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Prevalence of the nutrient foramen in tibia from Bihar region population

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Abstract
Comprehensive information about the blood supply of long bones is one of the vital factors for success of new techniques in bone transplant and resection in orthopaedics. During transplant techniques, the variant of distribution of nutrient foramina guides the operating surgeons to place the graft without injuring the nutrient arteries. The topography of nutrient foramina may contrast in its growing and non-growing end, specific understanding of this becomes essential in certain surgical procedures to conserve the circulation. Hence present study was planned to generate the data on nutrient foramen in tibia from Bihar region and to compare the findings with the similar studies done in other parts of the world.
The present study was planned in the Department of Anatomy, Anugrah Narayan Magadh Medical College, Gaya. The study was performed from the duration of feb 2017 to nov 2017. Total 30 tibia were samples were selected in the present study. The presence of nutrient foramina was confirmed by identifying a well-marked grove which led to the commencement to the foramen. Number, distribution and direction of nutrient foramen in relation to specific surfaces of tibiae were analysed. Only diaphyseal nutrient foramina were observed in all tibiae. Direction of the nutrient foramen was carefully observed by using a magnifying hand lens and then passing a fine needle (25 gauges) through the foramen to confirm its patency and direction.
The knowledge of exact location of nutrient foramen of tibia is highly useful for the surgeons who perform fracture repair or are involved in surgical interventions of tibia. So we measured the distance of nutrient foramen from junction of upper & middle 1/3rd of the shaft and the Soleal line.

Keywords: tibia, nutrient foramen, long bones, etc

Introduction

The tibia also known as the shinbone or shankbone, is the larger, stronger, and anterior (frontal) of the two bones in the leg below the knee in vertebrates (the other being the fibula, behind and to the outside of the tibia), and it connects the knee with the ankle bones. The tibia is found on the medial side of the leg next to the fibula and closer to the median plane or centre-line. The tibia is connected to the fibula by the interosseous membrane of the leg, forming a type of fibrous joint called a syndesmosis with very little movement. The tibia is named for the flute tibia. It is the second largest bone in the human body next to the femur. The leg bones are the strongest long bones as they support the rest of the body.

In human anatomy, the tibia is the second largest bone next to the femur. As in other vertebrates the tibia is one of two bones in the lower leg, the other being the fibula, and is a component of the knee and ankle joints. The leg bones (femur, tibia and fibula) are the strongest long bones as they have to support the rest of the body. The ossification or formation of the bone starts from three centers; one in the shaft and one in each extremity. The tibia is categorized as a long bone and is as such composed of a diaphysis and two epiphyses. The diaphysis is the midsection of the tibia, also known as the shaft or body. While the epiphyses are the two rounded extremities of the bone; an upper (also known as superior or proximal) closest to the thigh and a lower (also known as inferior or distal) closest to the foot. The tibia is most contracted in the lower third and the distal extremity is smaller than the proximal.

The proximal or upper extremity of the tibia is expanded in the transverse plane with a medial and lateral condyle, which are both flattened in the horizontal plane. The medial condyle is the larger of the two and is better supported over the shaft. The upper surfaces of the condyles articulate with the femur to form the tibiofemoral joint, the weightbearing part of the kneejoint [1].

The medial and lateral condyle are separated by the intercondylar area, where the cruciate ligaments and the menisci attach. Here the medial and lateral intercondylar tubercle forms the intercondylar eminence. Together with the medial and lateral condyle the intercondylar region forms the tibial plateau, which both articulates with and is anchored to the lower extremity of the femur. The intercondylar eminence divides the intercondylar area into an anterior and posterior part. The anterolateral region of the anterior intercondylar area are perforated by numerous small openings for nutrient arteries. The articular surfaces of both condyles are concave, particularly centrally. The flatter outer margins are in contact with the menisci. The medial condyles superior surface is oval in form and extends laterally onto the side of medial intercondylar tubercle. The lateral condyles superior surface is more circular in form and its medial edge extends onto the side of the lateral intercondylar tubercle. The posterior surface of the medial condyle bears a horizontal groove for part of the attachment of the semimembranosus muscle, whereas the lateral condyle has a circular facet for articulation with the head of the fibula. Beneath the condyles is the tibial tuberosity which serves for attachment of the patellar ligament, a continuation of the quadriceps femoris muscle [1].

The medial surface is smooth, convex, and broader above than below; its upper third, directed forward and medialward, is covered by the aponeurosis derived from the tendon of the sartorius, and by the tendons of the Gracilis and Semitendinosus, all of which are inserted nearly as far forward as the anterior crest; in the rest of its extent it is subcutaneous.

The lateral surface is narrower than the medial; its upper two-thirds present a shallow groove for the origin of the Tibialis anterior; its lower third is smooth, convex, curves gradually forward to the anterior aspect of the bone, and is covered by the tendons of the Tibialis anterior, Extensor hallucis longus, and Extensor digitorum longus, arranged in this order from the medial side.

The posterior surface presents, at its upper part, a prominent ridge, the popliteal line, which extends obliquely downward from the back part of the articular facet for the fibula to the medial border, at the junction of its upper and middle thirds; it marks the lower limit of the insertion of the Popliteus, serves for the attachment of the fascia covering this muscle, and gives origin to part of the Soleus, Flexor digitorum longus, and Tibialis posterior. The triangular area, above this line, gives insertion to the Popliteus. The middle third of the posterior surface is divided by a vertical ridge into two parts; the ridge begins at the popliteal line and is well-marked above, but indistinct below; the medial and broader portion gives origin to the Flexor digitorum longus, the lateral and narrower to part of the Tibialis posterior. The remaining part of the posterior surface is smooth and covered by the Tibialis posterior, Flexor digitorum longus, and Flexor hallucis longus. Immediately below the popliteal line is the nutrient foramen, which is large and directed obliquely downward.

All bones possess larger or smaller foramina (openings) for the entrance of blood-vessels; these are known as the nutrient foramina, and are particularly large in the shafts of the larger long bones, where they lead into a nutrient canal, which extends into the medullary cavity. The nutrient canal (foramen) is directed away from the growing end of bone. The growing ends of bones in upper limb are upper end of humerus and lower ends of radius and ulna. In lower limb, the lower end of femur and upper end of tibia are the growing ends [2]. The nutrient arteries along with veins pass through this canal. A nutrient canal is found in long bones, in the mandible [3] and in dental alveoli [4]. In long bones the nutrient canal is found in the shaft.

Comprehensive information about the blood supply of long bones is one of the vital factors for success of new techniques in bone transplant and resection in orthopaedics. During transplant techniques, the variant of distribution of nutrient foramina guides the operating surgeons to place the graft without injuring the nutrient arteries. The topography of nutrient foramina may contrast in its growing and non-growing end, specific understanding of this becomes essential in certain surgical procedures to conserve the circulation. Hence present study was planned to generate the data on nutrient foramen in tibia from Bihar region and to compare the findings with the similar studies done in other parts of the world.

Methodology

The present study was planned in the Department of Anatomy, Anugrah Narayan Magadh Medical College, Gaya. The study was performed from the duration of Feb 2017 to Nov 2017. Total 30 tibia were samples were selected in the present study. The presence of nutrient foramina was confirmed by identifying a well-marked grove which led to the commencement to the foramen. Number, distribution and direction of nutrient foramen in relation to specific surfaces of tibiae were analysed. Only diaphyseal nutrient foramina were observed in all tibiae. Direction of the nutrient foramen was carefully observed by using a magnifying hand lens and then passing a fine needle (25 gauges) through the foramen to confirm its patency and direction. Approval of the institutional ethical committee was taken prior to conduct of this study.

Results & Discussion

The nutrient artery plays cardinal role in blood supply of a long bone. The nutrient artery to tibia is derived from posterior tibial artery near its origin. It is one of the largest of the nutrients arteries. Rhinelander *et al.* (1972) have reported that the nutrient artery to the tibia supplies the inner two-thirds of the cortex and is the chief blood supply of cortical bone [5].

A single nutrient foramen on the shaft of the tibia is a common observation of the past studies. Few researchers have also reported the double diaphysial nutrient foramen on the tibia as a rare occurrence [6].

Table 1: Distribution of nutrient foramina in the Femur

Side	Right	Left	Total
Total no. of bones	12	18	30
Total Nutrient Foramen	10	15	25

Table 2: Lengthwise distribution of nutrient foramen in tibia

Lengthwise distribution	Right	Left	Total
Upper 3rd	7	10	17
Middle 3rd	3	5	8
Lower 3rd	0	0	0

There are about 84.29% of the cases in which the nutrient foramen was located in upper 3rd part. In the middle 3rd part about 15.71% of the nutrient foramen was observed. In the lower 3rd of the part no nutrient foramen was seen.

Table 3: Location of nutrient foramina

Location	Right	Left
Post Surface	3	8
Medial Surface	2	4
Lateral Surface	2	3
Total	7	15

The understanding of the nutrient foramen location might be useful in particular surgeries like fracture management. In vascular bone grafts, the arterial supply is essential to the osteoblasts and osteocytes [7]. The bone graft should have the periosteal and endosteal blood vessels along with the plenty of anastomosis [8]. The topographical evidence about the nutrient foramen will help the surgeon in fixing the bony defect with the grafts, tumor removal. This is mainly important in selecting the grafts without injuring the nutrient artery. This conserves the vascularization of the shaft [9-10].

In a study by Murlimanju *et al*. a single foramen was observed in 98.6% of the tibiae and 90.2% of fibulae. 1.4% of the tibiae and 9.8% of the fibulae had absent foramina [11]. In those cases with absent foramina the bones derive their nutrition from periosteal vessels [12]. In a study by Patel *et al*. 100% of tibia had a single primary nutrient foramen and 80% of fibula had single foramen and the remaining 20% fibula had double foramina [13]. In a study by Sharma *et al*., 96% of tibia had a single nutrient foramen on its posterior surface. Double foramina were observed in 4% of the tibia. In the fibula 92% had single nutrient foramen and in 8% it was absent [14].

In the present study majority of the foramina were on the posterior surface of both the bones. A similar observation was made by Murlimanju *et al*., [11], and Gümüsburun *et al*. [15], in their studies. In the study by Pereira *et al*. in Brazilian ethnic group it was observed that most of the nutrient foramina are located on the posterior aspect in the lower limb bones [16]. In a study by Mazengenya and Fasemore in black and white South Africans the foramina were located mostly on the posterior surface of tibia and the fibula in both ethnic groups [17].

Location of the nutrient foramen in tibia was observed to be consistent by many authors i.e. in the upper one third and on the posterior surface. In the present study also nutrient foramina are located predominantly in the upper third of the bone than the middle third. No foramina of the size greater than 24 gauze were observed in lower third of the bones, which may be the reason for delayed or non-union of fractures in the lower third of tibia.

This data will enable the surgeons to efficiently avoid the damage to the nutrient artery of tibia during surgical procedures involving this region which can have significant impact on overall recovery of patient. The data can also be of great significance for surgeons involved in free vascular bone graft surgeries [18-19].

Conclusion

The knowledge of exact location of nutrient foramen of tibia is highly useful for the surgeons who perform fracture repair or are involved in surgical interventions of tibia. So we measured the distance of nutrient foramen from junction of upper & middle 1/3rd of the shaft and the Soleal line.

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