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Anatomical Features of the Descending Genicular Artery to Facilitate Surgical Exposure for the Subvastus Approach—A Cadaveric Study

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ABSTRACT

Background: The purpose of this cadaveric study was to clarify the proximal limit for the subvastus approach (SVA) in total knee arthroplasty to decrease potential vascular injury.
Methods: Seventy embalmed knees underwent a modified SVA using a 14-cm oblique medial incision. Anatomical features of the descending genicular artery (DGA) were investigated with regard to variation, distance of the vessels from surgical landmarks, and sex differences.
Results: The DGA was identified in 62 knees (89%), while it was absent in 8 knees (11%); in the latter, the articular, saphenous, and muscular branches arose separately from the femoral artery. The mean distances from the tibial tuberosity and medial joint line to the origin of the DGA were 15.5 ± 1.6 cm and 12.6 ± 1.6 cm, respectively. Both distances were significantly longer in males than in females ($P < .01$, respectively). A strong positive correlation was found between the distance from the tibial tuberosity to the origin of the DGA and the distance from the medial joint line to the origin of the DGA (Spearman's correlation coefficient, $R^2 = 0.72$, $P < .01$). A weak positive correlation was found between the distance from the tibial tuberosity to the origin of the DGA and lower leg length ($R^2 = 0.13$, $P < .01$). No vascular injuries were observed in this surgical exposure.
Conclusion: The DGA showed several variations and was absent 11% of the time. An oblique medial incision within 14 cm from the tibial tuberosity followed by arthrotomy is considered a safe zone for the SVA.

Total knee arthroplasty (TKA) is performed to relieve pain and improve limited function in patients with knee osteoarthritis. The need for TKA will increase in the next 15 years [1]. According to the arthroplasty registries, about 95% of the prostheses last at least 10 years with improved procedures and instruments [2]. The medial parapatellar approach (MPPA) has been popularized because of its excellent exposures to the knee joint [3]. However, this approach damages the extensor mechanism and blood supply to the patella, and thus, it causes surgical complications such as patellar button loosening, patellar dislocation, and anterior knee pain [4,5]. As the number of TKAs increase, the desire of patients to integrate early recovery has increased and surgeons have been encouraged to explore a less invasive approach. Hofmann first reported the subvastus approach (SVA) with a direct anterior midline incision of the knee, which preserves the quadriceps muscle and the blood flow to the patella; good results using this approach have been reported [6–8]. But with the SVA, it is difficult to obtain sufficient exposure of the surgical field, especially to evert the patella [4,9]. For better exposure using the SVA, the incision and arthrotomy must be extended proximally because the distal end is limited by the tibial tuberosity. For proximal extension, attention must be paid to the vascular anatomy. The descending genicular artery (DGA), the final branch of the femoral artery, is at risk of damage, even though it is protected by the intermuscular fascia and the adductor hiatus. Fauré et al [10] stated there were 2 patients with symptomatic

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medial-thigh hematomas caused by damage of the DGA and its branches in the SVA. The past study recommended that the proximal limitation for mobilization of the vastus medialis in the SVA was the adductor hiatus, with further mobilization increasing the risk of damaging the DGA and its accompanying vein [11]. However, in clinical practice, the adductor hiatus is seldom identified during the usual SVA procedure. A cadaveric study is required to define the safe zone between the DGA and the tibial tuberosity for the SVA. The purpose of this cadaveric study was to clarify the proximal limit for a safe incision and arthrotomy via the SVA in TKA to avoid potential vascular injury.

Materials and Methods

The research protocol of this cadaveric study was in compliance with the Helsinki Declaration, approved by the institutional review boards, and informed consent was obtained for the donation before death.

At the Clinical Anatomy Laboratory of our university, 80 embalmed human cadaver lower legs (40 male and 40 female) were obtained. The inclusion criterion was a lower leg with 170°-190° of femorotibial angle. The exclusion criteria were a history of previous knee surgery and a knee with contracture greater than 20° of flexion, or undesirable leg position. After the inspection, 70 embalmed cadaver knees (35 male and 35 female) met the criteria. The average age at the time of death was 86.0 years (range, 64-105 years).

The procedure for the SVA was modified with a 14-cm oblique medial incision, starting from the tibial tuberosity along with the midpoints of the muscle belly of the vastus medialis in the knee extension position. Subcutaneous fat and the superficial fascial layer were incised directly to the sheath of the vastus medialis muscle. The sheath of the vastus medialis muscle was then incised in the direction of the muscle fibers. The muscle fibers were intentionally pulled laterally within the sheath by the surgeon's index finger and 2 wound retractors to visualize the capsule of the knee joint. The superficial layer of the medial capsule was incised along with the incision, and then fat tissue was identified on the deep layer of the capsule (synovial layer). The synovial tissue was preserved in a flap as laterally as possible at arthrotomy, because it was useful to reconstruct the medial capsule at closure in the TKA procedure. After the knee arthrotomy, the sartorius and vastus medialis muscles were mobilized from the intermuscular septum with blunt dissection distally. After removal of the vastoadductor membrane, the femoral artery and femoral vein were exposed toward the knee joint, and the underlying vascular patterns were isolated. The anatomical structures of the DGA and its 3 branches (articular, saphenous, and muscular) were identified. This procedure was performed by 2 board-certified orthopedic surgeons who were well trained in this approach. Dissection was performed using surgical loupes with 3.6× magnification. The first 4 specimens were used as trial (data not shown) to provide an overview of the anatomical structures located in the subvastus region and to determine a reproducible technique in accordance with the method described by Iorio et al [12]. We defined the most distal point of the medial femoral condyle in a knee extension position as the point at the medial joint line and the superomedial edge of the tibial tuberosity as the point of the tibial tuberosity. For each specimen, the following data were collected thrice using a digital caliper in 0° of knee extension; the 3 values were then averaged. In all cases, several photographs of the anatomized vessels were obtained. All measurements were taken by a single surgeon (M.M.).

(1) The branching pattern of the DGA, according to the classification by Dubois et al [13] (Figs. 1 and 2). Type 1: the 3 branches (articular, saphenous, and muscular) arise from a common trunk (DGA); type 2: one of these branches arises from the femoral artery independently and the others through a trunk (DGA); type 2A: isolated articular branch type, type 2B: isolated saphenous branch type, and type 2C: isolated muscular branch type; type 3: the 3 branches arise separately from the femoral artery.
(2) Vascular injury of the DGA during exposure via the SVA.
(3) The distance from the superomedial edge of the tibial tuberosity to the origin of the DGA.
(4) The distance from the medial joint line of the knee to the origin of the DGA.
(5) The distance from the lateral epicondyle of the femur to the lateral malleolus of the ankle (lower leg length).

Statistical Analysis

Values were presented as mean ± standard deviation. Continuous values were compared with Mann-Whitney *U* test using JMP Pro 12 (SAS Institute Inc., Cary, NC). The Spearman's rank test was calculated for correlations between lower leg length, the distance

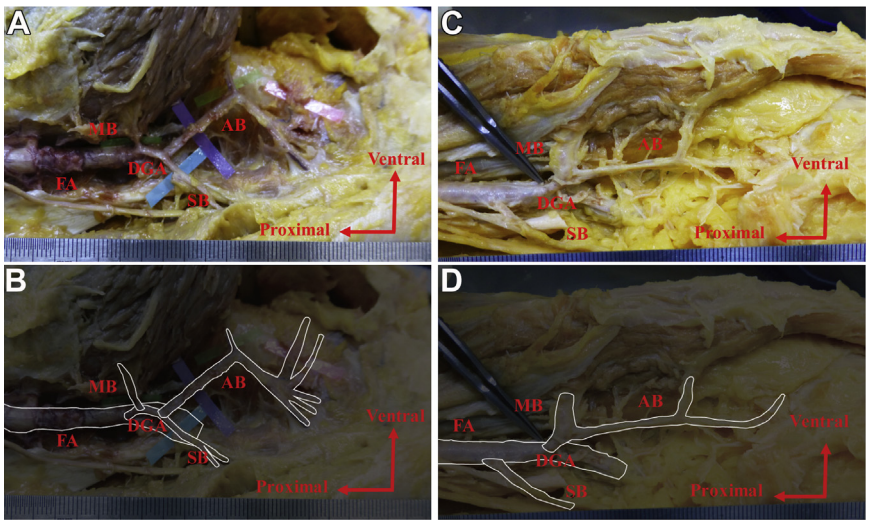

Fig. 1. Classification of branching patterns of the DGA. Type 1: common trunk type (A) and the schema (B). Type 2B: isolated saphenous branch type (C) and the schema (D). The tip of the forceps is pointing to the origin of the DGA. AB, articular branch; DGA, descending genicular artery; FA, femoral artery; MB, muscular branch; SB, saphenous branch.