Do the Presence of Pathologic Changes and the Level of Operator Experience Alter the Rate of Intra-Articular Injection of the First Metatarsophalangeal Joint? 

A Cadaver Study

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Background: Injections, punctures, and aspirations of the first metatarsophalangeal joint are common interventions. Accurate intra-articular placement of the needle is a prerequisite for the achievement of desirable results and the avoidance of complications. We evaluated the rate of successful intra-articular injections and the influence of the degree of operator experience in achieving this success.

Methods: A total of 106 cadaveric metatarsophalangeal joints were injected with a methylene blue–containing solution and subsequently dissected to distinguish intra-articular from periarticular injections. To evaluate the importance of experience, 38 injections were performed by a student, 38 by a trained resident, and 30 by an experienced surgeon. In the second part of the study, we examined the relation of pathologic findings of the metatarsophalangeal joint and the accuracy of intra-articular injection.

Results: The overall rate of unintentional periarticular injections remained low (9.4%; 10 of 106 joints). The student achieved a successful intra-articular injection in 86.8% of joints (33 of 38), the resident in 92.1% (35 of 38), and the specialist in 93.3% (28 of 30). The number of extra-articular injections increased significantly with the presence of deformity (hallux valgus) and arthritis of the first metatarsophalangeal joint.

Conclusions: The presence of pathologic changes reduces the rate of successful intra-articular joint puncture. However, the overall frequency of successful intra-articular injections can be improved through experience and the use of imaging. (J Am Podiatr Med Assoc 103(3): 000-000, 2013)

Injections and aspirations of the first metatarsophalangeal joint are common interventions for diagnosis and therapeutic intervention in patients with acute injuries or chronic conditions affecting their metatarsophalangeal joint.1-5 The aspiration of an effusion or hemarthrosis aids in the confirmation of a diagnosis, and the injection of therapeutic agents, such as corticosteroids, hyaluronic acids, and local anaesthetic agents, forms part of the treatment of these patients. Several complications due to unintentional periarticular placements of injections have been described.6-11 Accurate placement of intra-articular injection avoids complications and improves the therapeutic value of the intervention.12 The aims of this study were 1) to estimate the frequency of successful intra-articular injections into the first metatarsophalangeal joint without the aid of imaging and 2) to investigate the influence of operator experience and pathologic changes in the first metatarsophalangeal joint on success using a cadaver model.
Materials and Methods

This study was in two main parts. We first compared the rate of successful joint puncture and its relation to operator experience. For this part, joints with signs of pathologic abnormality were excluded, and the rate of successful joint puncture of the student was compared with that of the resident. In the second part of the study, we observed how the presence of pathologic abnormalities and deformities of the metatarsophalangeal joint influenced the rate of success of intra-articular puncture by an experienced surgeon.

This study used 106 first metatarsophalangeal joints from 53 cadavers (28 men and 25 women) with a mean age of 74.8 years (range, 59–98 years) preserved by the method of Thiel.13 This special embalming technique, which was developed over a 30-year period, provides a close-to-life model through the preservation of the original tissue color, consistency, and degree of transparency and full range of passive motion of the articular joints. Pathologic skeletal changes were detected by plain radiographs and recorded. A medical student (S.F.), a resident (N.H.), and a skilled specialist (T.K.) performed the injections. The student and resident punctured 38 metatarsophalangeal joints each (19 left and 19 right), and the surgeon punctured 30 (15 left and 15 right). The injections were performed with the cadavers in a supine position. The joint line was located by flexion and extension of the great toe. Gentle distal traction allowed better visualization of the joint line. The intra-articular puncture was then performed with a 14-gauge needle connected to a 1-mL syringe and filled with methylene blue. The needle was angled 60° to 70° to the plane of the foot and pointed distally to match the slope of the joint. Approximately 0.2 mL of methylene blue dye was injected into each joint. An arthrotomy was performed in all of the joints to define the location of the injected methylene blue (Fig. 1). The injection was deemed to be a failure if the dye was located outside of the synovial joint.

All of the results were entered into a computerized database and analyzed using Microsoft Excel 2003 (Microsoft Corp, Redmond, Washington). The \( \chi^2 \) test was used to assess correlations. All \( P \) values less than 0.05 and \( \chi^2 \) values greater than 3.84 were deemed statistically significant.

Results

Overall, 90.6% (95% confidence interval [CI], 85.0%–96.2%) of the injections (96 of 106) were within the joint (Table 1). The resident’s rate of intended intra-articular injections was 92.1% (95% CI, 83.5%–100.7% ; 35 of 38), and the student was successful in 86.8% (95% CI, 75.8%–97.8%; 33 of 38). No significant correlation between experience and the rate of successful punctures was detected (\( P = .45, \chi^2 = 0.56 \)). The specialist had a success rate of 93.3% (95% CI, 84.2%–102.4%; 28 of 30).

We found that 40.0% (95% CI, 22.5%–57.5%) of the joints (12 of 30) that the specialist injected had evidence of pathologic changes (Table 2). Arthritic changes were present in 10.0% (95 CI, 0%–20.7%) of the joints (3 of 30), hallux valgus in 20.0% (95% CI, 5.7%–34.3%; 6 of 30), and brachymetatarsia in 3.3% (95% CI, 0%–9.7%; 1 of 30). The presence of pathologic abnormality alters the success rate substantially. The combination of arthritis and hallux valgus occurred in 6.6% (95% CI, 0%–15.5%) of the joints (2 of 30), and the injections in both of these cases were extra-articular.

Discussion

Accurate intra-articular placement of the needle is a prerequisite for the achievement of desirable results and the avoidance of complication. In this study, we evaluated the rate of successful intra-articular injections and the influence of the degree of operator experience in achieving this success. Although such data are available for other synovial joints, such as the ankle,14 acromioclavicular,15 and sternoclavicular16 joints, this is the first study, to our knowledge, investigating the rate of successful joint puncture of the first metatarsophalangeal joint using an objective method in a cadaver model. These results are in accordance with those of other
authors with a high rate of success in intra-articular punctures (97%), confirming this by visual analog scale for pain, edema, and morning stiffness.\(^1\) The rate of successful joint puncture is high in the first metatarsophalangeal joint, even in relatively inexperienced hands, as evidenced by the present results. Although we did not demonstrate a statistically significant correlation between expertise and successful joint puncture, there is certainly a trend toward this. In the second part of the study, pathologic changes akin to those seen in a conventional clinical setting were investigated in relation to a successful joint puncture. The presence of pathologic changes made for a more difficult procedure, as demonstrated by the increased rate of periarticular injections. This finding is of considerable importance because it is patients with pathologic changes who are offered these injections. Of the six joints in this study that had combined hallux valgus and arthritis, two were not successfully punctured. Note that in a study by Solan et al\(^1\) it was these arthritic and deformed joints that had the least benefit from intra-articular injections. It is of questionable wisdom to offer these patients an injection in light of this evidence. Intra-articular punctures are associated with the risk of complications. The unintended introduction of microorganisms into the joint can cause disabling infections; therefore, great care must be taken to ensure a sterile procedure.\(^6\) Other complications include possible adverse effects of local corticosteroid injection, such as tendon rupture, increased ligament stiffness, skin depigmentation, and periarticular soft-tissue calcification.\(^7\)\(^–\)\(^10\) Intra-articular corticosteroid injection is a common therapeutic intervention, and its benefits are well documented. In this study, punctures were not image guided, as in routine clinical practice.

In the clinical setting, joint injections and aspirations are performed in patients with pathologic changes in their joints. It is well known that this makes periarticular injections more likely. In such cases, aspiration of synovial fluid is a clear indicator of correct needle placement, but this is not possible in “dry” joints. In these cases, insufflation of the joint with physiologic saline and subsequent aspiration may confirm needle placement. This method, however, is not foolproof. The position of the needle can also be confirmed with fluoroscopy, but this requires the injection of contrast media and the use of ionizing radiation.\(^1\) An alternative is the use of ultrasound with air as contrast medium to allow real-time visualization of intra-articular placement of the needle.\(^17\) A study by Reach et al\(^18\) demonstrated 100% accuracy of intra-articular injection using ultrasound guidance; this avoids the use of ionizing radiation but is technically demanding, especially in smaller joints. In the metatarsophalangeal joint, the joint space is rather superficial and can be easily identified by gentle traction of the toe.

To our knowledge, this is the first study to explore nonguided intra-articular needle placement of the first metatarsophalangeal joint in an objective manner by using a cadaver model. Even inexperienced physicians have a high frequency of success. However, accurate needle placement in joints with high-graded pathologic findings, such as hallux valgus combined with arthritis, seems difficult, and the therapeutic benefit has to be questioned.

**Financial Disclosure:** None reported.

**Conflict of Interest:** None reported.

**References**

4. **SOLAN MC, CALDER JD, BENDALL SP:** Manipulation and

### Table 1. Comparison of the Success of Different Investigators

<table>
<thead>
<tr>
<th>Investigator</th>
<th>Successful Joint Punctures (% [No./Total No.])</th>
<th>95% Confidence Interval (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>90.6 (96/106)</td>
<td>85.0–96.2</td>
</tr>
<tr>
<td>Student</td>
<td>86.8 (33/38)</td>
<td>75.8–97.8</td>
</tr>
<tr>
<td>Resident</td>
<td>92.1 (35/38)</td>
<td>83.5–100.7</td>
</tr>
<tr>
<td>Surgeon</td>
<td>93.3 (28/30)</td>
<td>84.2–102.4</td>
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</tbody>
</table>

### Table 2. Frequency of Pathologic Findings in 30 Metatarsophalangeal Joints

<table>
<thead>
<tr>
<th>Pathologic finding</th>
<th>Frequency (% [No.])</th>
<th>95% Confidence Interval (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>40.0 (12)</td>
<td>22.5–57.5</td>
</tr>
<tr>
<td>Hallux valgus</td>
<td>20.0 (6)</td>
<td>5.7–34.3</td>
</tr>
<tr>
<td>Arthritis</td>
<td>10.0 (3)</td>
<td>0–20.7</td>
</tr>
<tr>
<td>Arthritis + hallux valgus</td>
<td>6.6 (2)</td>
<td>0–15.5</td>
</tr>
<tr>
<td>Brachymetatarsia</td>
<td>3.3 (1)</td>
<td>0–9.7</td>
</tr>
</tbody>
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Queries for apms-103-03-07

1. This paragraph was moved from a later part of the paper. Placement OK?