury during its dissection and ligation.[11] Therefore, comprehensive knowledge of the hepatobiliary triangle with the possible arterial variant is paramount for the safety in Laparoscopic cholecystectomy.[9,14] Hence, careful dissection and demonstration of safe triangle Strasburg in laparoscopic cholecystectomy before division or ligation of any structure in the Calot triangle will help surgeons to understand the aberrant anatomy and avoid complications with Moynihan's hump of the right hepatic artery.[13,14]

Conclusion

This study showed that the right hepatic artery was subjected to this rare anatomical variation. This anomalous presentation increased the risk of vessel ligation or injury during laparoscopic Cholecystectomy. Thus, the awareness of caterpillar hump within Calot triangle, during surgical procedures is useful. Future high-quality, large-scale reports will be of interest in helping future researchers in this field.

Study limitation

This was a retrospective study with a small size.

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Availability of data and materials

The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.

Data collection and Ethical approval

Nawaloka Research and Education Foundation,
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Colombo.

Conflict of interest

None

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Legislation for Cadaver Procurement for Teaching Anatomy in Sri Lanka

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Abstract

Cadaver-based teaching remain as an integral and imperative component of anatomy education. In the past, bodies obtained from execution, grave robbing, and murder were used to carry out cadaveric dissection. It appears that body donation and the procurement of unclaimed bodies are the typical methods that are currently employed for such purposes universally. The former method is recommended by the International Federation of Associations of Anatomists. Body donation in Sri Lanka is governed by the legislation, and the policies of medical institutions. Therefore, any request for body donation that does not meet the requirements of both the legislation and the individual medical institution will not be accepted. This manuscript aims to review the current legislation of the country along with other selected international laws and guidelines pertaining to procurement of bodies for anatomy education.

Running title: Legislation for Cadaver Procurement

Keywords: Legislation, guideline, act

Introduction

The dissection of cadavers remained centuries as the gold standard for teaching anatomical science (McLachlan 2004). Cadaveric dissection and other cadaver-based teaching methods, for example learning through prosected gross specimens, are regarded as an integral and imperative component of contemporary anatomy education despite the introduction of novel methods. The visual, auditory, and tactile experiences gained through the active participation of students in dissection sessions underpins the knowledge that is acquired from traditional didactic lectures, tutorials, and relevant study materials. Thereby, dissection enables medical students to create and retain three-dimensional mental images of the human body.

Cadavers (or cadaveric materials) are viewed as a valuable source, not only for teaching anatomy, but also for learning surgery (Hong et al 2017) and to conduct research (Hardy et al 2007). In addition, cadavers serve as a resource for organs for transplantation purposes (Cantarovich 2005).

Source of Cadavers and Early Laws

Earlier days of dissection were performed on the dead bodies of the executed, and Hildebrandt (2008) summarized the legislation related to use of such bodies for anatomical purposes from the 13th to 20th century in the United States and Europe. As an example, the ‘‘Murder Act’’ of 1752 passed in Britain incorporated dissection as part of the death sentence. Since the community was not in

favor of dissection, (as it was viewed as a great dishonor for the person being dissected), the "threat of dissection" was used by law makers as a deterrent to discourage the public from committing high-level crimes (Hulkower 2011). This post – execution punishment (being subject to dissection following execution) was viewed as "double sentenced" and considered worse than capital punishment alone (Halperin 2007).

In the United States and Europe, the corpses of executed criminals met the requirement of bodies for the anatomical dissection until the 18th century. However, as the demand for cadavers increased along with the growth of the study of anatomy, an alternate method referred to as "grave robbing" became widespread in the 18th and 19th centuries (Hulkower 2011).

Grave robbing (body snatching) is a gruesome, illegal, and immoral act by which newly buried dead bodies were acquired for dissection by digging up burial grounds. The "New York Resurrection Riot" of 1788 ("Doctors' Riot") was a public outcry against grave robbing which prompted the passing of legislation in New York ''to prevent the odious practice of digging up and removing for the purpose of dissection, dead bodies interred at cemeteries or burial places''. The enacted legislation empowered judges to add dissection as a further punishment to those being hanged for the crimes of arson, burglary and murder [Hulkower 2011), (Halperin 2007)].

The Anatomy Act of 1832 which was passed in Britain ended the era of grave robbing in that country. It permits "unclaimed bodies to be dissected and used in anatomy theatres". Cadavers had also been acquired through murder at times in history (Humphries 2014). It is noteworthy that the Anatomy Act of 1832 was replaced after thirty-nine years by the newer Act (referred to as the Anatomy Act of 1871) which requires "consent to be given before a body could be used for anatomical examination". Subsequently, the Anatomy Act of 1984 and Human Tissue Act 2004 were enacted in the United Kingdom (Riederer et al 2012).

Body donation: Concept, Law and Guidelines

The most common sources of cadavers for contemporary medical education are body donation, and procurement of bodies that are unclaimed (Habicht et al 2018). The former method, body donation, can be explained as an "act of providing one's own intact body for medical education and / or research upon demise by his/her informed consent given prior to death" (Chenthuran 2021).

Body donation depends exclusively on the generosity of the donors and their family members. Body donation programmes are centered on creating awareness of body donation among the potential donors / general public. In this regard, body donation awareness programmes conducted in India involving mass media and society had proved to be an effective way to increase body donation and registration for such purposes (Amanrao et al 2012). There are many factors determining the perception and attitude of communities towards body donation, and Fennel and Johns

(1992) reported that "aid medical science and teaching in some way" was the most common reason for making a body bequest while "gratitude to the medical profession" was the next (Fennel and Johns 1992).

The Uniform Anatomical Gift Act (UAGA) which is regarded as a landmark in the practice of body donation was enacted in the United States in 1968. This act admitted that body donation is "a right, morally based on free choice and volunteerism" (Hulkower 2011). It was revised subsequently in 1987 and 2006 (UAGA, 2006).

In 2005, the Trans-European Pedagogic and Anatomic Research Group (TEPARG) [also known as "Trans-European Pedagogic Research Group for Anatomical Sciences"] had discussions on the ethical and legal stance of different countries in Europe namely Austria, Germany, France, Netherlands, Italy, Romania, Serbia, Portugal, Spain, Switzerland, and the United Kingdom related to body donations for anatomical examination (McHanwell et al 2008). They provided "recommendations of good practice for the donation of human bodies and tissues for anatomical examination". Subsequently the first update of current practices on body bequest in these countries excluding Serbia, but incorporating novel contributions from Malta and Turkey, was published in 2012. Two important facts that were observed in their latter work were the lack of control over the import / export of human dead bodies, and commercialization of body parts. The authors highlighted the necessity of establishing a common regulation regarding the usage of human dead bodies - not only in Europe - but also in other countries (Riederer et al 2012). In 2012, the International Federation of Associations of Anatomists (IFAA) provided "recommendations of good practice for the donation and study of human bodies and tissues for anatomical examination" (Plexus 2012).

The recommendations of TEPARG and IFAA agrees in many aspects including, but not limited to, obtaining informed consent, preserving anonymity of the donor, encouragement to hold Services of Thanksgiving or Commemoration to the donors who bequeathed their bodies for medical education and research, various rejection criteria, maintaining transparency in procedures, delivering special lectures in ethics (related to donation of human remains) to the students who learn anatomy etc. (McHanwell et al 2008) (Plexus 2012).

It is instructive to note that medical institutions should practice highest ethical standards in the procedures related to body donation, and indeed, they should establish a clear transparency in the usage of cadavers (or cadaveric material) in medical education and /or research to enhance public trust to gain more public support for body donation.

Legislation of Sri Lanka for Body Procurement

In Sri Lanka, the Transplantation of Human Tissues Act (No. 48 of 1987) (hereinafter referred to as THTA) is the legislation that oversees the "donation of human bodies and tissues for therapeutic scientific, educational

and research purposes" and, "preservation of such tissues" (THTA, 1987). In addition, the policies of individual medical institutions - in accordance with the legislation of the country - govern the procurement of bodies for anatomy education.

The body donation programmes usually focus on obtaining informed consent from the donor – during his or her lifetime on ethical and legal grounds. The IFAA precisely indicated that written informed consent must be obtained from donors before accepting any bequest (Plexus 2012). Sri Lankan law passed in 1987, the THTA, (THTA, 1987) agrees with the said IFAA recommendations made in 2012 (Plexus 2012) in obtaining written consent.

It is apt, albeit briefly, to discuss the salient features of the THTA insofar as it relates to the procurement of cadavers for dissection. Section 2 of the act specifies that "any person above the age of twenty-one years may consent to the donation" "of his body" for inter alia advancement of medical education and medical science, and purposes of research. Such donation shall take effect upon the death of the donor (Section 2; THTA, 1987). The consent may be given either in writing or in the prescribed form attested by at least two competent witnesses, or orally in the presence of at least two competent witnesses. This provision is wide enough to cover the procurement of cadavers much as possible through body donation for medical education and research purposes.

Requiring the donor's consent is a reflection of the concept of bodily integrity and autonomy. The donor may specify the exact purpose for which his or her body shall be used, but a lack of indication of a purpose in the consent cannot be a reason to invalidate the donation effective upon death (Section 3 (2)). However, if a purpose is specified, utilizing the body for any purposes other than for which the consent is given is a punishable offense (Section 13 (a)).

The THTA also allows a relative of a deceased to donate the body of the deceased. Section 5 of the act specifies that the next of kin of the deceased can give consent in writing for the removal of the body of the deceased for any of purposes enumerated in section 2 (Section 5 (1)). This right, however, has two prerequisites. First, the next-of-kin making the donation must be or above twenty-one years old, and second, the deceased person must not at any point in his or her life expressed a contrary intention to donate his or her body (Section 5 (1)). Further, the purpose for which such donation can be made is confined to the same purposes enumerated in section 2. With regard to a deceased child, it is lawful for both parents or if one parent is absent or incapacitated, the other parent who is sane or in the absence of both parents, the guardian of the child to give written consent for the removal of the body for any of the purposes enumerated in section 2 (Section 5(2). The Age of Majority (Amendment) Act No.17 of 1989 has reduced the age of consent as eighteen years. Therefore, the age of consent specified in the THTA must be interpreted in light of the Age of Majority (Amendment) Act.

There is also a difference between consent given by the donor and that of their next-of-kin / guardian. When the consent is given by the

former, it is not mandatory to specify the donee. In such cases, the government hospital or any prescribed institution nearest to the place where the donor died shall be deemed to be the donee (Section 4 (2)). Whereas when the consent is given by the latter, a lack of indication of the donee will invalidate the consent (Section 5 (3)). However, the precise reason behind this distinction is unclear.

The dual approach for body acquisition (i.e. either by the free choice of an individual or his/her surrogate) is observed also in the UAGA (UAGA, 2006) and viewed as "two bites of the apple" (Glazier 2018). It is notable that both Sri Lanka and the United States follow the "opt in" principle where a person becomes a donor only based on his or her willingness or of another individual acting on behalf of that person ("surrogate"). However, in some countries, mainly in Europe, a person is deemed to be a donor unless he or she, or his or her surrogate "opts out" ("presumed consent") (UAGA, 2006).

Section 4 of the UAGA indicates that every adult and emancipated minor has the freedom to donate his or her body for the purpose of transplantation, therapy, research, or education. In case of unemancipated minors, a parent of the donor or guardian can give the consent. Interestingly enough, an agent of the donor who has the power of attorney for healthcare can also consent to such donation unless such document prohibits the agent from making an anatomical gift. The THTA, however, is silent in this regard.

Section 5 of the UAGA speaks about the methods whereby donations can be made. Such methods are wider compared to the ones in Sri Lanka. For instance, making of an anatomical gift can be made by a donor card, will, state-issued driver's license, state-issued identification card or a donor registry (Section 5; UAGA, 2006).

Furthermore, Sri Lankan law mentions that the next-of-kin can make a donation when the deceased had expressed no intention to donate during his or her lifetime. The counterpart, UAGA, provides a comprehensive list of classes of persons in the order of priority for the same purpose (Section 9: UAGA, 2006). It is also notable that when there is a conflict of opinion among the members of the same class (e.g., adult children of the deceased) who are authorized to donate the body of a deceased, the majority opinion will be decisive.

One of the salient features of the UAGA (section 8) is that the family members / relatives do not have the right to overrule the decision made by an individual during his or her lifetime to donate his or her body upon death. However, it is not applicable in the case of death of an unemancipated minor donor under the age of eighteen where a parent can revoke or amend the anatomical gift made by the said donor (UAGA, 2006). In Sri Lanka, the legal approach to the views / objections of the close–relatives is not clear.

On a purely legal viewpoint, the concepts of bodily integrity and autonomy, which makes the donor the master of his or her own body, would oppose the denial of donation by the relatives. Accordingly, one could argue that the deceased person's wish to donate his or her body should be respected regardless of any

objections by the relatives the same way as a person's valid last will and testament is given effect regardless of the next-of-kin's protest and objections to disposal of property by such will. Nevertheless, if such an approach were to be adopted, it would devalue the body of the deceased to merely another of his or her property. In a religious background, such a view would create ethical and moral dilemmas. Hence, it is for this reason that relative's objections can be considered by medical institutions on humanitarian grounds. Revocation of previously given consent by the donor is permitted in Sri Lankan legislation (THTA, 1987).

Unclaimed bodies remain an important source of cadavers for anatomy education. A recent study revealed that 45 of 68 countries which utilize cadavers for anatomy teaching use unclaimed bodies for such purposes (Habicht et al 2018). However, the guideline of IFAA excludes the usage of unclaimed bodies (Plexus 2012). Jones and Whitaker (2012) viewed that using unclaimed bodies is a form of exploitation, and pleaded with anatomists to cease their usage (Jones and Whitaker 2012). In the case of Sri Lanka, the legislation as it stands does not preclude the use of unclaimed bodies for any anatomical research (THTA, 1987).

Description of policies and practices of individual medical institutions in Sri Lanka as related to the procurement of bodies for anatomy education is beyond the scope of this manuscript. An outline of fundamental information regarding the body donation programme of selected Sri Lankan medical institutions has been reported (Chenthuran, 2021).

Reflective remarks

Using the cadavers obtained through informed consent for medical education would indirectly teach the medical students the importance of obtaining consent from the patients for the procedures involved in their healthcare. In addition, understanding the concept of informed consent would enable the medical students to respect the views or concerns or even dissent or revocation of already given consent (if applicable) by the patients in their future clinical practice.

In Sri Lanka, as discussed earlier, usage of donated and unclaimed bodies for medical education is legally permissible at present. According to the ethical perspectives and the social, cultural, and religious values of the country, the body donation through informed consent provided during the lifetime of an individual along with his or her close relatives would be considered as the preferred choice of body procurement for medical education in Sri Lanka. It is not clear whether there is a requirement for unclaimed bodies for medical institutions in the country at present and when documentary evidence proves that the body donation alone is self-sufficient to fulfill the requirement of all medical institutions in the country, it shall be declared as the sole method for body procurement in the subsequent revision of the relevant Act.

Conflict of interest

None

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ORIGINAL RESEARCH

Histopathological changes due to osteoarthritis in articular cartilages of the knee

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Abstract

Introduction: The bony ends of a synovial joint are lined by a specialised hyaline cartilage termed the articular cartilage. Articular cartilage can be affected with degenerative diseases such as osteoarthritis. Knee being one of the larger joints built for weight bearing is the commonest site for osteoarthritis. The aim of this study was to describe the macroscopic and microscopic features of articular cartilages of the knee joint in patients diagnosed with primary osteoarthritis.

Methods: Seventy-two articular cartilages removed during total knee replacement surgery were observed for macroscopic damage and graded according to the direct visual assessment score. Thirty specimens randomly selected were processed for histology and stained with Safranin-O-fast green-iron hematoxylin and observed and scored using the Mankins histological and histochemical grading system.

Results: majority of specimens showed severe damage in the medial compartment and much less damage in the lateral compartment. In the tibia the damage was greatest on the medial most edge where the articular cartilage was absent leaving the bone exposed. Anteromedial area was relatively spared. In the femur the middle part of the medial condyle was seen to be more severely damaged. A similar pattern was observed in 19 (63.3%) of the specimens and showed exposure of bone. In the lateral compartment worst damage was observed in the middle of the lateral femoral condyle, with the rest of the lateral compartment being well persevered. This pattern was observed in 26 (86.6%) of the knee specimens.

Conclusion: OA of the medial compartment causes the two cartilage surfaces to grind together, mechanically denuding the cartilage layers, while the lateral compartment which receives much less mechanical stress is well preserved.

Running title: histopathological changes in osteoarthritis

Key words: articular cartilage, osteoarthritis

Introduction

The bony ends of a synovial joint are lined by a specialised hyaline cartilage termed the articular cartilage. The articular cartilage is about 2.5mm thick in a normal adult (1).

However, the thickness of the cartilage changes from bone to bone in accordance with the tensile stresses it has to withstand. On histological examination the articular cartilage shows a transparent matrix with chondrocytes arranged in layers. Four layers are commonly described (Figure 1).

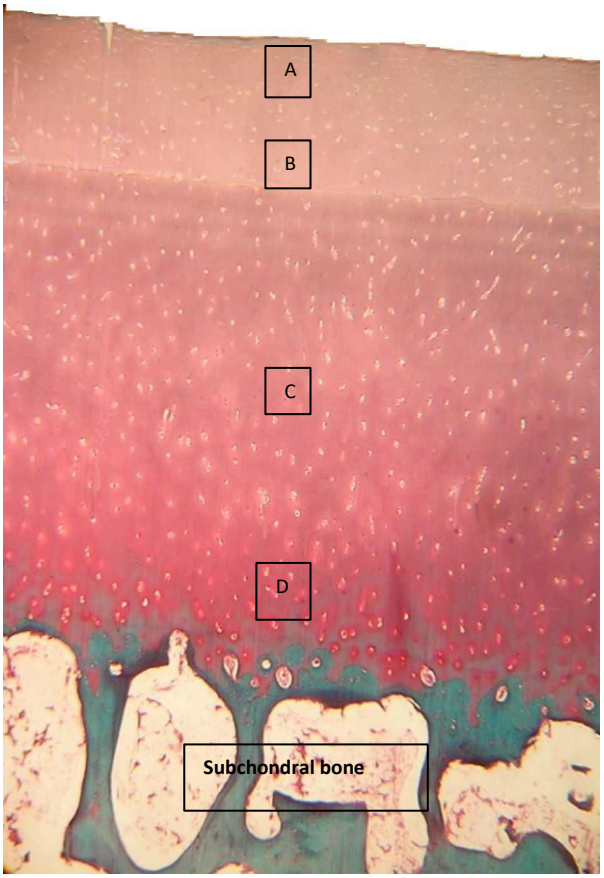


Figure 1: Histological appearance of the articular cartilage of a normal tibia

A. The tangential layer, where the chondrocytes are small and flattened and arranged parallel to the surface.

B. The transitional zone, where the chondrocytes are slightly larger and can be seen singly as well as in isogenous groups.

C. The radial zone being the thickest show large chondrocytes forming radial columns arranged perpendicular to the articulating surface.

D. The calcified cartilage layer rests on the underlying bone. The matrix of this layer consists of calcium salts as the name suggests.

The articular cartilage in the knee joint has to withstand the body weight as well as the stresses of bending and straightening during the many movements of everyday living. Therefore, it is designed specially to withstand these stresses. However, disease processes such as osteoarthritis (OA) can damage this intricate structure. The articular cartilage lacks a perichondrium and has no blood vessels penetrating it. Therefore, the regenerative ability is minimal in this type of cartilage.

OA is defined as a heterogeneous group of conditions that lead to joint symptoms and signs which are associated with defective integrity of articular cartilage in addition to related changes in the underlying bone at the joint margins (2). The characteristic features include focal areas of damage to the articular cartilage of synovial joints and sclerosis of the underlying subchondral bone.

OA of the knee is the most common form of OA worldwide and is commoner in females. (3) The documented risk factors for knee OA are female gender, increasing age, obesity, ethnicity, genetic factors and local factors affecting the knee, such as ligament laxity, reduction in proprioception with age and knee joint mal alignment (4).

The knee joint formed by the articulation of the tibia and femur, is described as having three

compartments: the medial compartment formed between the medial tibial plateau and the medial femoral condyle, the lateral compartment formed between the lateral tibial plateau and the lateral femoral condyle and the anterior compartment formed between the intercondylar area and the patella. OA is commonly seen in the medial compartment with varus malalignment of the knee.

The OA disease process is thought to start at around the age of 30 years and slowly progress. It may range from mild to moderate knee pain increased with activity to severe deformity and loss of ambulation. Initial treatment methods include management of pain and advice on minimizing the strain on the knee joint. However, severe disease requires surgical intervention with joint replacement.

The first demonstrable change in articular cartilage with OA is the softening of the cartilage on palpation (5). These softened areas develop macroscopic fibrillations which finally split to form fissures. The fissures become deeper and deeper until it reaches the subchondral bone. Complete loss of the cartilage layers result in exposure of the bone surface (6,7).

Microscopically the first change is loss of stainability with special stains such as Safranin O, which is the result of reduced proteoglycans in the cartilage matrix (8,9). Then chondrocyte necrosis occurs. Chondrocyte clusters are observed and the tangential and radial orientation of chondrocytes is lost. The boundary between the deep cartilage layers and the calcified layer is disrupted and blood vessels are seen to cross the tide mark (10). Finally, the architecture of the cartilage is completely disrupted and the bone is denuded and exposed.

The aim of this study was to study the histopathological changes seen in the articular cartilages of patients with osteoarthritis of the knee joint and grade the lesions observed, macroscopically and microscopically.

Methods

Articular cartilages removed from 72 knee joints during total knee replacement in patients diagnosed with primary knee joint osteoarthritis were obtained from the theatre at Teaching Hospital Peradeniya. Femoral condyles and the tibial plateau removed at surgery were retrieved and placed in 10 formal saline. Five articular cartilage specimens from above knee amputations due to trauma were obtained as a control sample.

All collected specimens were examined under normal light to assess the cartilage wear patterns. The widest diameter of each lesion was measured using a calibrated Vernier calliper (120 mm dual scale metal). The two articular surfaces of each joint were accessed using the scoring system described by Noyer et. al. in 1989 (11). This scoring system takes into account the depth, severity and the size of the lesion on the articular cartilage and assigns a stage and a numerical value for each (Figure 2). Table 1 shows the scoring system in detail.

Table 1: Direct visual assessment score

Grade	**Description of lesion**	**Points for 10 - 15mm sized lesion**	**Points for >15mm sized lesion**
1A	No visible lesion	0	0
2A	Lesion with fissures, fragmentation, half thickness	2	4
2B	Lesion with fissures, fragmentation full thickness	3	6
3	Bone exposed	5	10

In this scoring system normal appearing cartilage is classed as grade 1A and does not receive any points. A lesion with fissures and fragmentations of the articular cartilage extending to half its thickness is classed as grade 2A. A grade 2A lesion with the widest diameter between 10-15mm is given 2 points and if the lesion is wider than 15mm it's given a score of 4. Grade 2B is given to a lesion where the articular cartilage has fissures and fragmentation extending to its full thickness. If a grade 2B lesion has a diameter between 10-15mm it is given 3 points and if the diameter exceeds 15mm 6 points are given. A lesion where the articular cartilage is denuded and the bone is exposed is a grade 3 lesion and is given 5 points if the diameter is between 10-15mm and 10 points if it exceeds 15mm.

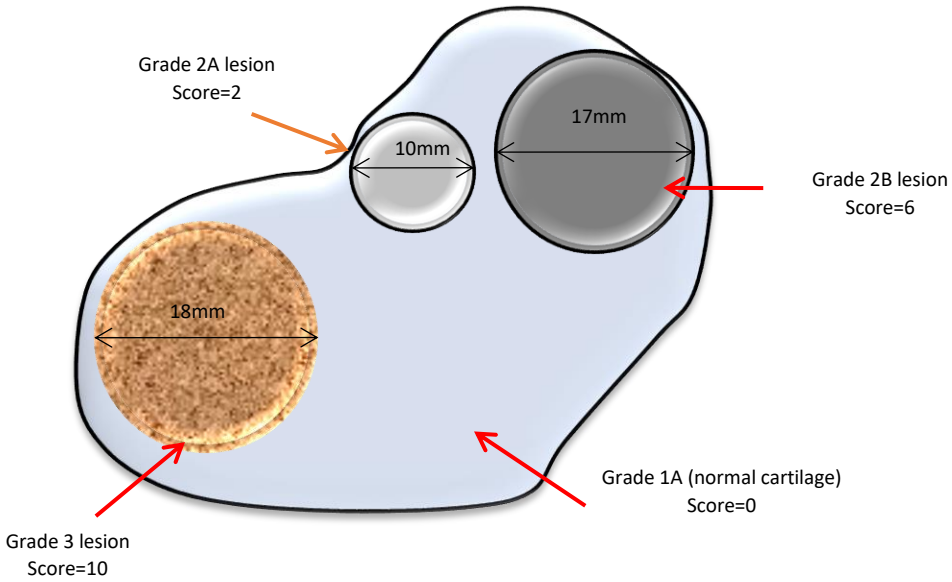


Figure 2: Tibial plateau with the articular cartilage lesions graded and scored

Using these scores, the final macroscopic damage severity was expressed out of a score of 20 for each compartment. A score of 20 for the medial compartment means that the

articular cartilages on the medial tibial plateau and the medial femoral condyles are completely destroyed with exposure of bone. A score of 10 for the compartment means that half the articular cartilage in the relevant compartment is damaged.

Articular cartilage specimens from osteoarthritic knees and the control samples were fixed in 10% formal saline for two days, and processed for histopathological studies. The fixed specimens were cut into 1×1cm size blocks using a hacksaw and a scalpel as specified in figure 4.

All blocks contained bone with the articular cartilages, therefore they were decalcified in 20% EDTA and for three weeks. Decalcified specimens were then processed for normal microscopy and embedded in paraffin wax. Three longitudinal consecutive sections, of 2 µm thickness were cut from each wax block using a microtome (Reichert-Jung BIOCUT 2030), mounted on clean glass slides and stained with Safranin-O-fast green-iron hematoxylin according to the regular procedure.

A total of 42 sections for each knee joint were finally prepared and examined under a normal light microscope. The damage to the articular cartilage was graded according to the Mankins histological and histochemical grading system given in table 2 (12). This grading system assigns separate scores to structure of the cartilage, cell distribution and density, intensity of Safranin-O staining, and the integrity of the tile tidemark. Each of these subcategories is given a separate numerical value. Once the values given for the subcategories are totaled the final score for each area assessed is produced. The highest score thus obtained is 14 and denotes completely destroyed cartilage or absence of cartilage in the area. A score of 0 denotes a histologically normal articular cartilage.

From each of the slides, three non-overlapping fields were examined and the histological score was determined. Slides prepared from the normal cartilage specimens were used as a reference when deciding the grade. The histological score for each visual field was totaled and an average score was obtained for each slide. This score was taken as the score for the area of the articular cartilage sampled. The scores obtained for the areas studied in the two knee compartments namely the medial and the lateral was totaled to arrive at a histological score for each knee.

Table2: Mankin's Histological and histochemical grading system

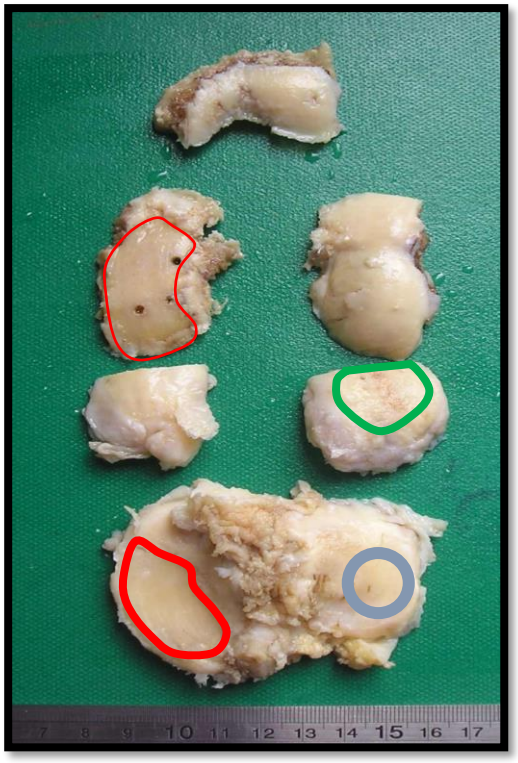
		Grade
I. Structure	a. normal	0
	b. surface irregularities	1
	c. pannus and surface irregularities	2
	d. clefts to transitional zone	3
	e. clefts to radial zone	4

	f. clefts to calcified zone	5
	g. complete disorganizations	6
II. Cells	a. normal	0
	b. diffuse hypercellularity	1
	c. cloning	2
	d. hypocellularity	3
III. Safranin-O staining	a. normal	0
	b. slight reduction	1
	c. moderate reduction	2
	d. severe reduction	3
	e. no dye noted	4
IV. tide mark integrity	a. intact	0
	b. crossed by blood vessels	1
		14

Results

Direct visual assessment of the articular cartilages showed that the medial compartment was more severely damaged than the lateral compartment. The damage score of the medial compartment ranged from 12 (60%) to 20 (100%) with a mean of 12.53 (±5.3). It was observed that 37% of the specimens had lesions with a score of 20 in the medial compartment. This denotes that these specimens had lesions more than 15mm in diameter where bone was exposed on the medial tibial plateau and the medial femoral condyle. Damage to the lateral compartment was comparatively less and ranged from 0 to 10 with a mean of 1.28 (±2.2). Of these 44 knee specimens (61.1 %) had macroscopically normal appearing articular cartilages in the lateral compartment.

The knee joint specimen of a single patient with the lesions outlined and scored is given in figure 3 for reference.



The 2 lesions outlined in red has a diameter more than 15mm and the bone is exposed therefore they are grade 3 lesions and are given 10 points for each.

The lesion outlined in green has a diameter between 10mm-15mm and the lesion extends to the full thickness of the articular cartilage and therefore is a grade 2B lesion and is given a score of 3.

The area outlined in blue has a normal appearing articular cartilage

Figure 3: Articular cartilage specimen with the lesions graded

Microscopic examination confirmed that the medial compartment showed more severe damage than the lateral compartment. The specific Mankins histopathological score for each area in the tibia and femur is given in figure 5 for reference.

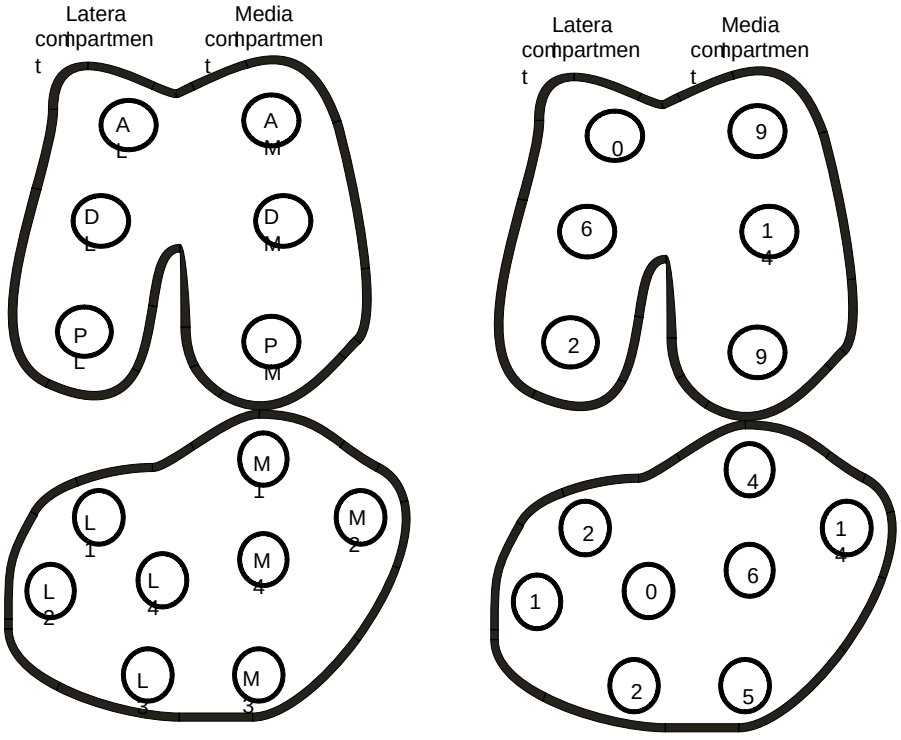


Figure 4: Mankins score for each area in the tibia and femur of the right knee

Cartilages with maximum damage were completely denuded of cartilage and only bone with a thin layer of cartilage matrix and few scattered cells could be seen. Less serve damage showed cartilage with varying thickness and amounts of Safranin O staining with rapid loss of staining as the severity progressed. Macroscopically normal appearing cartilages showed fissuring and fragmentation of the surface layers under microscopy. Chondrocyte orientation was lost and cell clustering and nesting was observed in many specimens.

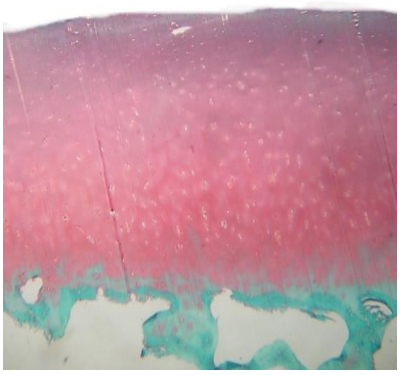
Cartilage in the lateral compartment was well preserved with good staining and well-preserved cell architecture and orientation.

The score in the medial compartment of both the femur and tibia ranged from 4-14. In the tibia the damage was greatest on the medial most edge in the area marked M2 in figure 5. These areas did not show articular cartilage leaving the bone exposed. This pattern was seen in most specimens. The areas marked M1 and M3 were relatively spared. In the femur the middle part of the medial condyle marked DM was seen to be more severely damaged. A similar pattern was observed in 19 (63.3%) of the specimens and showed exposure of bone.

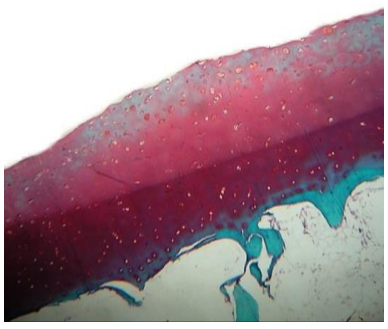
The score in the lateral compartment in both the tibia and femur ranged from 0-6. The worst damage was observed in the middle of the lateral femoral condyle, the area marked DL. The rest of the lateral compartment was well persevered with most of the areas having a score of 0-2, which is considered similar to normal cartilage. This pattern was observed in 26 (86.6%) of the knee specimens.

The overall microscopic score for the medial compartment of each knee specimen was calculated by adding the scores from all the areas sampled in the medial tibial plateau (M1, M2, M3, M4) and the medial femoral condyle (AM, DM, and PM). The overall score ranged from 43-79 with a mean of 55.34±10.59. The score for the lateral compartment was also calculated similarly and it ranged from 6-38 with a mean of 14.2±9.15

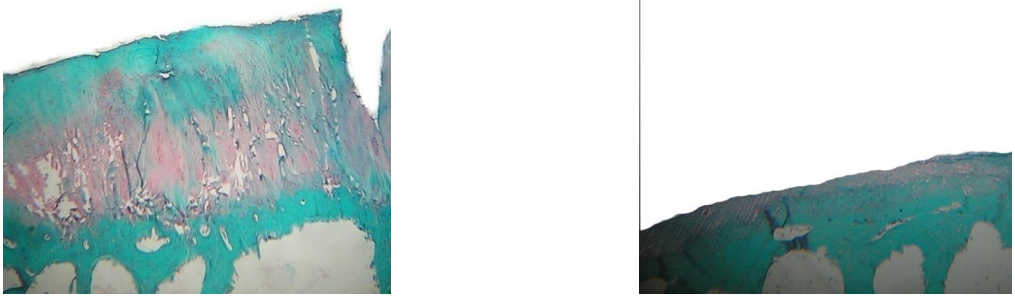
Figure 5 shows the microscopic appearance of the articular cartilage of the tibia in four different stages of damage with the specific Mankins scores.



Score = 0 – denotes normal cartilage. Maximum thickness and staining



Score = 5 – 50% loss of thickness. Fissuring and slight loss of staining



Score = 9 – loss of staining. Complete disruption of chondrocyte architecture.

Score = 14 – complete loss of cartilage thickness

Figure 5: Microscopic appearance of articular cartilage with the specific Mankins scores

Discussion

The direct visual assessment score described by Noyers et al (11) has been designed to stage lesions in arthroscopy. This scoring system has the advantage of considering the depth as well as the size of the lesions and assigning a stage and a numerical score for each observed lesion. It can be stated that this scoring system is comprehensive and provides an excellent idea about the lesion. The description of lesions and the scoring system devised by them has been used for staging lesions by naked eye examination in international studies (13.14).

Mankins histopathological score was designed by Mankin et al in 1971(12) by studying osteoarthritic human hips. It is a widely accepted score for assessment of articular cartilage damage in joints with osteoarthritis. van der Sluijs et al (1992) (15) validated this score and demonstrated an excellent inter and intra observer agreement. Although other scoring systems have been designed in the recent past Mankin score is still widely used in international studies (16,17). It is considered a reliable score and its use in this study can be justified since it offers more opportunities for comparing results with previous studies.

Two studies available in the literature have looked at macroscopic changes in articular cartilage due to OA (18,19). Both these studies have looked at only the tibial plateau, while the current study looks at the tibia as well as the femur. These studies do not offer histopathological evidence. In the current study the medial compartment articular cartilage was seen to be severely damaged. The knees with least damage had 60% of the medial compartment articular cartilage affected and the severely damaged knees had 100% of its medial compartment articular cartilage affected. Histological assessment confirmed these findings.

Histological assessment of the lateral compartment showed the articular cartilage to be normal in more than 80% of the knees examined. The microscopic score was seen to be 0-2 in these knee specimens with the articular cartilage thickness being normal.

The above findings can be due to the excessive medial orientation of the femur on the medial tibial plateau which shifts the whole of the body weight on to medial compartment of the knee. This causes severe stress on the articular cartilage of the medial compartment causing the two cartilage surfaces to grind together, mechanically denuding the cartilage layers. The diseased cartilage has very little potential to regenerate and the severe trauma caused by day-to-day activities makes any attempts at healing unsuccessful. Examination of the lateral compartment in these knees however revealed well preserved articular cartilage. When the weight bearing is shifted to the medial compartment the lateral compartment receives very little mechanical stress on its articular surface. This prevents grinding of the articular surfaces on each other and removes most of the mechanical stress, allowing the cartilage to maintain its normal structure.

The pathophysiology of OA is complex and treatment options are limited (19). In-depth studies in to pathological mechanisms and treatment options are ongoing even though disability and deformity due to this debilitating disease is still common and continue to burden the health sector.

Conflict of interest

None

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Effectiveness of conducting online objective structured practical examination (OSPE) in anatomy among first year medical undergraduates

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Abstract

Objective: To assess the effectiveness of conducting an online OSPE (Objective Structured Practical Examination) in Anatomy for first year medical students.

Material and Methods: Following a 2-week prior notice, 222 first-year medical undergraduates who had undergone exclusively online learning for one semester, were subjected to an online OSPE conducted via conferencing platform. Subsequently, student feedback was obtained via a google form regarding exam environment, prior preparation, clarity of images, and technical problems faced during the exam. SPSS Version 25 was used for descriptive analysis and one-sample T-test was used to compare the results with a previous batch that underwent onsite face-to-face teaching and examinations.

Results: Satisfaction with images of gross anatomy specimens, radiographs, and histology slides were 48.2%, 90.5%, and 76.6% respectively. A majority agreed that the OSPE helped them to improve their knowledge (92.8%) and intrigued interest in the subject, motivating them to study (83.8%).

Compared to a previous batch that underwent onsite teaching and examination, the performance of the students in this group was significantly lower ($p<0.001$).

Conclusion: The lower performance of the students faced with the online OSPE may be due to learning anatomy only using online platforms hindering the three-dimensional understanding of Anatomy, short preparation time, and inexperience at facing online examinations. Even though technology-based learning and examination techniques have developed with the recent COVID 19 pandemic, it cannot yet replace the traditional methods in teaching and examination in Anatomy. However, this study shows that conducting online examinations is feasible with only 34.7% of students reporting minor technical difficulties.

Running title: Effectiveness of Online Anatomy OSPE

Keywords: online examination, medical education, anatomy learning, objective structured practical examination, exam performance

Introduction

Covid 19 pandemic has led to an evolutionary change in the educational sector worldwide. With the travel restrictions and health precautions implemented by the government of Sri Lanka, all universities had to abandon face-to-face teaching and adapt to exclusive online education. The pandemic situation

obligates training of future doctors which cannot be halted amidst any crisis.

Anatomy is the basic foundation of preclinical medical education. Being a highly virtual subject, it requires a good understanding of relationships between structures, often achieved by hands-on experience with cadaveric dissections, prosected specimens, plastic models, and virtual sources.

In the Faculty of Medicine, University of Peradeniya we transferred from the traditional methods of anatomy teaching to more innovative teaching methods based on learning management system such as online lectures, prerecorded dissection videos, interactive discussions via zoom platform, digital 3D Atlas software, online tutorials, etc. to deliver the same curriculum content to students.

With the online teaching process smoothly going on, our next challenge was to conduct the end-semester examinations for students in order to move to the next academic module of the curriculum.

Earlier, the Department of Anatomy conducted steeple chase OSPE stations which consisted of labeled prosected specimens, bones, radiological images with questions posted on each station to be answered at a given time.

With the existing pandemic situation, it was difficult to conduct onsite examination and walk around OSPEs. As the initial step, we conducted an experimental online OSPE and got feedback from the students regarding this online method of evaluation on the practical component.

In time-restricted E-OSPE we adopted a novel method by converting 3D specimens to 2D images. Students' viewpoint with regard to exam environment, prior preparation, clarity of images, technical problems they faced during the exam were evaluated here.

Methodology

A cross-sectional study with descriptive and analytical components was conducted involving 222 first-year undergraduates of the Faculty of Medicine, University of Peradeniya. Following the completion of the first semester, where foundation to human anatomy and anatomy of limbs were taught solely through online methods, the students were subjected to an online OSPE.

The OSPE was prepared by the academic staff of the Department of Anatomy according to the standards of semester exams. A total of 33 questions based on gross anatomy, histology, and radiology were made using photographs of prosections, histology slides, bones, and X-rays. This was pilot tested among 5 pre-intern doctors before finalizing. The OSPE was conducted as a PowerPoint presentation via zoom platform with two minutes given to answer each question.

Following 2 weeks prior notice, the students were divided into 10 groups with one invigilator appointed to each. WhatsApp groups were created for each group, for the delivery of proper instructions and clarification of doubts regarding the OSPE. Each group was given a separate zoom link to join the examination which was conducted at

the same time by the 10 invigilators, with the students instructed to keep videos and observed via web cameras. Following completion, the students were instructed to take clear photos of answer sheets and send them through WhatsApp to the appointed invigilator. Students were observed until all the students in that group submitted the answer scripts.

Following the OSPE, a feedback questionnaire consisting of 5-point Likert scale questions was administered to the whole batch via google forms regarding accessibility, preparedness, content, questions, images, and exam experience. SPSS Version 25 was used for descriptive analysis with one-sample T-test used to compare the test results with those of a previous batch that underwent onsite face-to-face learning and OSPE examinations.

Results and Discussion

A total of 222 responses were received for the feedback questionnaire of which 57.2% were from female students. The commonest devices used for the online OSPE were laptop computers (41.9%), tablets (27.5%) and smartphones (12.2%), and others a combination of devices. Internet access was gained by personal Wi-Fi connections (64%) and personal mobile data (25.6%). Of the respondents, 63.1% were comfortable in taking the test via their devices. Majority (92.8%) agreed that they were given clear prior instructions. Only 46.85% felt comfortable sitting for the exam via the online platform and 30.18% said that they had enough time to prepare for the test.

The majority (92.8%) agreed that the language used in questions was simple and easy to understand and 89.6% said that the question format was clear. Of the respondents, 44.14% felt that the allocated time was enough for each question and only 32.88% said that the questions were too difficult for them.

More than half (63.6%) agreed a comfortable environment and a minority (34.7%) reported technical problems. Majority (90.1%) said that the instructions were heard clearly and 93.2% agreed that exam conductors were available during the exam to guide them. Only 33.78% said that they felt uncomfortable being observed via video camera during the exam.

While 48.2% said that the photographs of gross anatomy specimens were clear enough to identify the structures, 35.59% were neutral regarding this statement. Only 39.19% said that the anatomical orientation of the displayed specimens was clearly understandable, though 90.5% agreed that the given radiographs were clear, and 76.6% agreed that the histology slides were clear and understandable. The effectiveness of virtual microscopy in teaching and assessing knowledge in histology has been shown by a recent study (1).

A percentage of 42.79% were stressed in performing the test via online platforms and 44.2% said that they would have performed better if the test was conducted onsite. Recent similar studies in other countries mention student preference for conventional compared to online anatomy assessment methods (2,3). This is understandable considering the high practicality of the subject.

While 92.8% said that the mock OSPE helped them to improve their knowledge, 83.8% said that it intrigued interest in the subject and motivated them to study during the current pandemic situation. More than half the students (55.41%) recommended the conduction of online mock spot exams in the future.

The average result of the batch who had experienced exclusive online learning with online examination was 54.05% while that of a previous batch that had undergone conventional onsite teaching with onsite examination was 72.92%. One-sample T-test was conducted to compare the mean scores of the two batches which revealed a statistically significant difference (t value- -15.46, $p<0.001$). This may divulge the consequence of learning methods limited to online platforms hindering the three-dimensional understanding of the students. A previous study comparing the scores of similar examinations held online and in the traditional format has found no significant difference between the two (4). The inexperience in facing online examination and imperfections in transforming and understanding actual specimens as two-dimensional images may have had an effect on this outcome. Further, a short time was provided for revision of anatomy since this exam was conducted at short notice as an experiment.

Conclusions

Even though technology-based learning and examination techniques have expanded and flourished especially due to the limitations caused by the recent COVID 19 pandemic, it cannot yet replace the traditional methods. However, during this pandemic, teachers are left with no choice but to revert to online methods.

This to our knowledge is the first study to evaluate online anatomy OSPE examinations and sets the stage for further experiments and conducting online examinations in the future. This experiment can be considered a success since it helped us motivate students and identify the drawbacks and problems in conducting online examinations.

Conflict of interest

None

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Morphometric Analysis of Peroneus Tertius and Extensor Digitorum Longus

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Abstract

Objective: The objective of this study was to analyse morphometric characteristics of the Peroneus Tertius (PT) and Extensor Digitorum Longus (EDL) muscles with important correlations and associations that may describe their functional significance.

Material and Methods: The measurements PT and EDL muscles of cadavers were taken using a standard measuring tape. Minitab software Version 20.1 was used for statistical analysis methods of Spearman rho, Mood's Median test, Fishers Exact test, and Two-sample T-test.

Results: Of the 54 specimens of lower limbs, the mean length of origin of the PT from the fibula was 13.80±5.52 cm and 76% of the specimens with a separate origin of PT extended to its proximal half. The distal insertion of PT tendon was mostly as a single insertion into the base of the fifth metatarsal bone (55.55%). Spearman rho correlation value for the EDL muscle belly circumference with the number of intertendinous connections showed a mild negative correlation.

Conclusions: Knowledge of morphometric characteristics and the variations of these muscles aid in clinical applications and suggest the use of radiological assessment of the muscle prior to surgical intervention.

Introduction

Peroneus Tertius (PT) and Extensor Digitorum Longus (EDL) muscles in the anterior group of the lower limb are very closely related topographically. Some texts consider PT to be a part of EDL and even describe it as its 5th tendon [1], while some consider it to be a proximal migration of Extensor Digitorum Brevis [2].

The PT is considered of evolutionary significance as it is limited to humans and few apes closest in the evolutionary chain [3]. Electromyographic studies indicate that it works actively with the extensor digitorum longus during the swing phase of walking to induce dorsiflexion and eversion and to elevate the foot and toes from the ground, thus aiding bipedal motion [1, 4]. It also participates in strong eversion of the foot along with peroneus brevis and longus to prevent hyper inversion of the foot [5].

PT serves as a reference landmark for the anterolateral portal insertion during ankle arthroscopy [6]. The site of insertion of PT at the fifth metatarsal suggests that its actions can

impose torsional stresses on the areas of the bone in which Jones fractures and stress fractures occur [7], thus being important in its pathophysiology. The PT is further utilized in plastic surgery and orthopedic surgery for tendonoplasty, tendon transfer, or resection procedures on the foot [8]. Earlier studies have noted variations of PT [3, 9-11] and a recent study [9] has introduced a classification system for the sites of origin and insertion.

The wide diversity of the PT muscle requiring further in-depth evaluation inspired this study which analysed the PT muscle concerning variations of proximal and distal insertion, morphometry, and associations with the EDL muscle. This will expand the knowledge on the evolutionary significance of this muscle and be of value in its utilization during surgical procedures.

Materials and Methods

Following routine dissections done on 27 cadavers by medical students at the Faculty of Medicine, University of Peradeniya, the anatomy of the PT and EDL muscles of the lower limb were defined clearly using blunt dissection. Measurements were taken using a standard measuring tape.

The length of the fibula was measured from the proximal end of the head of the fibula to the prominence of the lateral malleolus. The muscle belly morphology of PT and EDL muscles were identified. The presence and the number of inter-tendinous connections between PT and EDL were noted.

The sites of proximal and distal attachment were identified. The muscle lengths of PT (Fig 1; a) and EDL (Fig 2; f) and their muscle belly circumferences were measured. Four measurements of the PT tendon length were taken, from starting point distinct from the muscle fibers to the point of insertion (Fig 1; b), from the starting point distinct from the muscle fibers to the lateral malleolus (Fig 1; c), from the starting point within the muscle fibers to the lateral malleolus (Fig 1; d) and from the starting point within the muscle fibers to the point of insertion (Fig 1; e). The tendon length of EDL was measured from the starting point distinct from the muscle fibers to the lateral malleolus (Fig 2; g) and from the starting point within the muscle fibers to the lateral malleolus (Fig 2; h).

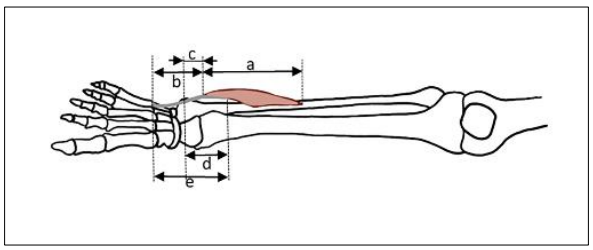

Figure 1: The measurements of peroneus tertius muscle length (a), tendon length from starting point distinct from the muscle fibers to the point of insertion (b), from the starting point distinct from the muscle fibers to the lateral malleolus (c), from the starting point within the muscle fibers to the lateral malleolus (d) and from the starting point within the muscle fibers to the point of insertion (e).

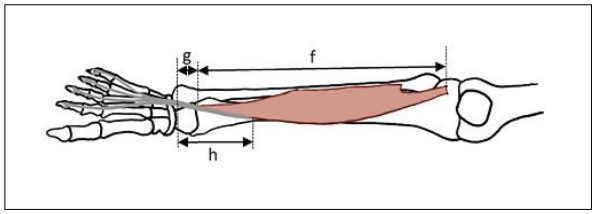

Figure 2: The measurements of extensor digitorum longus muscle length (f), tendon length from the starting point distinct from the muscle fibers to the lateral malleolus (g), and from the starting point within the muscle fibers to the lateral malleolus (h).

Minitab software Version 20.1 was used for statistical analysis methods of Spearman rho for correlations, while the Mood's Median test, Fishers Exact test, and Two-sample T-test were used to determine associations.

Results

Of the specimens, 32 (59.26%) were male. Twenty six (48.15%) had a single continuous origin for PT and EDL, while in 25 (46.30%) they had separate origins. Intertendinous connections between PT and EDL were identified in 16 specimens. The number of intertendinous connections ranged from one to seven, with nine of the specimens having 1 intertendinous connection between the two muscles.

Only one (4%) of the specimens which had a separate origin for PT had the classic site of origin from the distal third of the fibula, while five (20%) had an origin from the distal half and nineteen (76%) had an origin extending even proximal to the distal half.

The mean length of origin of the PT from the fibula was 13.80±5.52 cm ranging from 2.70 cm to 30.70 cm. Length of origin of PT from the fibula as a percentage of the length of the fibula was 39.92±14.68% ranging from 7.20% to 82.31%.

The distal attachment of the tendon of PT was mostly as a single insertion into the base of the fifth metatarsal bone (55.55%). The sites of insertion of the muscle observed are shown in Table 1 and Figs 3-4.

Table 1. The sites of insertion of peroneus tertius.

Site of Insertion	Olewnik et al., 2019 Classification type (9)	Count (Percentage)
Single insertion into the shaft of 5th metatarsal	I	1(1.85%)
Single insertion into the base of the 5th metatarsal	II	30(55.55%)
Wide insertion into the base of 4th and 5th metatarsal	III	3(5.55%)
Split insertion, one of which inserted into the base and other into shaft of 5th metatarsal	IV	6(11.11%)

Split insertion, one to base of 5th and the other to the 4th metatarsal	V	8(14.81%)
A slip to Extensor digitorum longus (EDL[2]) or peroneus brevis (PB[3]) in addition to the attachment to the base of the 5th metatarsal (Figs 3 & 4)	-	2(3.70%)
Wide insertion extending from the base to the shaft of the 5th metatarsal	-	4(7.40%)
Damaged (Difficult to identify the proper anatomy)	-	3(5.55%)
Absent PT[1]	-	1(1.85%)

(1)PT: peroneus tertius; (2)EDL: extensor digitorum longus; (3)PB; peroneus brevis

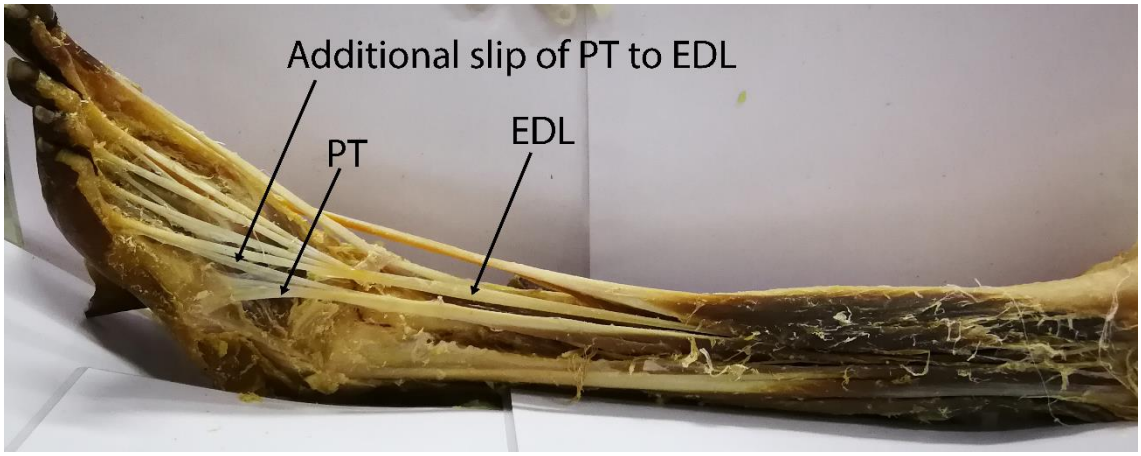

Figure 3: A slip from peroneus tertius tendon communicating with the 4th tendon of extensor digitorum longus in addition to the attachment to the base of the 5th metatarsal.

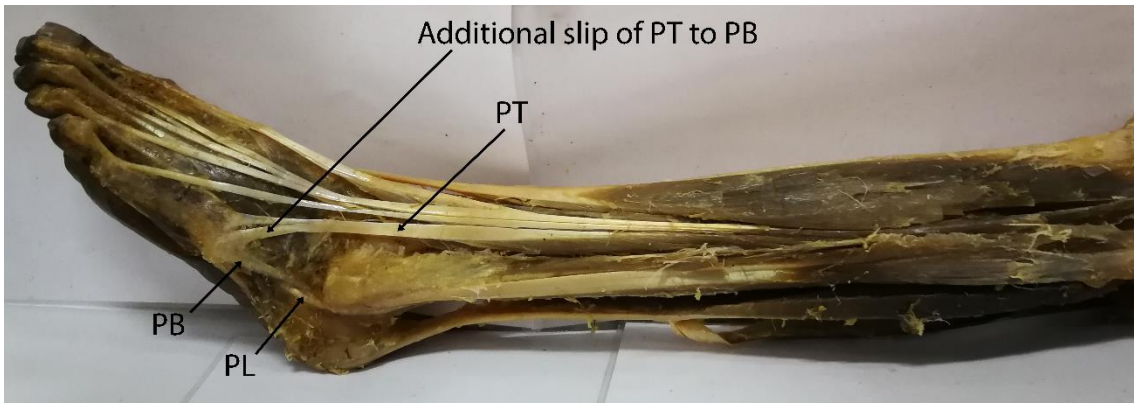

Figure 4: A slip from peroneus tertius tendon communicating with the tendon of peroneus brevis in addition to the attachment to the base of the 5th metatarsal.

The muscle belly circumference of PT measured 3.52±0.72 cm ranging from 2.0 cm to 4.9 cm while that of EDL was 4.18±0.76 cm ranging from 2.8 cm to 6.5 cm.

The length of the PT muscle was 20.38±6.05 cm ranging from 10.40 cm to 39.50 cm and that of the EDL muscle was 28.83±6.50 cm ranging from 13.40 cm to 40.00 cm. The length of the PT tendon without muscle fibers to its point of insertion was 7.06±2.17 cm. The lengths of the muscle tendons are summarized in Table 2.

Table 2. Tendon lengths of peroneus tertius (PT) and extensor digitorum longus (EDL). (SD: standard deviation, Min: minimum, Max: maximum)

Tendon		**Mean (cm)**	**SD (cm)**	**Min (cm)**	**Max (cm)**
PT tendon to insertion	Total extension	21.77	7.67	6.00	35.70
	Section without muscle fibers	7.06	2.17	4.20	17.70
PT tendon to lateral malleolus	Total extension	12.30	6.07	4.50	26.00
	Section without muscle fibers	1.17	2.02	0.00	8.00
EDL tendon to lateral malleolus	Total extension	22.33	3.30	15.40	35.30
	Section without muscle fibers	6.39	6.51	0.00	21.50

PT: peroneus tertius; EDL: extensor digitorum longus

Spearman rho was calculated to find out the correlations between morphological characteristics of PT and EDL. The value for the EDL muscle belly circumference with whether the PT and EDL were of single or separate origin was 0.014 with a p-value of 0.921 which shows that the size of EDL was not dependent on this factor. Spearman rho for the muscle belly circumference of PT and EDL was 0.521 with a p-value of 0.008 which showed a positive moderate correlation and the Spearman rho for the EDL muscle belly circumference with the number of intertendinous connections (-0.227) had a p-value of 0.106, which showed a mild negative correlation.

The Mood's median test revealed no significant association of intertendinous connection presence with the gender of the cadaver (p=0.454) while the fisher's exact test showed no significant association between the gender and the site of insertion of PT. A Two-Sample T-Test was used to find out the association between gender and the morphometric measurements of PT and EDL which showed no significant gender difference in any of the measurements except the EDL muscle belly circumference which was larger in males (shown in Table 3).

Table 3. Two-Sample T-Test p values for morphometric measurements and gender of the specimens.

Measurement	The P-value for association with gender
PT muscle belly circumference	0.459
EDL muscle belly circumference	<0.001
PT muscle length	0.242
EDL muscle length	0.087

Discussion

PT is encountered in the majority of humans and is affiliated with bipedal gait [6]. In this study, PT was absent in the left leg of one male cadaver while it was present in the right leg of the same. Though always comprising the minority, absence of this muscle has been reported in a small number by many studies [2-3, 12] and noted to be on the left side by similar studies [13-14]. Although data on the dominant side of the person is not available, a question is raised whether this tendency has a functional significance. Contrary to this study, a meta-analysis [6] reveal a weak association between male sex and the presence of PT. Peroneus tertius syndrome is a rare cause of foot pain and is successfully treated with excision of this muscle without resulting in a significant functional deficiency [15]. The PT thus considered a non-essential muscle is widely used for tissue replacement surgeries. It should be taken into consideration that being present in the majority, may have an important role in maintaining the stability of the foot. Long-term follow-up studies of patients with absence or surgical removal of PT are required to assess its functional significance.

Contrary to the textbook description of the proximal attachment of PT from the distal third of the fibula, 96% of the specimens had a much extensive origin with 76% extending to more than half of its length. Similarly, Stevens et al., 1993 reports 87% of studied specimens have an origin extending proximal to the distal third of the fibula [3]. Contradictory findings of some studies show that PT originates mostly from the distal third of the fibula [11, 16].

In this study, 26 (48.15%) specimens had an origin continuous with that of EDL and the length of origin of PT averaged from 39.92± 14.68% of the length of the fibula which can be comparable to the findings of Stevens et al. (1993) [3]. This feature could cause difficulties in separating the two muscles during surgical procedures. It was also noticed that the size of EDL was not dependent on whether the PT and EDL were of single or separate origin.

The length of the PT tendon without muscle fibres averaged at 7.06 cm which is akin to other similar research [17], though, that measured by Gusmao et al. (2013) was averaged at 1.2 cm [18]. Knowledge of such morphometric features of this muscle favours its use in reconstruction surgeries of the lower limb. The average length of the PT muscle

measured at 20.38 cm which is comparable to the mean length of 23 cm measured by Nayak (2017) [19].

Inter-tendinous connections were present in 30.77% (16) of the specimens ranging from 1 to 7 in number. In a similar study by Stevens et al. (1993) [3], they were present varying from 1 to 4 in number in 15.0% of the limbs. These connections could have an importance in the distribution of forces during gait and balance which are the main functions of the lower limb muscles. A higher number of intertendinous connections could have a supportive role to the EDL as its size decreases. The size of EDL had an inverse correlation with the number of intertendinous connections, though the relationship was not statistically significant.

Insertion of PT to the base of the 5th metatarsal has been implicated in the pathology of Jones fracture. In this study 48 out of the 54 specimens had a clear distal insertion to the base of the 5th metatarsal supportive of the above. The sites of the distal insertion of the specimens in this study included the first five types out of the six distinguished by Olewnik (2019) [9], while additional sites of insertion were identified as to be communicating with EDL (Fig 3) or peroneus brevis (PB) (Fig 4) in addition to the attachment to the base of the 5th metatarsal and as a wide insertion extending from the base to the shaft of 5th metatarsal. Thus, it could be suggested that the proposed classification be further improved. This study revealed that the size of PT and EDL show a moderately positive correlation which suggests a complementary action between the two muscles.

Knowledge of morphometric characteristics and variations of these muscles aid in clinical aspects such as using as a landmark for procedures, tendon and muscle replacement surgeries, and in the assessment of pathological conditions such as Jones fracture or PT syndrome. The presence of a wide range of variations suggests radiological assessment of the muscles before surgical intervention.

Conflict of interest

None

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WHO COLLABORATING CENTRE FOR ORAL PRECANCEROUS LESIONS. Definition of Leukoplakia and related lesions: an aid to studies on oral pre cancer. Oral Surg Oral Med Oral Pathol 1978; 46: 518-539.

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No author given International statistical classification of diseases and related health problems, 10th revision, vol 1. Geneva: World Health Organization, 1992; 550-564.