**Hit and miss: The accuracy of intra-articular injections of the first metatarsophalangeal joint**

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**Introduction:** Therapeutic injections provide a treatment option for patients with joint and periarticular pain, those who are not surgical candidates, whom conservative treatment has failed, or those that are awaiting surgery. Injectable glucocorticoids are one of the most common therapeutic interventions in musculoskeletal healthcare and are widely used in pathologies of the first metatarsophalangeal joint. The aim of this paper is to highlight current concepts around first metatarsophalangeal joint injection injection accuracy.

**Anatomy:** The first metatarsophalangeal joint is a condyloid synovial juncture and consists of the head of the first metatarsal, the base of the proximal phalanx, six muscles, eight ligaments and two sesamoid bones, with associated ligamentous attachments. The joint capsule is shaped like a box.

**Methods:** To achieve the research aim, a scoping review was undertaken with a search strategy that identified evidence via the following sources: Electronic databases, Google scholar, and Reference lists.

**Results:** The search yielded 193 articles, 48 of which appeared of potential relevance. After removing duplicate articles this total was reduced to 37 articles. After scanning the content, 27 were excluded to leave 10 articles. Twenty eight further articles were found through related author research, examination of reference lists and free text searches of Google Scholar. One reference was unobtainable. The final count of papers utilised for review was 37 which produced three themes, one of which was injection accuracy.

**Injection accuracy:** In the long history of injection therapy, infiltrations have often been performed without image guidance, i.e., using palpation guidance, anatomical landmarks and clinical judgement to direct needle entry and advancement. Needle placement may also be confirmed by use of diagnostic imaging. Typical imaging modalities are fluoroscopy or ultrasound, used alone or in combination with contrast media.

**Discussion:** The perceived wisdom is that if an injectate misses its target it is likely to be less effective and lead to false negative reporting of poor treatment outcomes, but the literature is not equivocal. This article discusses the recent literature in the field.

**Conclusions:** The literature suggests that steroid injections are safe and effective for the short-term relief of joint pain. When injecting small synovial joints using palpated-guided methods, clinicians must be alert to the potential for failure of technique from the needle penetrating too far into the articulation and exiting the joint on the contralateral side from the entry point. Use of shorter needles and use of imaging, +/- the use of contrast media, might reduce the number of such failures.

**Keywords:** steroid injection, injection accuracy, synovial joint, hallux limitus

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pronounced and may be achieved with only minor systemic effects; however, this suppression is often only temporary [21–26].

Despite their frequency of use, there are no strict guidelines regarding the administration of corticosteroid injections (CSIs) and injection regimen vary widely across anatomical injection sites and speciality [27–34]. The dose and frequency of corticosteroid use are similarly opaque and often based on professional opinion/experience and manufacturer recommendations [13,35–39]. A Delphi consensus study by Uson, et al., provided overarching principles and recommendations for intra-articular injection therapy (IAIT), noting their use in improving patient-centred outcomes as part of shared decision making [13].

The two most common diseases affecting the first metatarsophalangeal joint (1st MTP) of the foot are hallux limitus/rigidus (osteoarthritis; OA) and hallux abducto valgus (HAV; bunion) [40,41]. Other common pathologies of the joint include rheumatoid arthritis, gout and sesamoiditis [42]. Injectable glucocorticoids are widely used in hallux limitus though high-quality evidence for their use is lacking [4370]. IAIT is rarely used in the pre-operative management of HAV though it is employed for postoperative arthrofibrosis; restricted joint motion, typically painful as a result from an exaggerated fibrotic response after joint trauma or surgery [40, 71-73]. IAIT (+/- local anaesthetic injections) can be both diagnostic and therapeutic in sesamoiditis [53,74–76], though Cohen [77] counsels against repeated injections. While joint fluid aspiration and CSI injection are commonly performed in clinical practice for gout [78,79] its use has not been investigated by controlled trials [80–82]. Nonetheless, IA CSIs for gout are recommended by rheumatologic societies around the world including the British Society of Rheumatology (BSR) [83], the European League against Rheumatism [84], and the American College of Rheumatology (ACR) [85].

This work forms part of a doctoral thesis. The objectives of the project are to identify, synthesise and critique the evidence base for the use of CSIs in the management of 1st MTP pathology, to highlight gaps in our knowledge and to generate research questions for future study. The thesis is presented in six parts as a scoping review for CSIs of the 1st MTP; a systematic review of CSIs for OA of the 1st MTP; a best practice technique for IA CSI of the 1st MTP; a cadaveric experiment on 1st MTP injection accuracy, IA CSI case studies, and an outline study design for a high-level prospective study. The aim of this paper (in two parts) is to highlight current concepts in 1st MTP injection accuracy with reference to the wider CSI literature.

**Anatomy of the 1st MTP Joint**

**Structure**

The 1st MTPJ is a condylar synovial juncture [86]. It differs from the lesser MTP joints by its sesamoid mechanism: a single dominant fibrocartilaginous capsular thickening does not exist at the 1st MTPJ in contradistinction to the lesser MTPJs [87,88]. The metatarsol-sesamoid complex consists of the head of the first metatarsal, the base of the proximal phalanx, six muscles, eight ligaments and two sesamoid bones. The six muscles are the abductor and (the two heads of) adductor hallucis, flexor hallucis longus and brevis, and extensor hallucis longus and brevis [89]. The ligaments of the joint are the joint capsule, the medial and lateral collateral ligaments, the medial and lateral sesamoid ligaments, the plantar transverse metatarsal ligament, the intersesamoid ligament, and the hood ligament [88].

**Osteology**

The head of the first metatarsal is large and quadrilateral in general contour, with the transverse diameter exceeding the vertical dimension (Figure 1). The articular surface covering the head presents two fields in continuity: a superior phalangeal and an inferior sesamoidal [90] (Figure 2).

The proximal phalanx is directed transversely and has a large base to receive its muscular and ligamentous attachments [91]. It bears an oval, concave articular surface, the glenoid cavity, smaller than the corresponding articular surface of the metatarsal head [90]. The sesamoids are often likened in shape to coffee beans, but their overall configuration of the sesamoids is variable: they also may be semi-ovoid or circular in shape. They are embedded in the plantar pad which is a mass of dense fibrous tissue attached firmly to the base of the proximal phalanx.
Figure 1 First metatarsal (distal view) in a cadaveric specimen: right foot.

Figure 2 First metatarsal (medial border) in a cadaveric specimen: right foot.

Figure 3 Joint capsule of the 1st MTPJ.

On the plantar surface of the metatarsal the inferior articular surface is separated into two sloped surfaces by a rounded ridge or crest (the crista) oriented antero-posteriorly [92]. The sesamoids function to absorb weight-bearing forces, decrease friction, protect the flexor hallucis brevis tendons, and increase the functional length of metatarsal in propulsion [77].

Ligaments

Alvarez, et al., [88] list nine ligaments of the joint. Collateral and suspensory ligaments originate from medial and lateral epicondyles on the head of the first metatarsal. The collateral and sesamoid ligaments run forward and downward to attach to the base of the proximal phalanx and the appropriate sesamoid.

Synovial membrane

Weston [93] notes that the joint capsule is shaped like a box and cites that the best anatomical description of the synovial cavity of the 1st MTP is by Testut and Jacob in 1943. The synovial membrane was shown to reflect proximally on the palmar and plantar aspects of the heads and necks of metacarpals and metatarsals (Figure 4).
Methodology

Scoping reviews are used to assess and understand the extent of the knowledge in an emerging field or to identify, map, report, or discuss the characteristics or concepts in that field [94]. A scoping review is commonly used to map out and clarify working definitions and conceptual boundaries of a topic or field; it is a ‘reconnaissance’ of an area [95]. It is a form of knowledge synthesis that addresses an exploratory research question and maps the key concepts underpinning a research area by systematically searching, selecting, and synthesising existing knowledge [96,97].

A scoping review was considered to be the most suitable first step to question the wider themes about injection therapy of the 1st MTPJ. An a-priori protocol [98] was developed before undertaking the scoping review. The ‘Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) extension for Scoping Reviews’ – PRISMA-ScR [99] was used to guide the reporting of this protocol and is used to structure the reporting of the full review available for review in the doctoral thesis.

To achieve the research aim, a three-step strategy was adopted that involved searching for research evidence from the following different sources:

I. Electronic databases
II. Google Scholar
III. Reference lists

Step 1: The following databases was searched via the NHS Healthcare Advanced Database Search (HDAS) search engines using MeSh terms/free text:

- CINAHL (Cumulative Index to Nursing and Allied Health Literature: 1981 – 01.01.2021)
- EMBASE (Excerpta Medica Database: 1974 – 01.01.2021)
- MEDLINE (Medical Literature Analysis and Retrieval Online: 1946 – 01.01.2021)

Search terms

"((GLUCOCORTICOIDS/ OR (Steroid*).ti,ab OR (glucocorticoid*).ti,ab) AND ("INJECTIONS,
INTRA-ARTICULAR"/ OR (Injection*).ti,ab)) AND (HALUX/ OR (hallux).ti,ab OR ("big
toe*").ti,ab OR ("great toe*").ti,ab OR (arthrofibrosis).ti,ab OR (gout).ti,ab OR
(sesamoid*).ti,ab)"

Step 2: Google Scholar was searched using key words identified from an analysis of the text words contained in the title and abstract of retrieved papers, and these keywords were used to search for articles.

Step 3: Examination of the reference lists of all identified sources from steps 1 and 2.

Results

The search yielded 193 articles, 48 of which appeared of potential relevance. After removing duplicate articles this total was reduced to 37 articles. After scanning the content, 27 were excluded to leave 10 articles. 28 further articles were found through related author research, examination of reference lists and free text searches of Google Scholar. One reference was unobtainable. The final count of papers utilised for review was 37.
Needle placement may also be confirmed by use of diagnostic imaging. Typical imaging modalities are fluoroscopy or ultrasound (US), used alone or in combination with contrast media [106–109].

Injection by palpation guidance: options

Aywani, et al., [40] and Feuerstein, et al., [71] state that distension of the joint and flexion of the toe are signs of a successful IA injection of the 1st MTP. Joint fluid aspiration in larger joints may aid confirm needle placement [110–112] though aspiration of the 1st MTP] is more difficult as it is a smaller joint with less fluid available to aspirate [105,113]. Luc, et al., [114] describe a backflow technique, which involves re-positioning the needle (in the knee) until a free backflow of pre-injected lidocaine occurs. This has been demonstrated in the 1st MTP] by Bhattia [115] using iohexol contrast media.

Al-Jabri and Charalambides describe their ‘sulcus sign’ technique. The joint line was marked by a surgeon prior to needle insertion in a cohort of 30 patients[43]. The point of insertion was identified using the 'sulcus sign' technique as described in table 8 of their paper (note that Figure 1 of their paper shows a direct dorsal rather than dorso-lateral needle entry as they describe). This was then compared to the actual point of insertion following fluoroscopic identification of the joint line. The distance from the image-guided joint line to the marked joint line identified using the ‘sulcus sign’ technique and measured and recorded using a technique similar of Manadan, et al., [113]. These authors found no difference between the joint lines identified using image guidance versus the ‘sulcus sign’ technique and no difference in the point of needle entry marked using either technique, with only a single attempt required to establish an IA needle position, even in patients with advanced degenerative changes at the joint.

In contrast to Al-Jabri and Charalambides, Reilly et al. found that the presence of pathologic changes reduces the rate of successful IA puncture, but that the overall frequency of successful IA injections can be improved through experience and the use of imaging [43, 110]. 106 cadaveric 1st MTPs were injected with a methylene blue solution and then dissected to distinguish IA from periarticular injections.

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Figure 5 PRISMA-ScR flowchart.

Iterative charting of the literature yielded three broad and overlapping themes:

1. Evidence of IA CSIs by joint disease/pathology,
2. Non-evidenced based descriptions of injection technique and regimen,
3. Accuracy of the injection.

Nineteen articles are summarised Themes 1 and 2 (two articles appear in Theme 2 also) with a systematic review of the result of further work [69]. 20 articles (plus one, one unreferenced, and one found after the initial search) were technical/technique articles (Theme 2) and led to the development of a best practice IT guideline [100]. The cadaveric work that led from the initial scoping review has already been published [101]; part 2 of this paper will look at the wider concepts around injection accuracy of the 1st MTP.

Injection Accuracy

Workman [102] posits that there are four main considerations regarding injections: the route, site, technique, and equipment, for a given injection. In the long history of IAIT, the technique is done using palpation guidance, anatomical landmarks and clinical judgement to direct needle entry and advancement [103–105].
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, the authors examined the relation of pathologic findings of the 1st MTPJ and the accuracy of IA injection. The overall rate of unintentional periarticular injections was low (9.4%; 10 of 106 joints). The student achieved a successful IA 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) or OA of the 1st MTPJ.

The aim of Manadan’s study was to determine the accuracy of radiocarpal (RC) joint and 1st MTPJ arthrocentesis using fluoroscopy [113]. Ten rheumatologists with a mean of 17.9 years of clinical experience were asked to mark their usual site of arthrocentesis over fluoroscopically identified joint lines of the right RC and right 1st MTPJs. The sites marked were a mean of 0.85 cm and 0.33 cm from the fluoroscopically identified RC and 1st MTPJs, respectively.

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The authors concluded that traditional palpation-guided joint aspiration may be inaccurate, and that fluoroscopic guidance has the potential to improve accuracy of arthrocentesis of small joints.

As noted above, a best practice palpation-guided IT of the 1st MTPJ has been the subject of a previous study with further work evidencing the failure rate of this technique in a cadaveric model [100, 101]. The cadavers were subsequently used as part of a foot and ankle anatomy teaching course for podiatric surgery students. On one of the feet, following dissection of the soft tissues and subcutaneous layer away from the joint capsule and periosteum, a 1.0mm Kirschner wire was inserted into the joint using the senior author’s standard technique. With minimal extra pressure the wire was pushed further into the joint and exited the capsule dorso-laterally (Figures 6 and 7).

The patient in Figures 8 and 9 was undergoing open HAV surgery. With consent, prior to dissection of the 1st MTPJ capsule off the bony structures, a 23-gauge (blue) needle was inserted into the joint using the author’s standard injection technique. This demonstrates how easy it is to ‘overshoot the target’ if the needle is orientated slightly too dorsally or inserted too far laterally.

**Injections using image guidance: options**

**Fluoroscopy**

X-rays can be used to guide and confirm needle placement, with or without the use of contrast media [116,117]. Careful patient positioning before the procedure facilitates patient comfort and safe and efficient access to the joint - for the 1st MTPJ a supine position is appropriate, with a bent knee to allow the foot to rest flat on the table or radiography sensor [118]. A radiopaque object may be placed on the skin overlying the target to mark an appropriate skin entry site [57]. After skin penetration the needle is advanced into the joint with intermittent fluoroscopic guidance to reduce radiation dosage. Prior to injection, the joint may be aspirated; some authors inject local anesthetics at this point.

Direct injection of contrast media comes in two basic forms: injection via percutaneous needle access, such as direct arthrography, and injection via an indwelling catheter or tube, such as in cystography or sinography [119]. Arthrography is the IA injection of contrast media with image guidance to improve the evaluation or visualisation of IA structures (i.e., outline the articular structures, and gives information on basic joint architecture) or for confirmation of IA needle placement prior to intra articular delivery of medication(s) [109,115,120,121]. Contrast agents have long been used for the imaging of anatomic boundaries and to explore normal and abnormal physiologic findings. Iodinated contrast agents (ICAs) have been in use since the 1950s to facilitate radiographic imaging modalities and are widely applied contrast agents in use today. Physicians in almost all specialties will either administer these agents or care for patients who have received these drugs. Different iodinated contrast agents vary greatly in their properties, uses, and toxic effects. Therefore, clinicians should be at least superficially familiar with the clinical pharmacology, administration, risks, and adverse effects associated with iodinated contrast agents [119,122].

When a contrast medium is injected, it should flow freely into the joint recesses rather than clustering around the needle tip [7,118,123]. The normal 1st MTPJ arthrogram demonstrates the opaque medium seen as a thin layer over the head of the metatarsal, and between it and the base of the proximal phalanx. On the lateral aspects of the joint the small recess has a waist due to the collateral ligaments. A large recess is noted on the plantar aspect of the metatarsal head and neck which extends proximally by about 1cm [93]. The volume of the joint will be in the region of 1-1.5ml, negatively affected by joint disease [118]. Careful attention must be paid to the distribution of iodinated contrast to recognize unexpected findings such as extracapsular extension of contrast, which may indicate capsular injury or variant joint communications. Trauma to the 1st MTPJ leads to spindle-shaped swelling of the joint capsule; the shape of the capsule also changes from cylindrical to spindle - and joint density increases - in rheumatoid arthritis (RA) [93]. Sacculation may also be seen in RA [121].

Chow and Brandser use a flexible tube connecting the syringe to the needle to minimise movement of the needle once it has been placed within the joint or the tendon sheath and inject a small amount of contrast to confirm IA position. Spot films are taken for documentation [7]. Images should be obtained in both anteroposterior and lateral projections and show contrast filling the plantar aspect of the articulation.
This is countered by the (earlier) work of Saifuddin, et al., who used computed tomography (CT) who concluded that CT is a simple and safe alternative to fluoroscopy for guiding diagnostic and therapeutic foot injections and may be the technique of choice in cases of disordered anatomy [130].

In a classic reference, Weston posits the following for the metacarpo- (and metatarsal-) phalangeal joint technique:

“The metacarpophalangeal joint is flexed to a right angle. The joint space is then easily palpated on the dorsolateral aspect of the joint on either side of the extensor tendon. Once the space is located, the 26-gauge needle is inserted through the extensor expansion, which fixes the needle. As the opaque medium enters the joint, the synovial cavity is distended. This can be palpated by the left index finger of the operator, which is placed on the palmar aspect of the joint. The distended cavity is tense and cystic, and it displaces the index finger away from the metacarpal head” [93].

**Ultrasound**

The use of US for guidance for interventional radiologic procedures is well known, including guidance for vascular and visceral interventions. Multiple authors state that US-guided injections are more accurate than landmark-guided CSIs though not all clinicians agree [2,105,106,131–150–153]. Sofka, et al., state that regional CSIs, traditionally performed using anatomic landmarks, can be inaccurate and miss their intended target [140]. They posit that the use of USS for guidance for interventional radiologic procedures is well known, and that using sonography to guide for interventions in the musculoskeletal system, specifically the foot and ankle, yields accurate placement of the needle tip and subsequent CS/LA injections (as well as diagnostic aspiration of tendon sheaths, joint spaces, and bursae).

Balint, et al., demonstrate the use of US to localise joint and soft tissue fluid collection greatly improved the rate of diagnostic synovial fluid aspiration, particularly in small joints [105]. 32 joints in 30 consecutive patients, referred for injection to an experienced consultant rheumatologist for joint aspiration and injection were aspirated in a conventional (non-guided) group.

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**Figures 10 and 11** Osteophytic lip on the proximal phalanx.

Newman suggests that to avoid the dorsal lip of the proximal phalanx, the needle should be inserted just proximal to the joint line and angled slightly distally [124]. Note the osteophytic lip on the dorsal aspect of the base of the proximal phalanx undergoing an arthrodesis procedure seen in Figures 10 and 11, which might impede needle entry into the joint space from a dorsal approach.

Karpman and MacCollum suggested that longitudinal traction is placed on the hallux and the contrast media is injected into the joint under fluoroscopic control [125]. The joint is then brought through a passive range of motion several times to allow for proper distribution of the contrast material.

Khoury et al., found that radiographically guided diagnostic injections of foot and ankle symptomatic patients demonstrated better success in identifying the source of pain, confirming diagnosis in 90.9% of the patients and predicting success of surgical treatment with fusion of the affected joints [126]. However, in a contrast radiography study of 108 films of multiple anatomical sites in an oft-cited study, Jones et al. reported that 56 injections were intra-articular, 31 extra-articular; and in 21 the location was uncertain because of a lack of contrast in the radiograph [127].

In contrast, Messina, et al., state that X-rays should be avoided when other radiation-free modalities such as (US can be used and note that the European Union directive 2013/59 clearly states that if a radiation-free imaging modality can achieve the same therapeutic and diagnostic results, it should invariably be used [128,129].
In the US guided group, 31 consecutive patients were examined by US to confirm the presence and location of fluid. Following US examination, aspiration was performed by a second rheumatologist based on the US localization of fluid or under direct US guidance. Successful aspiration was achieved in 10 (32%) joints in the conventional group but in 31 (97%) joints in the US guided group.

Beard and Gousse suggests that using US to guide for interventions in the musculoskeletal system, specifically the foot and ankle, yields accurate placement of the needle tip and subsequent anesthetic/steroid injection, as well as diagnostic aspiration of tendon sheaths, joint spaces, and bursae[154]. They suggest that US is distinctly more accurate than landmark guidance for small joints. Daniels, et al., performed a comprehensive review of the literature for the accuracy of US-guided injections regardless of anatomic location[132]. In the lower extremity, the authors found that US-guided injections at the knee, ankle, and foot have superior efficacy to landmark-guided injections. Fredberg used air for correct placement of the needle before injection - the sterile air that is contained in the capped vial is used as a contrast medium [31]. The needle is guided into the joint space of the distended capsule by US.

Goldschmiedt, et al., describe the injection jet sign as colour Doppler flow that is directed away from the needle tip at the point of entry as well as the flow within, and often outlining the joint capsule or bursa as a method to assure the desired target delivery of the injectate [144].

Khosla, et al., demonstrated that needle placement was only correct in 3 of 14 (21%) and 4 of 14 (29%) cadavers using palpation guidance into 1st and 2nd tarsometatarsal joints, respectively [112]. US-guidance significantly improved the accuracy of needle placement for both joints.

Lucas et al. sought to determine the value of injections of LA and CSIs in the foot and ankle in localising the source of pain, and their effect on clinical confidence and decision making [155]. 106 intra- and extra-articular foot and ankle injections were performed on 47 patients. Questionnaires were completed by the referring surgeon before and after injections to evaluate the level of confidence regarding the source of pain for each site injected and the proposed treatment plan. Forty-three (91%) patients reported pain relief after injections. The level of confidence that the site injected was the source of pain increased in 68 (64%) sites, decreased in 19 (18%) sites, and remained unaltered in 19 (18%) sites. The treatment plan was changed from nonsurgical initially to surgical in three (8%) of 36 patients and was changed from surgical to nonsurgical in three (27%) of 11 patients after injections. Of the remaining eight patients, treatment was altered in three (37%) because of pain relief after the injections. The authors concluded that fluoroscopically guided injections of local anaesthetic and steroid in the foot and ankle can improve clinical confidence regarding the site of pain and may be valuable in clinical decision making and patient.

In a cadaveric mode, Muir, et al., found that US-guided peroneal tendon sheath injections were significantly more accurate than palpation-guided injections [136]. Nordberg, et al., study [152] indicates that the efficacy of IA injections varies according to US findings at the time of injection, supporting the use of US as a tool to select joints that will benefit from intra-articular injections, however, ultrasound needle-guidance was not superior to palpation-guidance. In the hand, Raza, et al., found that IA needle positioning was 59% accurate in palpation-guided injections and that no fluid could be aspirated prior to injection [137]. With US-guidance, initial IA needle placement was intra-articular in 96% of cases and that synovial fluid cells were lavaged from 63% of joints.

Sahler, et al., describe a longitudinal US-guided, in-plane approach for injection into the 1st MTPJ and assess its accuracy in a cadaveric model[58]. Ten 1st MTPJs were injected with 0.5 mL of dye under US-guidance. The joints were later dissected, and accuracy was classified as accurate, accurate with overflow, or inaccurate with no injection in the target area. Of the injections, nine were classified as accurate injections, and one was classified accurate with overflow. The authors concluded that US-guided injections of the 1st MTPJ can be accurately and reproducibly performed with a gel standoff, long-axis in-plane approach. This technique attempts to minimise the collateral damage to the surrounding tissue, specifically the articular cartilage.
The authors acknowledge the small sample size which was not powered to determine the true accuracy of this technique but with a relative accuracy was 100%, considered strong enough to recommend as an acceptable alternative to palpation-guided 1st MTPJ injections.

Sibbitt, et al., found that sonographic needle guidance improves the performance and outcomes of IA injections in a clinically significant manner [139]. Schumacher provides a narrative review regarding the variety of IA therapies available and need comparison for indications, routes used for aspiration and injection, ease of use, benefits, and adverse reactions [156]. This review addresses all these aspects but focuses on neglected technical concerns.

Sconfienza, et al., report the results of a Delphi-based consensus of 53 experts from the European Society of Musculoskeletal Radiology (ESSR)[157]. The authors reviewed the literature for evidence on image-guided interventional procedures offered around foot and ankle to derive their clinical indications and drafted a list of statements. These were graded according to the Oxford CEMB centre for levels of evidence. 16 evidence-based statements on clinical indications for image-guided musculoskeletal interventional procedures in the foot and ankle were drafted. A consensus was considered strong when > 95% of experts agreed with the statement or broad when > 80% but < 95% agreed. The highest level of evidence was reported for four statements, all receiving 100% agreement.

Simkin suggests that inflamed synovial tissue comprises a large and completely appropriate target for injection by a clinician. In that situation, an injection that missed the pocket of fluid may have accurately hit the site of joint involvement in cases that otherwise would be considered “successful failures” [158]. Sofka and Adler posit that regional corticosteroid injections, traditionally performed using anatomic landmarks, can be inaccurate and miss intended targets[140]. The use of ultrasound for guidance for interventional radiologic procedures is well known, including guidance for vascular as well as visceral interventions. Using sonography to guide for interventions in the musculoskeletal system, specifically the foot and ankle, yields accurate placement of the needle tip and subsequent CS/LA injection as well as diagnostic aspiration of tendon sheaths, joint spaces, and bursae.

Needle placement for sesamoid pathology has been considered by Wempe, et al., [159]. US guidance was used to accurately inject the 1st MTPJs of five unembalmed cadaveric lower limb specimens with blue-coloured latex. 24 hours after injection, each specimen was dissected to determine whether the latex was present between the metatarsal head and sesamoid bones (metatarsal-sesamoid articulations). In all 5 cadaveric specimens, US-guided 1st MTPJ injection accurately delivered latex into the joint and in each specimen, latex was seen between the metatarsal head and both the fibular and tibial sesamoid bones. The authors suggest that clinicians administering diagnostic or therapeutic injections for patients with sesamoid disorders should consider injecting the 1st MTPJ as an alternative to direct metatarsal-sesamoid articulation injections.

**Discussion**

Shoor [160] notes that the review by Arroll, et al., [161] raises several questions: which group of OA patients are likely to respond to knee CSIs? Those with less severe disease or those with clinical evidence of inflammation such as an effusion? To what degree is the apparent success of intra-articular steroids affected by how the procedure is performed? For example, how much fluid is withdrawn if lavage is used rather than saline instillation? At what point in the treatment regimen should intra-articular corticosteroids be used (i.e., after or before NSAID or physical therapy)? What is the effective and safe interval for repeat injections? These questions remain largely unanswered for the 1st MTPJ.

So, how much does needle placement matter? The perceived wisdom is that if an injectate misses its target it is likely to be less effective and lead to false negative reporting of poor treatment outcomes, but the literature is not equivocal. Lopes, et al., state that blind injections prove safe and accurate when performed by a trained professional but without image guidance, how do we ensure accuracy of injection? [162] Hawker posits that about 50% of intra-articular and intrasional injections are placed incorrectly. The findings of the position statement by the American Medical Society for Sports Medicine indicate that there is strong evidence that US guided CSIs are more accurate than those that are landmark guided, moderate evidence that they are more efficacious, and preliminary evidence that they are
more cost-effective [163]. They also note that if an injectate is misplaced, it may lead to complications such as skin depigmentation, subcutaneous fat atrophy, tendon rupture, neurovascular injury, increased procedural and postprocedural pain, or intra-arterial injection.

Cunnington, et al., found that accurate injections led to greater improvement in joint function, as determined by VAS scores, at 6 weeks, as compared with inaccurate injections [103]. Schumaker considers that accuracy is critical as we continue to assess the value of joint injections[164]. Jones, et al., state that the steroid should be injected into the synovial space for IA infiltrations [165]. Lopes, et al., feels that accurate IA placement of the needle is a prerequisite for the achievement of desirable results and the avoidance of complications [162]. Sibbitt, et al., found that US guidance significantly improved the performance and outcomes of outpatient IA injections. Conversely, Cole and Schumaker note that the effects of IA corticosteroids - though variable - are frequently observed on non-injected involved joints, suggesting the importance of systemic effects [139,165]. Jones, et al., found that almost half of those with extra-articular CS placement experienced good therapeutic response, suggesting that total accuracy of needle placement may not be essential to a satisfactory outcome [165].

Hall and Buchbinder [150] ask:

1. Do radiologically guided corticosteroid injections confer any added clinical benefit over blinded injections in the short and long term?
2. If there are added benefits, is the routine use of imaging to improve the accuracy of steroid placement, cost effective?

They conclude that while some joints such as the hip and midtarsal joints demand imaging for any accuracy of steroid placement, for most joints which have conventionally been injected by rheumatologists following an anatomical landmark approach, imaging guided injection should be reserved for those cases who have not responded to injection following anatomical landmarks. Imaging is therefore recommended for joints by many authors that are difficult to access due to factors including site, degree of deformity and obesity [13,39,145,150,167]. Without radiological confirmation, it is difficult to ensure the exact location of the needle. Because of this - and practising defensively - many authors advocate the use of image guidance. But with Simkin suggesting that inflamed synovial tissue may often be the target for the CS, perhaps close is close enough [158]? Fortuitous, since needle placement is therefore often less accurate than many practitioners would suggest and even in the most experienced hands, large joint injections such as the shoulder and knee have demonstrated accuracy rates that have varied. The small joints and peritendinous areas of the foot and ankle present an even greater challenge to blind injection accuracy.

As the 1st MTPJ varies in size and shape, and it may be difficult to palpate in patients with conditions such as advanced degenerative arthritis and osteophyte formation [42,46,110]. This finding is of considerable importance because it is often the case that patients with pathologic changes who are offered these injections. Of the six joints in Heidari, et al., cadaveric injection study that had combined hallux valgus and hallux rigidus cases, two were not successfully punctured [110]. The understanding of anatomical landmarks of the foot and ankle is therefore relevant for correct needle placement [50]. Lungu and Moser target the articular recess and feel that the main theoretical advantage of targeting this point is that it facilitates IA injection when the joint space is obscured, either by patient positioning or degenerative changes to the joint (reliable depth estimation can be provided by bone contact) [62]. By targeting the articular recess, the needle path is often shorter, thus diminishing the number of structures whose integrity is compromised, and that this approach inflicts less pain to patients, they state. In practical terms, however, the dorsal recess of the 1st MTPJ is a small target.

Yablon provides a technical article on CSI considerations [142]. Yaftali & Weber also note that the use of image guidance can improve accuracy of IA placement of CSIs or hyaluronic acid injections[143]. D’Agostino, et al., found that use USS frequently led the physician to change his diagnosis of inflammatory lesions in painful foot, and consequently the planning of CSI injections with a probable improvement in the response to local treatment [168]. While many injections are given with anatomical- or palpation guidance on an outpatient basis, accurate needle placement can be aided by image guidance [138,154]. The accuracy of IA injection depends on the joint and on the skills of the practitioner, but use of imaging may improve accuracy.
Conclusion

The literature shows that CSIs of joints and periarticular structures are safe and effective when administered by an experienced physician. IA CSIs are effective for short-term relief of pain in OA but predicting the best responders is not currently possible. When injecting small synovial joints using palpated-guided methods, clinicians must be alert to the potential for failure of technique from the needle penetrating too far into the articulation and exiting the joint on the contralateral side from the entry point. Use of shorter needles and use of imaging, +/- use of radiopaque dyes, might reduce the number of such failures though as noted above, close might often be close enough.

The variability in outcomes following injection for 1st MPJ OA raises numerous questions: to what extent is pain reduced? Is joint function improved? Which patients are most likely to benefit from this treatment? What is the frequency with which corticosteroid should be administered and whether the use of image-guided injections improves treatment outcomes? The key information to produce would be delineate:

1. Which CS drug to use,
2. In what dose,
3. Targeting which patient at which point in their disease process,
4. With or without the use of local anesthesia,
5. With which injection technique,
6. With or without image guidance (or contrast media),
7. In which regimen (how many injections over what period),
8. With what post injection advice/follow-up,
9. For a given pathological condition (and given disease progression),
10. What short- and long-term complications are seen with CSIs.

Concurrently, the author has recorded several cases for the use of CSI in advanced cases of OA of the 1st MTPJ and will form part of a case series. Many patients have responded well in the mid-to-long-term to IA CSI using 3-400mg IA CSI of triamcinolone acetonide. This case series will be produced according to CARE guidelines [169].

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