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Direction and location of the nutrient artery to the fifth metatarsal at risk in osteotomy for bunionette

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ABSTRACT

Background: The aims of this study were to identify the artery feeding the fifth metatarsal and determine how bunionette osteotomy could injure this vessel.
Methods: The nutrient artery entering the fifth metatarsal was investigated in 10 adult cadaveric lower limbs by barium injection and enhanced computed tomography.
Results: The nutrient artery entered the medial aspect of the fifth metatarsal around the junction of the middle and proximal thirds obliquely from a distal direction (mean angle 36°) in the coronal plane in all cases; in the axial plane, the point of entry and direction of the artery was medial-plantar (mean angle 49°).
Conclusions: This report revealed direction and location of the nutrient artery entering the fifth metatarsal.

1. Introduction

Bunionette, also known as “tailor’s bunion”, is characterized by lateral prominence of the fifth metatarsal head with associated varus of the metatarsophalangeal joint [1]. The symptoms are mechanically induced and often associated with hyperkeratotic lesions and adventitious bursae [2]. If nonoperative treatments fail, surgical treatments are considered, including lateral condylectomy of the fifth metatarsal head [3], fifth metatarsal distal metaphyseal osteotomy [4–6], fifth metatarsal diaphyseal osteotomy [7–11], and fifth metatarsal proximal osteotomy [12–16]. Proximal osteotomies provide good correction for severe deformity, but the possibility of complications such as damage to the vascular supply to the fifth metatarsal has been reported [14,15].

These complications, which include nonunion and delayed union of the fifth metatarsal, may be related to disruption of the nutrient artery supplying the fifth metatarsal and have prompted recommendations to restrict use of proximal metatarsal osteotomy. There was the report that described delayed union in 3 of 10 patients who underwent proximal dome osteotomy to the proximal third of the diaphysis [16]. Non-union and delayed union might be rare but cause serious problems when they occur.

The location of the artery feeding the first metatarsal has been described in a few reports [17–20]. However, there has been no study describing in detail the direction of the nutrient artery supplying the fifth metatarsal. The aims of this study were to assess the direction and location of the nutrient artery supplying the fifth metatarsal in fresh cadavers on coronal and axial enhanced computed tomography (CT) and to identify factors that could help to prevent injury to this artery during osteotomy for bunionette.

2. Materials and methods

This study was approved by the research board at our institution and included 10 feet of 10 fresh cadavers (7 male, 3 female; mean age 76 years at the time of death). Cadavers with a history or signs of previous ankle trauma or surgery, congenital or developmental deformity, or inflammatory arthritis were excluded after checking their clinical records and CT images. The left fifth metatarsal of one specimen was dissected for anatomical observation.

The vessels were flushed with warm normal saline solution through a plastic catheter placed in the external iliac artery, and barium sulfate suspension (Barytester®, Fushimi Pharmaceutical Co., Inc., Marugame, Japan) was injected into the external iliac artery with firm manual pressure, as in our previous report [21].

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Multi-slice CT images (Somatom Emotion 16, Siemens Healthcare, Erlangen, Germany) of the lower extremities were obtained in 1.0-mm-thick axial slices. Coronal and axial images were reviewed at bone window setting (window, 2200; level, 200).

We confirmed the continuity of the nutrient artery after it entered the fifth metatarsal and that it ran distally and proximally within the medullary canal (Fig. 1A–D). As Table 1 showed, the following parameters were measured: (1) the distance from the distal epiphysis to the point of entry of the nutrient artery into the fifth metatarsal in the coronal plane (Fig. 2A); (2) the distance from the lateral proximal epiphysis to the point of entry of the nutrient artery in the coronal plane (Fig. 2A); (3) the distance from the medial proximal epiphysis to the point of entry of the nutrient artery in the coronal plane (Fig. 2A); (4) the angle between the distal longitudinal axis of the fifth metatarsal and the nutrient artery at the point of entry in the coronal plane (Fig. 2A); (5) the distance from the dorsal tangential plane parallel to a line between the most plantar point of the first metatarsal (Point A) and fifth metatarsal (Point B) to the point of entry of the nutrient artery in the axial plane (Fig. 2B); (6) the distance from a line between the most plantar point of the first metatarsal (Point A) and fifth metatarsal (Point B) to the point of entry of the nutrient artery in the axial plane (Fig. 2B); (7) the distance from the lateral tangential plane vertical to a line between the most plantar point of the first metatarsal (Point A) and fifth metatarsal (Point B) to the point of entry of the nutrient artery in the axial plane (Fig. 2B); (8) the distance from the medial tangential plane vertical to a line between the most plantar point of the first metatarsal (Point A) and fifth metatarsal (Point B) to the point of entry of the nutrient artery in the axial plane (Fig. 2B); and (9) the angle between a line parallel to a line between the most plantar point of the first metatarsal (Point A) and fifth metatarsal (Point B) and the nutrient artery at the point of entry into the fifth metatarsal in the axial plane (Fig. 2C). For parameter (4), smaller degrees mean a more distal point of insertion into the fifth metatarsal. For parameter (9), smaller degrees mean a more medial point of insertion.

Measurements were made in triplicate by two orthopedic surgeons, and average values were calculated.

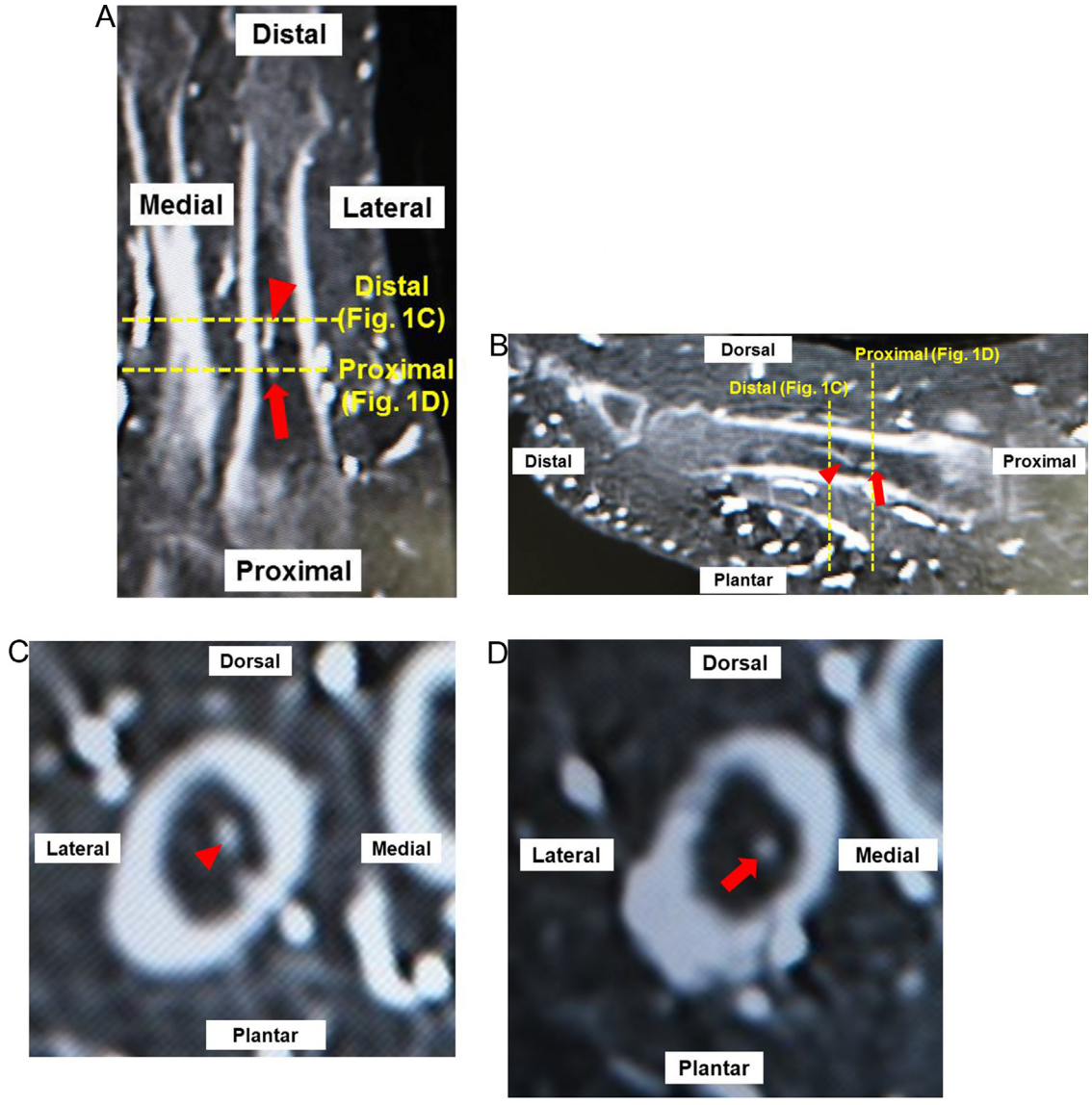

Fig. 1. Computed tomographic images injected with barium sulfate suspension showing continuity of the nutrient artery after entering the fifth metatarsal and running within the medullary canal proximally and distally in the coronal (A) and sagittal (B) planes. The section (C) in is the distal section in (A) and (B). The section (D) in is the proximal section in (A) and (B). The nutrient artery is running within the medullary canal distally (C) and proximally (D) in the axial plane. Red arrow heads show the distal branch, and red arrows show the proximal branch of the nutrient artery in the fifth metatarsal. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 1
Parameters of measurements of the entry point and direction of the fifth nutrient artery in CT images.

CT coronal plane	(1) Distance from the distal epiphysis to the point of entry of the nutrient artery into the fifth metatarsal (2) Distance from the lateral proximal epiphysis to the point of entry of the nutrient artery (3) Distance from the medial proximal epiphysis to the point of entry of the nutrient artery (4) Angle between the distal longitudinal axis of the fifth metatarsal and the nutrient artery at the point of entry
CT axial plane	(5) Distance from the dorsal tangential plane to the point of entry of the nutrient artery into the fifth metatarsal (6) Distance from the plantar plane to the point of entry of the nutrient artery into the fifth metatarsal (7) Distance from the lateral tangential plane to the point of entry of the nutrient artery (8) Distance from the medial tangential plane to the point of entry of the nutrient artery (9) Angle between the plantar plane and the nutrient artery at the point of entry

CT, computed tomography.

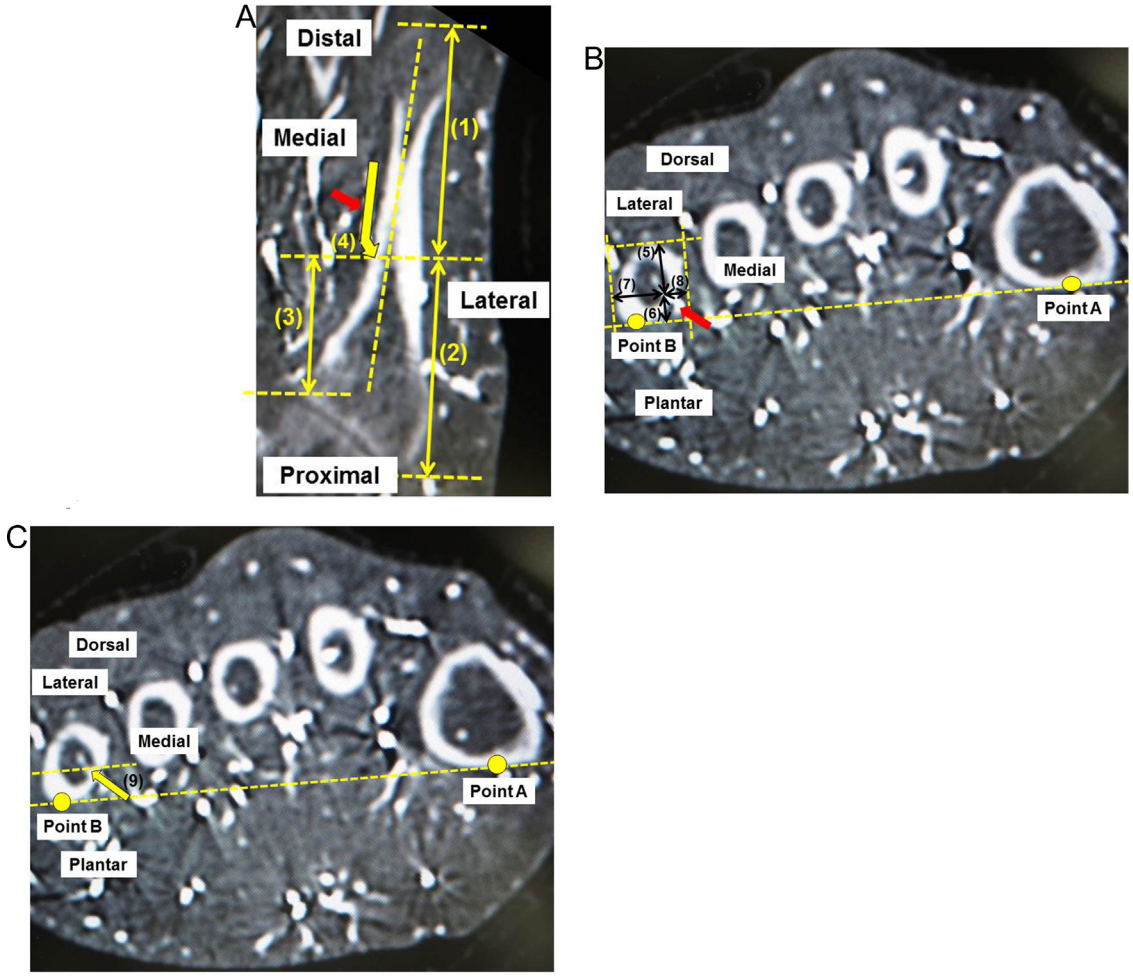

Fig. 2. Computed tomographic images injected with barium sulfate suspension showing each parameter for the nutrient artery entering the fifth metatarsal. (A) (1) The distance from the distal epiphysis to the point of entry of the nutrient artery into the fifth metatarsal, (2) the distance from the lateral proximal epiphysis to the point of entry of the nutrient artery, and (3) the distance from the medial proximal epiphysis to the point of entry of the nutrient artery in the coronal plane. Also shown in (A) is (4) the angle between the distal longitudinal axis of the fifth metatarsal and the nutrient artery at the point of entry in the coronal plane. The red arrow shows the nutrient artery. (B) (5) The distance from the dorsal tangential plane to the point of entry of the nutrient artery into the fifth metatarsal and (6) the distance from the plantar plane to the point of entry of the nutrient artery into the fifth metatarsal, (7) the distance from the lateral tangential plane to the point of entry of the nutrient artery, and (8) the distance from the medial tangential plane to the point of entry of the nutrient artery in the axial plane. The red arrow shows the nutrient artery. (C) (9) The angle between the plantar plane and the nutrient artery at the point of entry in the axial plane. The dorsal tangential plane at the level of the fifth metatarsal dorsal cortex is parallel to a line between the most plantar point of the first metatarsal (Point A) and fifth metatarsal (Point B) in the axial plane. The plantar plane means a line between the most plantar point of the first metatarsal (Point A) and fifth metatarsal (Point B) in the axial plane. The lateral tangential plane at the level of the fifth metatarsal lateral cortex is vertical to a line between the most plantar point of the first metatarsal (Point A) and fifth metatarsal (Point B) in the axial plane. The medial tangential plane at the level of the fifth metatarsal medial cortex is vertical to a line between the most plantar point of the first metatarsal (Point A) and fifth metatarsal (Point B) in the axial plane. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

3. Results

The nutrient artery was found to arise from the fourth plantar metatarsal artery in all feet, similar to the description in previous report [20]. A summary of the results is shown in Table 2.

The mean distance from the distal epiphysis to the point of entry of the nutrient artery to the fifth metatarsal in the coronal plane was 42 ± 4 (range 35–49) mm. The mean distance from the lateral or medial proximal epiphysis to the entry point of the nutrient artery in the coronal plane was 23 ± 4 (range 14–30) mm

Table 2
Results of measurements of the entry point and direction of the fifth nutrient artery obtained in each cadaveric specimen.

Specimen	Sex, age (y) and side of individual at death	Coronal plane				Axial plane				
		Distance from entry point of nutrient artery to (mm)				Distance from entry point of nutrient artery to (mm)				
		(1) distal epiphysis	(2) lateral proximal epiphysis	(3) medial proximal epiphysis	(4) Angle between distal longitudinal axis of metatarsal and nutrient artery at entry point (°)	(5) dorsal plane	(6) plantar plane	(7) lateral plane	(8) medial plane	(9) Angle between plantar plane and nutrient artery at entry point (°)
1	Female, 48, Left	49	18	11	70	13	0	8	7	79
2	Male, 70, Right	41	25	18	36	14	0	11	4	49
3	Female, 70, Left	35	24	20	57	7	5	11	1	16
4	Male, 96, Right	44	25	16	8	8	5	12	5	48
5	Female, 69, Right	36	30	22	5	9	3	8	2	79
6	Male, 70, Right	44	26	14	72	11	0	8	5	57
7	Female, 95, Left	43	20	13	20	13	0	10	4	46
8	Male, 78, Left	38	28	18	41	9	2	8	2	15
9	Male, 90, Right	49	14	8	39	10	1	8	3	56
10	Male, 77, Left	42	20	12	12	6	5	9	4	48
Mean ± SD	76 ± 13	42 ± 4	23 ± 4	15 ± 4	36 ± 23	10 ± 2	2 ± 2	9 ± 1	4 ± 1	49 ± 20

SD, standard deviation.

or 15 ± 4 (range 8–22) mm. The mean angle between the distal longitudinal axis of the fifth metatarsal and the nutrient artery at the point of entry in the coronal plane was 36° ± 24° (range 5°–72°). In all feet, the nutrient artery entered the fifth metatarsal around the junction of the middle and proximal thirds and entered the medial aspect of the fifth metatarsal distally (Fig. 3A).

The mean distance from the dorsal plane of the fifth metatarsal to the point of entry of the nutrient artery in the axial plane was

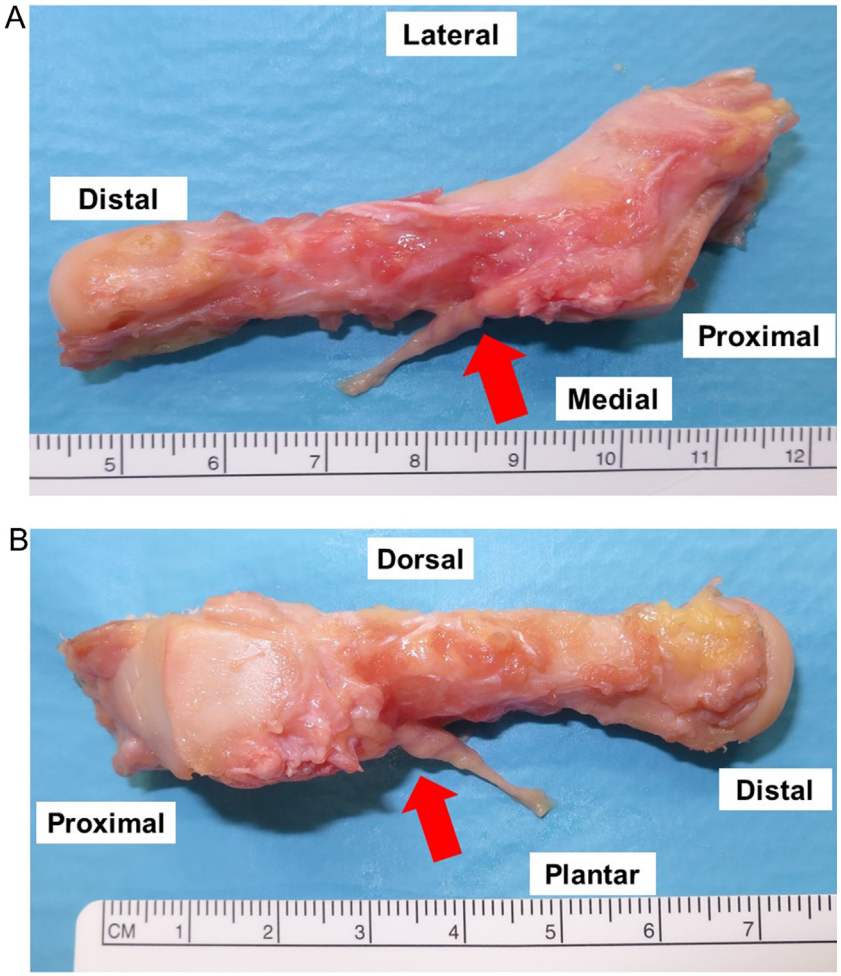

Fig. 3. Plantar (A) and lateral (B) sides of the left fifth metatarsal showing the nutrient artery entering the fifth metatarsal. Red arrows show the nutrient srtery. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

10 ± 2 (range 6–14) mm and the mean distance from the plantar plane of the fifth metatarsal to the point of entry of the nutrient artery in the axial plane was 2 ± 2 (range 0–5) mm. The mean distance from the lateral plane of the fifth metatarsal to the point of entry of the nutrient artery in the axial plane was 9 ± 1 (range 8–12) mm and the mean distance from the medial plane of the fifth metatarsal to the point of entry of the nutrient artery in the axial plane was 4 ± 1 (range 1–7) mm. The mean angle between the plantar plane of the fifth metatarsal and the nutrient artery at its point of entry in the axial plane was 49° ± 20° (range 15°–79°). In all cases, the nutrient artery entered the fifth metatarsal in a medial-plantar direction (Fig. 3B).

4. Discussion

In this study, the nutrient artery was observed to enter the fifth metatarsal around the junction of the middle and proximal thirds of the diaphysis in all cases ion the coronal plane, similar to findings reported previously [17–20]. In our study, the mean distance from the medial-proximal epiphysis to the point of entry of the nutrient artery to the fifth metatarsal was 15 (range 8–22) mm, whereas there was the report that the foramen of the nutrient artery was on average 26 (range 19–40) mm from the medial aspect of the base of the fifth metatarsal [20]. This discrepancy might reflect ethnic differences in foot and ankle anatomy.

The nutrient artery also entered the fifth metatarsal obliquely in a medial-distal direction in all cases, similar to the findings of some authors [18,20]. The mean angle between the distal longitudinal axis of the fifth metatarsal and the nutrient artery at the point of entry into the fifth metatarsal was 36° in the coronal plane and the mean angle between the plantar plane of the fifth metatarsal and the point of entry of the nutrient artery was 49° in the axial plane. This report on the use of enhanced CT in fresh cadavers revealed the direction of entry of the nutrient artery to the fifth metatarsal in the coronal and axial planes.

Our findings appear to support those of previous report [20] in that proximal osteotomies of the fifth metatarsal for bunionette, such as dome-shaped osteotomy [16] and chevron osteotomy [14,15] may have the disadvantage of a high risk of nonunion or delayed union. Moreover, the nutrient artery might be easily injured by overpenetration of the saw blade during diaphyseal osteotomy beyond the medial cortex of the fifth metatarsal if this artery enters the fifth metatarsal from the distal direction at a sharp angle. Further, a proximal osteotomy line on the more proximal-plantar side could disrupt the nutrient artery in long diaphyseal osteotomies, such as Coughlin's osteotomy [7–9] and scarf osteotomy [10,11], leading to delayed consolidation of the osteotomy and nonunion.

This study had several limitations, in particular the small number of specimens used, which is inevitable because of the restricted availability of fresh-frozen cadavers in Japan. Another limitation is that the intraosseous blood supply provided by the periosteal plexus and metaphyseal and epiphyseal vessels was not assessed, given that these arteries also supply blood to the fifth metatarsal.

5. Conclusions

In conclusion, this is the report showing that the point of entry of the nutrient artery supplying the fifth metatarsal enters around the junction of the middle and proximal thirds of the medial aspect of the fifth metatarsal. The nutrient artery enters the fifth metatarsal in a distal direction in the coronal plane and in a medial-plantar direction in the axial plane. The direction and location of the nutrient artery supplying the fifth metatarsal is important when performing an osteotomy for bunionette, because a proximal osteotomy may interrupt blood flow in the nutrient artery.

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Conflicts of interest

None.

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