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A STUDY OF ANATOMICAL VARIATIONS OF THE POPLITEAL ARTERY IN THIEL CADAVER AND CLINICAL APPLICATIONS

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ABSTRACT

This Anatomical variations occur in structures of the body, with the structures of the vascular system inclusive. This study seeks to observe the variations in the termination pattern of popliteal artery and their clinical significances. 24 right and left popliteal fossae of 12 ScottishThiel-embalmed cadavers within the age range of 32 – 110 years were dissected. The observed variations in the termination pattern of popliteal artery were classified using to Kim's method. Normal pattern of termination of popliteal artery at the lower border of the popliteus muscle (Type I) was seen in 75% (18 limbs), out of which 50% (12 limbs) were of the type IA and 25% (6 limbs) of the type IB. Type II-A2 variant pattern of termination was found in 25% (6 limbs). Atherosclerosis was observed in 12.5% of the specimen studied. Knowledge of these variation patterns in termination of popliteal artery could assist medical professionals in corrective surgical interventions.

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INTRODUCTION

Anatomical variation is the deviation from the normal relative positions and structures of tissues and organs of the body (Satti *et al.,* 2007). The popliteal artery continues from the femoral artery at the adductor hiatus and terminates into the anterior tibial artery and the posterior tibioberoneal trunk (Ellis, 2006). Variations in termination pattern of the popliteal artery are common (Kil and Jung, 2009). Popliteal artery could terminate variably either by at a high origin by bifurcation into anterior tibial artery and posterior tibioperoneal trunk, or by trifurcation into anterior tibial artery, posterior tibial artery and peroneal artery at a common point (Kropman *et al*., 2011). Several different modalities such as angiography (Day and Orme, 2006), cadaveric study (dissection method) (Okada *et al.,* 2012), MDCT – angiography (Oztekin *et al.,* 2015), Ultrasound (Zheng *et al.,* 2016) have been used to study the popliteal artery and its variations in terminal branching and course. Dissection studies using formalin-embalmed cadavers have been used to study categories of variations of anatomy of popliteal artery such as: variations in measurements (Telang *et al.,* 2016; Khandewal *et al.,* 2014; Barut *et al.,* 2009); and variation in the pattern of branching (Khandewal *et al.,* 2014; Sharma *et al.,* 2012; Singla *et al.,* 2012; Betaiah *et al.,* 2016; Sawant, 2013). However, cadaveric study using Thiel embalmed cadavers is more result yielding than the formalin/ethanol-embalming alternative method in the structures remain flexible and having their natural complexion retained as it were in life situation (Kennel *et al.,* 2018; Benkhadra *et al.,* 2011). Understanding variation of the popliteal arteries before surgical intervention enhances the planning for successful operations and reduces the incidence of unexpected, serious arterial injury that happens due to lack of full acquaintance of these variations (Kropman *et al.,* 2011). This study therefore seeks to observe the variation in the anatomy of the popliteal artery using Thiel embalmed cadavers from the Scottish population.

MATERIAL AND METHODS

Twenty four limbs of Twelve Thiel embalmed cadavers (eight males, four females) in the Centre for Anatomy and Human

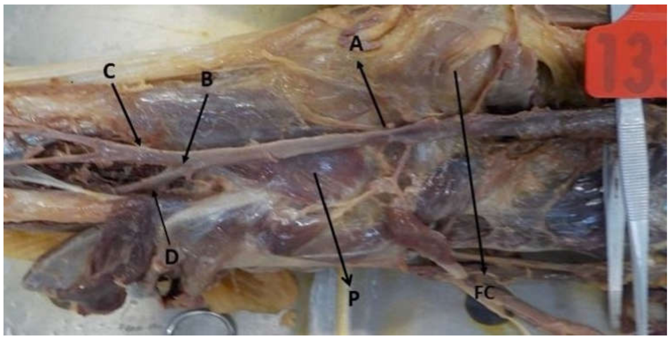
Identification (CAHID), University of Dundee Scotland were used for the study. Dissection equipment was used to dissect the popliteal fossae in order to expose the origin and the termination of the popliteal arteries and their relations, using standard dissection procedures. Variations of the termination patterns of popliteal arteries were observed and classified according to the Kim *et al.,* (1989) as follows:

1. **Type I:** Normal level of termination of the popliteal artery at the lower border of popliteus muscle.
   - Type IA: Anterior tibial artery originates first followed by posterior tibioperoneal trunk which divides into posterior tibial artery and peroneal artery.
   - Type IB – A trifurcate pattern in which the popliteal artery divides into three arteries: the anterior tibial artery, peroneal artery and the posterior tibial artery within a distance of 0.5cm.
   - Type IC: The posterior tibial artery is the first branch followed by the anterior tibioperoneal trunk which divides into peroneal artery and anterior tibial artery.
2. Type II: Higher level of termination: above the knee joint level
   - Type II-A1: Anterior tibial artery arises first a high level and runs anterior to the popliteus muscle.
   - Type II-A2: Anterior tibial artery arises first at a high level and runs posterior to the popliteus muscle.
   - Type II-B: Popliteal artery terminates into the posterior tibial artery and the anterior tibioperoneal trunk at a high level.
   - Type II-C: The origin of the peroneal artery from the popliteal artery is above the knee joint level, followed by a common trunk for the anterior tibial and the posterior tibial arteries.
   - The peroneal artery arises by the popliteal artery above or at the level of the knee joint.
3. Type III: Small size or absent terminal branches with substituted distal supply
   - Type IIIA: Reduced size or absent PTA. Posterior tibial artery is replaced by peroneal artery.
   - Type IIIB: Reduced size or absent ATA. Dorsal pedis artery is substituted by peroneal artery.
   - Type IIIC: Reduced size or absent PTA and ATA. Dorsal pedis artery is substituted by peroneal artery.

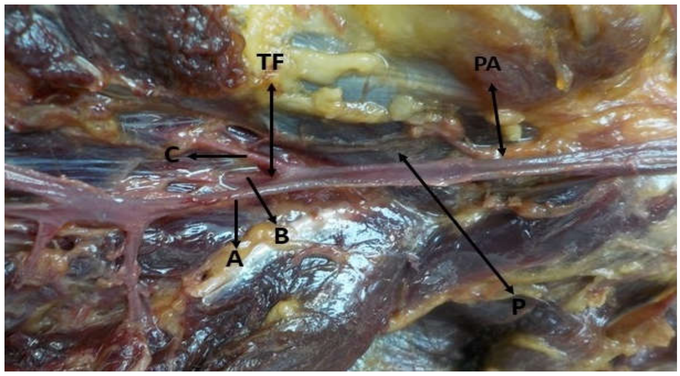
Ethics: This work was carried out in Centre for Anatomy and Human Identification (CAHID) under guidelines of Human Tissue Act Scotland.

RESULTS

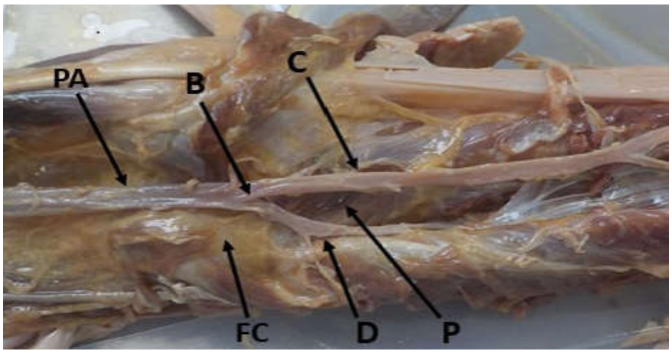
Out of the twenty-four (24) limbs used for this study, 50% (twelve limbs) had no variation in the terminal branches of their popliteal artery i.e. the popliteal arteries terminated at the lower border of the popliteus muscle into the anterior tibial artery and the posterior tibioperoneal trunks (Type IA). In 25% of the limbs (six limbs), popliteal arteries trifurcated into the anterior tibial arteries, posterior tibial arteries and the peroneal arteries at the lower border of the popliteus muscle (Type IB). High level of termination of the popliteal artery into anterior tibial artery and posterior tibioperoneal artery (Type IIA) was observed in 25% (six) limbs. In these limbs, the anterior tibial arteries ran on the posterior border of the popliteus muscle before they entered the anterior compartment of the leg. The posterior tibioperoneal trunk had a longer course before terminating into the peroneal artery and the posterior tibial artery.



Normal type of popliteal artery variation (Type IA): Popliteal artery (A) terminates into anteriotibial artery (D) and posterior tibioperoneal trunk (C) at a termination point (B) at the lower border of the popliteus muscle. FC = femoral condyle.



Normal type of popliteal artery variation (Type IB): Popliteal artery (PA) trifurcated at a point (TF) at the lower border of the popliteus muscle (P) into posterior tibial artery (A); anterior tibial artery (B); and = peroneal artery (C).



Variation pattern of the popliteal artery (Type IIA2): Popliteal artery (PA) terminates into anterior tibial artery (D) and posterior tibioperoneal trunk (C) at a high level of termination (B), at the level of femoral condyle (FC) or the upper border of popliteus muscle (P)

DISCUSSION

Principles by which variations in structure of blood vessels lies in the processes that occur during embryonic periods, when arteries that are supposed to degenerate either persists, becomes aplastic or have a reduced size or fuse with other arteries (Arey, 1974; Mauro *et al.,* 1988). The development of the popliteal artery occurs with the embryology of the fetal lower limb bud (Bowers and Bordoni, 2019). The intrauterine development of the popliteal artery is formed when the proximal part of the developing deep popliteal (the distal part of the sciatic artery) on the anterior part of the popliteus muscle regresses and joins the superficial popliteal artery, a derivative of the femoral system (which lies at the posterior surface of the popliteus muscle) (Red-horse *et al.,* 2017; Kuznetsov *et al.,* 2018). The frequency of occurrence of type IA from previous studies ranges from 82.4% to 92.2% (Mauro *et al.,* 1988; Kim *et al.,* 1989; Mavili *et al.,* 2011; Oztekin *et al.,* 2015; Mavili *et al* 2011; Bose *et al.,* 2018; Ogzur *et al.,* 2009). All the 40 popliteal arteries (100%) studied in Indian cadavers were of type IA normal variation pattern (Betaiah *et al.,* 2016) while the type IA variation in the present study occurred in half (50%) of the specimen. The incidence of type IB (trifurcation) normal pattern of termination as observed by angiography studies ranges from 2.0% to 5.4% (Mauro *et al.,* 1988, Kim *et al.,* 1989; Mavili *et al.,* 2011; Oztekin *et al.,* 2015; Bose *et al.,* 2018) which is very low as compared to the percentage occurrence of 25% (6 popliteal arteries) in the present study. The type II variation reported in the present study was type II-A2 where the anterior tibial artery passed on the posterior surface of the tibia. Such case was encountered during dissection by Sharma *et al*. (2012) in both left and limbs of a 40 year old in Nepal in both left and right limbs. The incidence of occurrence of type II-A2 variation as recorded from previous works ranges from 0.4% to 33% (Kim *et al.,* 1989; Sawant, 2013; Mavili *et al.,* 2011; Oztekin *et al.,* 2015; Dermitas and Parpar, 2016; Day and Orme, 2006) and do not correspond to the percentage of occurrence of type II-A2 (25%) observed in the present study. Unlike angiographic studies which recorded lower percentages of occurrence of type II-A2, dissection studies recorded higher percentages of occurrence of type II-A2: 33% and 2.4% (Sawant, 2013; Day and Orme, 2006) as well as that of the present study which recorded 25%.With the use of anteriorposterior arteriography, incidence of type IIA variation type as 2.3% although it was difficult report if it was type IIA-1 or type IIA-2 (Mauro *et al.,* 1988). This is an advantage when performing surgical vascular grafting for an artery that is occluded as a result of disease conditions e.g. popliteal artery atherosclerosis or in cases of popliteal artery aneurysms or in cases where the popliteal artery is damaged by direct trauma (Mauro *et al.,* 1988). Also, adequate knowledge of the variation pattern and pathologies is a necessary tool for radiologists and angiologists for accurate interpretation of arteriographs; and for orthopedic surgeons in successful total knee replacement in order to avoid accidental injuries to the arteries and their branches (Jiji and Sujatha, 2008).

Conclusion

Information about the variations in the terminal branching pattern of popliteal artery is very crucial in diagnosing clinical conditions by imaging scientists such as angiographers and radiologists and in surgical procedures in the knee and popliteal regions.

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