A cadaveric study showing the anatomical variations in the branches of the dorsalis pedis artery at the level of the ankle joint and its clinical implication in ankle arthroscopy

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ABSTRACT

INTRODUCTION Pseudoaneurysm formation following ankle arthroscopy is a rare but potentially catastrophic complication. The placement of anterior ankle portals carries inherent risk to the superficial and deep peroneal nerves, as well as to the dorsalis pedis artery. Anatomical variations in the dorsalis pedis and the presence of branches at the joint line may increase the risk of vascular injury and pseudoaneurysm formation during arthroscopy. There is limited anatomical evidence available regarding the branches of the dorsalis pedis artery, which occur at the point at which they cross the ankle joint.

OBJECTIVES The objective of the study was to describe the frequency and direction of branches of the dorsalis pedis crossing the ankle joint.

MATERIALS AND METHODS Nineteen cadaveric feet were carefully dissected to explore the course of the dorsalis pedis artery, noting in particular the branching pattern at the joint line.

RESULTS Eleven of the nineteen feet had a branch of the dorsalis pedis artery that crossed the level of the ankle joint. Out of these, six were lateral, four medial and one bilateral. Eight of the eleven specimens had one branch at, or just before, the level of the joint. Two specimens had two branches and one had three branches crossing the ankle, which were all in the same direction, crossing laterally to the main trunk of the dorsalis pedis.

CONCLUSIONS Our study demonstrated high rates of branching of the dorsalis pedis artery at the level of the ankle joint. The role of these branches in pseudoaneurysm formation during anterior hindfoot surgery remains unclear.

KEYWORDS

Dorsalis pedis – Cadaveric study – Anatomical variations – Ankle arthroscopy – Portal – Pseudoaneurysm

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Introduction

The dorsalis pedis artery has been found to have a variable origin, course and branching pattern.^{1,2} One study showed that there was an abnormal branching pattern in 16% of 50 dissected cadaveric specimens.² In the clinical setting, awareness of branching variation may help to reduce the risk of pseudoaneurysm formation during ankle arthroscopy.

A pseudoaneurysm is an arterial dilatation of greater than 50% of the vessel diameter where blood escapes the vessel but is contained by the surrounding connective tissue. This creates a mass that is both pulsatile and continuous with the vessel, differentiating it from a simple haematoma.⁵ Diagnosing a pseudoaneurysm is challenging, as clinical signs may be both subtle and delayed. The patient may present several weeks following surgery. The most common symptom reported in related case reports is disproportionate postoperative pain.^{4–8}

Using anterior arthroscopic portals carries an inherent risk to structures crossing the joint line longitudinally; in particular, the superficial peroneal nerve and dorsalis pedis artery. Fortunately, the incidence of pseudoaneurysm during ankle arthroscopy is only around 0.008%.⁵ One study reported a single vascular complication from 1,305 procedures.⁹ The aim of this cadaveric study was to identify the anatomical variation of the dorsalis pedis artery at the level of the ankle joint by describing the frequency and direction of branches crossing the ankle joint, which might be damaged by the placement of arthroscopic portals.

Materials and methods

Departmental approval was sought and received for the completion of this study. All dissection was carried out on formalin-preserved cadavers within an approved facility and

according to guidance laid out in the Human Tissue Authority Code of Practice.¹⁰ All images used in this study were taken with the consent of the individuals prior to death or of their relatives.

Marker probes were placed at the level of the ankle joint medially and laterally before commencing dissection. Cadaveric feet were then carefully dissected to expose the course of the dorsalis pedis artery and its branches (Fig 1). The branching pattern of the artery at the joint line was recorded. Each ankle was photographed to show the joint line and the dorsalis pedis artery. The presence of branches from the main arterial trunk at the level of the joint and the direction and number of branches was recorded.

Figure 1 A cadaveric foot dissection demonstrating the dorsalis pedis artery and two branches at the level of the ankle joint

Figure 2 Distribution of the branches of the dorsalis pedis artery at the level of the ankle joint

Results

The dorsalis pedis artery was identified in all specimens. The main finding of this study is the wide variation in the location of the dorsalis pedis artery branches crossing the ankle joint. Of the cadavers studied, 58% (11 of 19) showed a branch that crossed the ankle joint in addition to the main arterial trunk. Of these 11 cases, 6 had a branch that was lateral, 4 had a medial branch and one case had bilateral branches. The distribution of these branches is shown in Figure 2.

Discussion

About half of all aneurysms that occur around the foot and ankle do so at the dorsalis pedis artery.⁵ Unlike other studies, abnormal branching patterns of the dorsalis pedis artery at the level of the ankle joint occurred in the majority of patients in our study. The discrepancy between the high number of branches and the low incidence of pseudoaneurysm formation suggests there are other contributory factors.

We propose a clinical triad to explain how portal placement and surgical technique, abnormal branching and patient susceptibility can combine to result in the rare complication of a pseudoaneurysm (Fig 3). These factors should be individually addressed to reduce the chance of this complication following ankle arthroscopy.

The posteromedial and antero-central approaches for ankle arthroscopy have been particularly associated with neurovascular complications.^{11–15} One cadaveric study¹⁴ has demonstrated that the antero-central portal is relatively low risk for damaging the superficial peroneal nerve. However, in this study of 20 ankles, 90% of instruments in the antero-central portal touched the dorsalis pedis artery and in one case there was a laceration of the deep peroneal nerve.¹⁴ Another cadaveric study of 92 feet specimens classified the neurovascular bundle at the dorsum of the foot into four types.¹ The authors emphasised the importance of being aware of the anatomical variation of the trunk of the dorsalis pedis artery in relation to the deep peroneal nerve for portal placement but were unable to specifically recommend a safer portal.¹ The perceived increased risk of injury to the anterior tibial artery and deep peroneal nerve is supported by several reported cases of injury^{11,15} and, as such, the

Figure 3 Clinical triad of pseudoaneurysm formation during ankle arthroscopy

anterocentral portal remains less commonly used than the lateral portal.

As our study has demonstrated such variability in branches crossing the ankle joint, we cannot recommend a specific portal over the conventional anterolateral portal in preventing vascular damage.¹⁴ Dorsiflexion of the ankle during portal placement and the introduction of instruments may play a role in preventing damage to the dorsalis pedis.¹⁶ This relieves tension on vessel walls reducing the chance of injury. Indeed, blunt dissection during portal placement and care during anterior soft tissue resection seem particularly important factors in avoiding pseudoaneurysm formation regardless of anatomical variation.

Predisposing patient factors such as connective tissue disorders, immunosuppression, malnutrition and infection are linked to an increased likelihood of pseudoaneurysm due to a compromised vascular wall.¹⁷ Anticoagulation has also been associated with pseudoaneurysm formation.⁶

Studies by Vijayalakshmi et al. found that the dorsalis pedis artery ran a 'normal course' (definition set out by the paper itself) in only 56% of cases, with five other major variations in course.² Typically, it is found as a continuation of the anterior tibial artery but has been noted to arise from the peroneal artery.¹⁸ Only 16% showed more branches crossing the ankle joint.² The findings of our study are at odds with this, as we have demonstrated abnormal branching in the majority of specimens we examined.

Avoiding the main arterial trunk may be insufficient to prevent pseudoaneurysm formation if several branches also cross the ankle joint. There are no studies that have demonstrated the significance of these branches in pseudoaneurysm formation and further studies will determine whether these branches are important. Our study recommends consideration of the clinical triad of pseudoaneurysm formation (Fig 3) when planning surgery and the use of adjuncts such as ultrasound guidance in particularly high-risk patients such as those with collagen disorders.

Conclusion

Our study has demonstrated high rates of branching of the dorsalis pedis artery at the level of the ankle joint. To our knowledge, this has not been specifically investigated or

described in previous literature. The role of these branches in pseudoaneurysm formation during anterior hindfoot surgery remains unclear.

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