

VARIABILITY OF THE MORPHOLOGY OF GASTROCNEMIUS MUSCLE IN AN AFRICAN POPULATION

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ABSTRACT

Gastrocnemius morphological status is often designated as being bipennate. Its robustness in humans is a feature that accompanies the human mode of locomotion. The three-headed variant has often been reported, but paucity of information exists within the Nigerian population as regards gastrocnemius morphological variability. We therefore currently aim to determine the pattern of occurrence of variations of the muscle in both legs of thirty cadavers in four Anatomy laboratories of Universities in Southwestern part of Nigeria. Our current study shows that the multi-headed variants (three- and four-headed) are more dominant. A minority (35%) of the legs had two-headed gastrocnemius muscle, 13.3% had three-headed gastrocnemius while 51.7% had four-headed gastrocnemius muscle. This study provides a careful description of the gastrocnemius muscle in the studied population and also sheds light on the embryological and clinical implications of the findings. The knowledge of variant gastrocnemius anatomy will aid understanding of popliteal surface anatomy, palpation of popliteal arterial pulse, popliteal nerve block and the assessment of gastrocnemius muscle for autografting. The additional variant heads also bear evolutionary importance.

Key Words: Gastrocnemius; Multi-Pinnate; Popliteal Entrapment Syndrome; Variations; Four-Headed, Third Head Of Gastrocnemius

INTRODUCTION

Gastrocnemius morphology is important in understanding the evolution of bipedalism and in surgical and radiological assessment of the popliteal region. The gastrocnemius is known to typically arise by two heads, which are connected, separately to the condyles of femur by strong tendons (Williams *et al.*, 1995).

Variations of the gastrocnemius muscle could interfere with the neurovascular

transmission through the popliteal fossa (Ashaolu *et al.*, 2013). Such variations also alter the anatomical description of the popliteal fossa (Ashaolu *et al.*, 2013).

However, dearth of information exists on the occurrence and morphological variation of gastrocnemius in the African population. We currently aim to determine the frequency of occurrence of variant forms of gastrocnemius muscle in sixty

cadaveric legs in the Southwestern

Nigerian population.

METHODS

This study was conducted in four Departments of Anatomy in Universities in the Southwestern region of Nigeria. The research involved the use of thirty cadavers making up sixty legs from twenty-three males and seven females. This study was limited to this number of cadavers because of their shortages in the region of the study. Ages of the cadavers were not retrievable but they were presumably adults. This study was conducted between the months of February and May 2013.

Ethical clearance was sought from the concerned institutions. The use of cadavers was in line with the Nigeria Anatomical Act. Departmental approval was sought from all heads of Department of the involved institutions.

An incision ranging from the posterior mid-thigh region to the posterior aspect of

the calcaneus was made. Transverse incisions were made on the middle aspect of the posterior part of the thigh, on the dorsal aspect of the popliteal region and the calcaneus. The flaps of skin covering the incised region were reflected away as far anterior as possible to permit due dissection of the gastrocnemius muscle. Gastrocnemius dissection was performed.

Each head possessing distinct attachment was identified noting differences in fibre direction and separation by thin inter – muscular fascia reaching the deep surface of the muscle. Proximal bellies of gastrocnemius were examined by number and mode of attachment and recorded. Gastrocnemius headedness was recorded as two, three or four. General bony insertions were also recorded. Popliteal vascular arrangement was also noted. All photographic images were obtained for permanent record.

RESULTS

All examined subjects possessed the gastrocnemius muscle, but the pattern of headedness differed. No case of one-headed gastrocnemius was found. 35% of the studied gastrocnemius muscles were two-headed, 13.3% were three-headed while 51.7% were four-headed.

Multi-headed gastrocnemius was commoner in males, [76.1%] than in females [28.5%] in females. Two-headed gastrocnemius is commoner in females [71.4%] than in males [23.9%]. Subjects with two-headed gastrocnemius had 100% simultaneous occurrence of plantaris while subject with multi-headed gastrocnemius had its 90% simultaneous occurrence. Plantaris was present in 93.3 % of all cases studied.

Each head of the two-headed gastrocnemius was classified as medial and lateral; each head of the three-

headed gastrocnemius was classified as medial, lateral and middle. The middle head of gastrocnemius is often referred to as caput tertium or third head of gastrocnemius. Each head of the four-headed gastrocnemius were classified as medial, lateral, intermedio-medial and intermedio-lateral head (Figure 1-3).

Medial and lateral heads of gastrocnemius were attached to the medial and lateral condyles of femur respectively. The middle head of the three-headed gastrocnemius and the intermedio-medial and intermedio-lateral heads of the four-headed gastrocnemius were either attached to the popliteal surface, medial or lateral supracondylar lines, or posterior knee fascia or capsule (Fig. 2-5). All fibres and bellies of gastrocnemius muscle converged inferiorly on the calcaneal tendon in all cases.

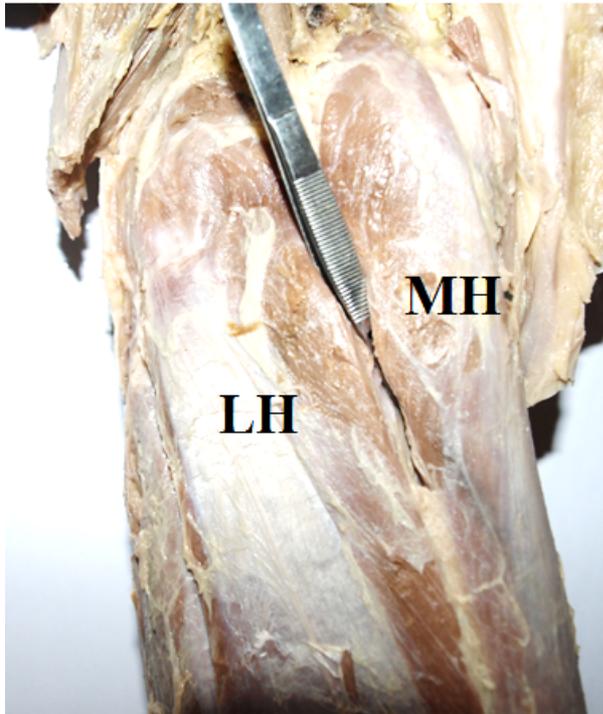


Figure 1. Showing the dorsal aspect of the two-headed gastrocnemius muscle. MH-medial head, LH- lateral heads

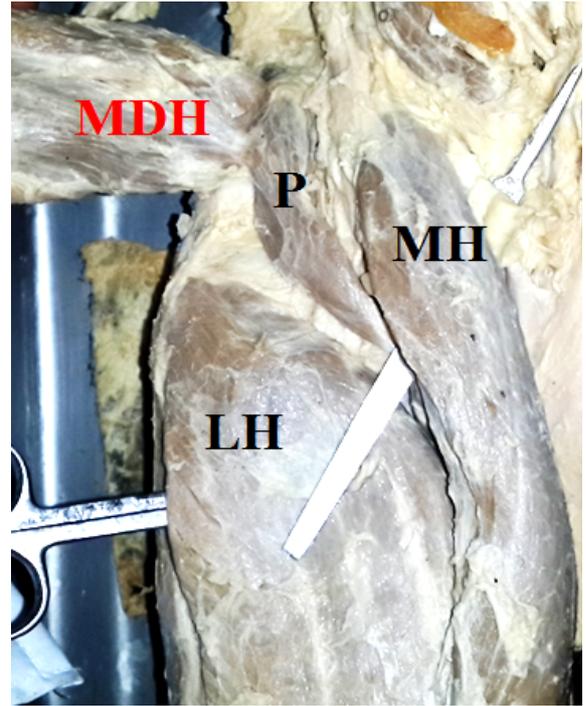


Figure 2: Showing the dorsal aspect of the three-headed gastrocnemius muscle, with the reflected median head in the left leg. MH-medial head, LH-lateral heads, MDH- Median head, P-Plantaris

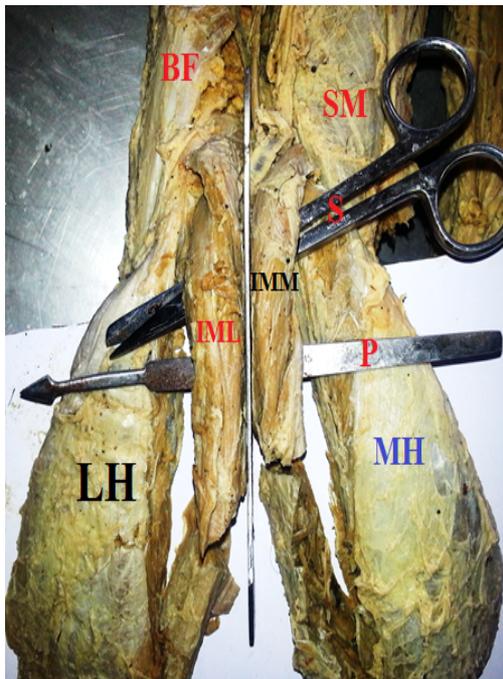


Figure 3: Showing the dorsal aspect of the four-headed gastrocnemius muscle in a left leg. MH-medial head, LH- lateral heads, IML- intermedio-lateral head, IMM-intermedio-medial head, P-Probe, Sm-semimembranosus, BF- Biceps femoris, S-Scissors

DISCUSSION

The results of this study confirm that the gastrocnemius muscle is predominantly multi-headed in the studied population.

The two-headed gastrocnemius is the most dominant form in most previous literatures, having a medial head, the most enlarged part, attaching on the medial condyle and the lateral head on the lateral condyle (Williams *et al.*, 1995; Arce, 2008). Our finding of 35% of the two-headed variant is unusually low compared to what is found in other populations. Arce (2008) reported 92.5 % prevalence of two-headed gastrocnemius in the Argentine populace. Koplaset *al.* (2009) reported 98.1 % of two-headed gastrocnemius occurrence within the United State of America population. Shalini *et al.*, (2013) reported 80% occurrence of the two-headed gastrocnemius in the Indian population.

Bergman (1995) reported three-headed gastrocnemius ranging in frequency between 2.9%-5.5%. In our study, 13.3% of three-headed gastrocnemius is reported. Arce (2008) reported 7.5% prevalence of three-headed gastrocnemius in the Argentine populace. Koplaset *al.*, (2009) reported 1.9% of three-headed gastrocnemius occurrence within the United State of America population. Shalini *et al.*, (2013) reported 20% occurrence of the three-headed gastrocnemius in the Indian population.

We currently report that the four-headed gastrocnemius is the most dominant form with 51.7% prevalence in the studied population. Ashaolu *et al.* (2013) reported a case of four-headed gastrocnemius. We did not find any other previous literature that determined the prevalence of four-headed gastrocnemius muscle either in an African population or other parts of the world. The finding of 90% simultaneous

occurrence of plantaris with the multi-headed forms of gastrocnemius indicate that the additional heads found are not derivatives of the plantaris and that plantaris retains its function and dominance in the studied population.

From the embryological perspective, the gastrocnemius muscle originates from the calcaneumblastomere and follows an ascending migration towards the inferior femoral epiphysis (Bergman *et al.*, 1988). It then moves medially and terminate as medial and lateral proximal attachments (Jager and Moll, 1951; Bergman *et al.*, 1988). These variations found may result from its different mode of embryological migration or termination.

In an earlier reported case of multi-headed gastrocnemius, it was mentioned that the multi-headed variants might be associated with popliteal vessel entrapment (Ashaolu *et al.*, 2013). On the contrary, our present finding of a thick popliteal sheath vastly binding the popliteal artery and vein may facilitate synergistic transport between the vessels and aid blood flow in the region; understandably, because the sheath would prevent independent displacement of popliteal arteries or veins. Dearth of descriptive information exists in literature regarding the popliteal sheath. Notwithstanding, multi-headed gastrocnemius variation may not be completely dissociable from the possibilities of popliteal vessel entrapment, in the studied population, considering our limited sample size. Various anomalous anatomic relationships between muscle and arteries in the popliteal fossa results in arterial compression (Aktan *et al.*, 1999).

While surgical resection of supernumerary heads has proven useful in alleviating popliteal entrapment syndromes, to prevent iatrogenic damages, it should be noted that neurovascular branches from the main popliteal neurovascular structures often exist between the clustered heads of gastrocnemius, as found in our study.

The supernumerary heads of the multi-headed gastrocnemius might be susceptible to damage during sudden propulsive force generation (Ashaolu *et al.*, 2013). It has been suggested that the intermediate heads of gastrocnemius muscle may be involved in functions other than propulsion and more of stabilization or proprioception at the knee joint, because of the differences in their fibre orientation (Ashaolu *et al.*, 2013). We currently further propose that the

supernumerary heads covering most part of the popliteal region may help to delimit hyperextension during sporting activities and helping to prevent anterior cruciate ligament tears.

In conclusion, total multi-headed dominance (65 %; three plus four-headed) compared to the two-headed form in our subject population seems to present a more diverse morphological form of gastrocnemius muscle.

Conflict of interest: There is no conflict of interest.

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