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Rationalizing the Vascular Anatomy for Oblique Osteotomy of the Metatarsal Head during Toe/Joint Transfers of the Metatarsophalangeal Joint

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Background: The metatarsophalangeal joint (MTPJ) of the lessor toe has been used to reconstruct the metacarpophalangeal joint. When an oblique osteotomy of the metatarsal head is performed, the orientation of the vascular pedicle is crucial to preserve the blood supply to the MTPJ. This study was conducted to identify the path of the nutrient artery to the MTPJ.
Methods: We reviewed our operative records in consecutive series of 45 patients during toe or joint harvest. Retrograde dissection of the vascular pedicle was performed starting from the distal communicating artery at the first webspace toward the first dorsal metatarsal and first plantar metatarsal arteries. All the vessels related to the MTPJ were explored and ligated if the MTPJ was not included in the flap.
Results: The condylar branches to the proximal phalanx and the metaphyseal branches to the second metatarsus were barely identifiable during the dissections. The articular branch running perpendicularly from the plantar artery toward the plantar surface of MTPJ was verified in all cases. The articular branches originated either from the first plantar metatarsal artery (92.1%) or from the tibial plantar digital artery (7.9%). The external diameter of the articular branches was around 0.5–1 mm. When the articular branch was included and preserved, the metatarsal heads oozed immediately after the flap was reperfused.
Conclusions: The study demonstrated the constant and sizable articular branch of the MTPJ that originates from the plantar artery system. The consistency of the vascular anatomy enables oblique osteotomies of the metatarsal head to be performed without fear of injury to the pedicle. *(Plast Reconstr Surg Glob Open 2018;6:e1805; doi: 10.1097/GOX.0000000000001805; Published online 3 October 2018.)*

INTRODUCTION

Transfer of the vascularized metatarsophalangeal joint (MTPJ) is not as common as proximal interphalangeal toe joint transfers because of its limited indication. MTPJ transfers are indicated in metacarpophalangeal joint (MCPJ) reconstruction mainly. To transfer the MTPJ of a toe to the hand, differences in arc of motion between the MTPJ and the MCPJ are usually corrected. The MTPJ tends to be hyperextended, while the MCPJ requires flexion for function. Two techniques have been described in transferring the MTPJ for the MCPJ reconstruction. One method is the turning over of the MTPJ along its longitudinal axis during the inset.[1–4] The other method involves performing an oblique osteotomy at the metatarsal head to neutralize the hyperextension of the MTPJ after the transfer.[5] Additionally, when MTPJ is included during lessor toe transfers, an oblique osteotomy of the metatarsal head is recommended.

Even though the procedure has been applied for several decades, the vascular anatomy of the MTPJ transfer is still not clear. During the MTPJ harvest, the flap is based on either the first dorsal metatarsal artery (FDMA) or the first plantar metatarsal artery (FPMA). Anatomically, the FDMA and FPMA connect to each other at the distal communicating artery, which is adjacent to the MTPJ. The ori-

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entation of the articular branches to the MTPJ becomes very critical, especially when an oblique osteotomy at the metatarsal head is performed. There is a paucity of literatures regarding the vascular anatomy related to the MTPJ. In 1984, Kuo et al.[1] described 3 patterns of nutrition vessels that supplies the MTP joint. Nonetheless, there were different reports from China regarding the typical number and diameter of the condylar, articular, and metaphyseal branches that nourish the MTPJ.[6–9] They describe the condylar branches being distributed usually between 5 and 12 mm proximal to the MTPJ, and the metaphyseal branches located around 5 mm distal to the joint (Fig. 1). According to these articles, the orientation of the nourishing vessels is not predictable. Hence, performing an oblique osteotomy of the metatarsal head could endanger the blood supply of the MTPJ.

To avoid devascularization of the MTPJ, it is imperative to clarify the vascular pedicle of the MTPJ. The second MTPJ is the most common joint transferred for MCPJ reconstruction. Instead of identifying the vessels around the MTPJs, this study attempts to report the crucial vessels that could be preserved when performing the oblique osteotomy of the metatarsal head for the toe/joint transfers including the MTP joint.

Fig. 1. Intraoperative photograph during vascularized PIP joint transfer demonstrating nutrient artery to the second toe metatarsal joint (Red marker) is arborized from the FPMA.

MATERIALS AND METHODS

When performing toe or the joint transfers in the clinical practices, the arterial pedicle usually has to be dissected from the toe to the FDMA and FPMA. When harvesting second toes and vascularized joints, a retrograde dissection of the vascular pedicle was performed starting from the distal communicating artery at the first webspace toward the FPMA and the FDMA. All the vessels related to the MTPJ were explored and ligated if the MTPJ was not included in the flap (**see** video, Supplemental Digital Content 1, which displays the video demonstrating the articular branch during a dissection for the PIP joint transfer, ***http://links.lww.com/PRSGO/A831***). The orientation of the vascular branches around the MTPJ were observed. Operation records were reviewed retrospectively in 16 second toes, 25 proximal interphalangeal toe joint, and 4 MTPJ transfers all performed by the senior author. There were 34 males and 4 females. The average age was 32 years. None of the patients had a history of trauma to the second toe.

RESULTS

The condylar branches to the proximal phalanx and the metaphyseal branches to the second metatarsus were barely identifiable during the dissections. The articular branch running perpendicularly from the plantar artery toward the plantar surface of MTPJ was verified in all cases. The articular branches originated either from the FPMA (92.1%, before the distal communicating branch between the FDMA and FPMA; Fig. 1) or from the tibial plantar digital artery (7.9%, after the distal communicating branch; Fig. 2). The external diameter of the articular branches was around 0.5–1 mm. When the oblique osteotomy of the metatarsal head was performed, the articular branch could be retracted and protected from injury. With inclusion of this articular branch, oozing from the obliquely osteotomized surface of the metatarsal head could be observed immediately with reperfusion of the flap in 1 toe transferred at the MTPJ level (Fig. 3). All the toes and joints were transferred without complications,

Video Graphic 1. See video, Supplemental Digital Content 1, which displays the video demonstrating the articular branch during a dissection for the PIP joint transfer, ***http://links.lww.com/PRSGO/A831***.

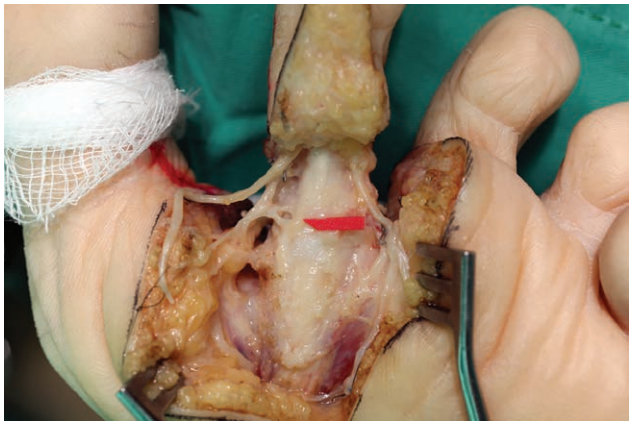

Fig. 2. Intraoperative photograph during a second toe transfer demonstrating nutrient artery to the second toe metatarsal joint (Red marker) is arborized from the plantar digital artery.

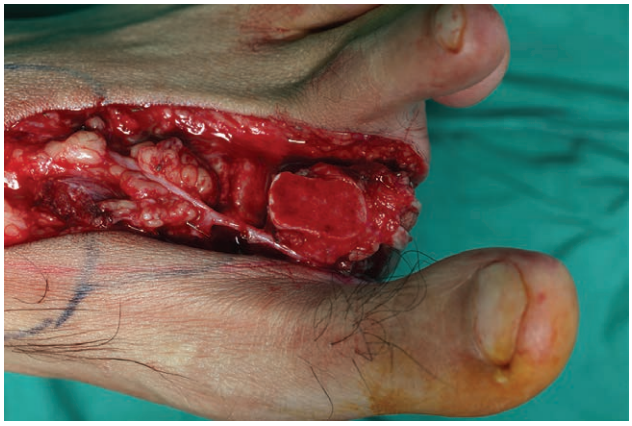

Fig. 3. Intraoperative photograph during a toe transfer including the MTP joint demonstrating nutrient artery to the second toe metatarsal joint (Red marker).

and adequate function was restored during the follow-up period.

DISCUSSION

Although the concept of oblique osteotomy has been described to correct the hyperextension of the MTPJ, only a very limited number of cases have been reported in English literature. Several authors from China have reported their series of MTPJ transfers using rotational osteotomy techniques in the Chinese literature. In 2004, Fang et al.[11] obliquely resected the plantar surface of the metatarsal head, rotated the head 90°, and osteosynthesized the resected surface to the metacarpal neck. Eight MTPJs were transferred, and 45–70° (average 66°) of motion was observed. Intracapsular wedge osteotomy of the metatarsal head was published as a technique from a group in China.[12,13] They reported that an average of 65° of active motion was obtained in their series. Nonetheless, performing an osteotomy greater than 5–12 mm proximal to the MTPJ was suggested to prevent injury of the vascular pedicle.[8,13]

When performing an oblique osteotomy of the metatarsal head, the plane of osteotomy has to be within 1 cm

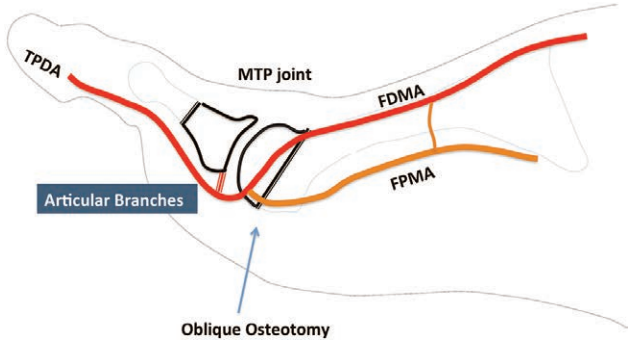

Fig. 4. Schematic diagram of oblique osteotomy of the metatarsal head demonstrates the relationship of articular branch to the osteotomized site.

from the articular surface (Fig. 4). If the osteotomy is too proximal to make the metatarsal too long, the MTPJ will protrude into the palm after inset. This would in turn have a knock-on effect on the flexor and extensor tendons, which would have distorted dynamics. The protruding metatarsal head would be a point of tenderness of which patients often complain of postoperatively. However, when the oblique osteotomy is performed within 1 cm from the articular surface, the condylar branches would be endangered and may be compromised, leading to an avascular joint. Furthermore, the condylar branches could not be identified during our clinical dissections. The blood supply to the metatarsal head might then be compromised with this approach.

Up to now, not as many studies were reported to describe the vascular anatomy in English literature. Kuo et al.[1] reported their observation of the articular branch nourishing the MTPJ in 1984. However, their results were not consistent with the findings stated by other articles reported from China.[6–9] The information presented in the literatures is thus confusing, and clarification of the vascular anatomy is needed to safely transfer the MTPJ, especially when an oblique osteotomy of the metatarsal head is indicated. This retrospective series is thus important from a surgical technique point of view.

From our intraoperative observations, constant articular branches running perpendicularly from either the FPMA or the tibial plantar digital artery toward the plantar surface of the MTPJ could be identified. The location and the diameter of these branches were constant and sizable, which were unlike the condylar branches to the proximal phalanx or the metaphyseal branches to the metatarsus. The metatarsal head with oblique osteotomy could be reperfused well with inclusion of the articular branches in 1 case. During the oblique osteotomy of the metatarsal head, the articular branches could be retracted and protected.

There are some limitations of this study. Although the articular branches from the plantar artery system could be well recognized in our dissections, we could not confirm that they are the only vessels that supply the MTPJ. Direct correlation between the inclusion of these branches and the functional outcomes could not be determined from our limited clinical experience. Nonetheless, by know-

ing the orientation of these articular braches, the MTPJ can be transferred with more confidence and certainty as demonstrated in our series.

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