Use and safety of corticosteroid injections in joints and musculoskeletal soft tissue: guidelines from the American Society of Regional Anesthesia and Pain Medicine, the American Academy of Pain Medicine, the American Society of Interventional Pain Physicians, and the International Pain and Spine Intervention Society

Honorio T Benzon ,[1] David Anthony Provenzano ,[2] Ameet Nagpal ,[3] Dmitri Souza,[4] Maxim S Eckmann,[5] Ariana M Nelson ,[6,7] Maged Mina,[5] Alaa Abd-Elsayed,[8] Dalia Elmofty,[9] Andrea L Chadwick ,[10] Tina L Doshi ,[11] Carlos A Pino ,[12] Maunak Rana,[9] Shalini Shah,[13] Hariharan Shankar ,[14] Alison Stout,[15] Elizabeth Smith,[16] Salahadin Abdi,[17] Steven P Cohen ,[18] Joshua A Hirsch,[19] Byron J Schneider,[20] Laxmaiah Manchikanti,[21] Timothy P Maus,[22] Samer Narouze ,[23] Harsha Shanthanna ,[24] Ajay D Wasan,[25] Thanh D Hoang,[26] Jessica Rivera,[27] Christine Hunt ,[28] John D FitzGerald[29]

For numbered affiliations see end of article.

Correspondence to
Dr Honorio T Benzon;
Honorio.Benzon@nm.org

CH and JDF are joint senior authors.

Received 9 May 2024
Accepted 3 February 2025

To cite: Benzon HT, Provenzano DA, Nagpal A, *et al*. *Reg Anesth Pain Med* Epub ahead of print: [*please include* Day Month Year]. doi:10.1136/rapm-2024-105656

ABSTRACT

Background Intra-articular corticosteroid (IACS) injection and peri-articular corticosteroid injection are commonly used to treat musculoskeletal conditions. Results vary by musculoskeletal region, but most studies report short-term benefit with mixed results on long-term relief. Publications showed adverse events from single corticosteroid injections. Recommended effective doses were lower than those currently used by clinicians.

Methods Development of the practice guideline for joint injections was approved by the Board of Directors of the American Society of Regional Anesthesia and Pain Medicine and the participating societies. A Corticosteroid Safety Work Group coordinated the development of three guidelines: peripheral nerve blocks and trigger points; joints; and neuraxial, facet, and sacroiliac joint injections. The topics included safety of the technique in relation to landmark-guided, ultrasound-guided, or radiology-aided injections; effect of the addition of the corticosteroid on the efficacy of the injectate; and adverse events related to the injection. Experts on the topics were assigned to extensively review the literature and initially develop consensus statements and recommendations. A modified version of the US Preventive Services Task Force grading of evidence and strength of recommendation was followed. A modified Delphi process was adhered to in arriving at a consensus.

Results This guideline focuses on the safety and efficacy of corticosteroid joint injections for managing joint chronic pain in adults. The joints that were addressed included the shoulder, elbow, hand, wrist, hip, knee, and small joints of the hands and feet. All the statements and recommendations were approved by all participants and the Board of Directors of the participating societies after four rounds of discussion. There is little evidence to guide the selection of one corticosteroid over another. Ultrasound guidance increases the accuracy of injections and reduces procedural pain. A dose of 20 mg triamcinolone is as effective as 40 mg for both shoulder IACS and subacromial subdeltoid bursa corticosteroid injections. The commonly used dose for hip IACS is 40 mg triamcinolone or methylprednisolone. Triamcinolone 40 mg is as effective as 80 mg for knee IACS. Overall, IACS injections result in short-term pain relief from a few weeks to a few months. The adverse events include an increase in blood glucose, adrenal suppression, detrimental effect on cartilage lining the joint, reduction of bone mineral density, and postoperative joint infection.

Conclusions In this practice guideline, we provided specific recommendations on the role of corticosteroids in joint, bursa, and peritendon injections for musculoskeletal pain.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Corticosteroids are injected into joints to relieve pain and improve function.

WHAT THIS STUDY ADDS

⇒ The study discussed the different causes of shoulder and hip pain, adverse events from corticosteroid joint injections, and provided the minimum effective and commonly used doses.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The study provides the foundation for prevention of some of the adverse events from joint corticosteroid injections.

JOINT INJECTIONS FOR ADULT CHRONIC PAIN AND THE ROLE OF CORTICOSTEROIDS

Pain in the shoulder, hip, knees, or fingers is common in patients over 40 years of age.[1] Degenerative joint disease is a consequence of repeated trauma, metabolic disease, or autoimmune disease.[2] The mechanisms for joint pain include the local release of proinflammatory cytokines, neurotransmitters, and growth factors that stimulate nociceptors, A-delta, and C-fibers.[3] Sympathetic nerves and low-threshold mechanoreceptors may be involved in generating and propagating pain signals in degenerative joint disease. The pain signal is modulated within the spinal cord and brain; central sensitization may contribute to amplification and continuation of the pain sensation.

The diagnosis and management of joint pain have been described[1] and are beyond the scope of this guideline. However, it is important to identify pathology and pain generators in complex joints such as the shoulder joint (acromioclavicular or glenohumeral joint, subacromial subdeltoid bursa (SASDB), biceps tendon), and the hip joint (trochanteric bursa gluteus medius/minimus tendon, iliopsoas bursa) to ensure injection at the appropriate location. Peripheral joint injections are used after failure of conservative management with the objective of reducing pain and improving function. Intra-articular corticosteroid injections (IACS) and other musculoskeletal injections alleviate inflammation and reduce pain, improve function, facilitate rehabilitation, or give some temporary relief until definitive treatment, for example, surgery, can be undertaken. Injectates include local anesthetic, hyaluronic acid, platelet-rich plasma (PRP), mesenchymal stromal cells, and corticosteroid.[2] The data are most robust for corticosteroid injections (CSIs).

CSIs fall into three broad categories: peripheral nerve blocks; joints and bursa; and neuraxial. CSIs are common procedures for patients with joint pain, such injections are performed using landmark techniques or aided by ultrasound (US) or fluoroscopy. Several studies revealed corticosteroid-related adverse events; these include decrease in bone mineral density (BMD), inhibition of the hypothalamic pituitary axis, increase in blood sugar, and postoperative joint infection. These events are compounded by clinicians injecting amounts higher than minimally effective doses. Regarding the safety of the different techniques, there has been no publication that compared the safety of the different procedures with landmark, US, or fluoroscopy across the joints' spectrum.

Cognizant of the above problems, the American Society of Regional Anesthesia and Pain Medicine (ASRA PM) authorized the development of practice guidelines (PGs) that address these issues. In this PG, we discuss the rationale, mechanisms, and efficacy of, and adverse events from CSIs into peripheral joints and related musculoskeletal structures (eg, tendons, ligaments, and bursa). This is the second of four PGs that the Corticosteroid Safety Work Group developed. The first is the recently published PG on sympathetic and peripheral nerve blocks and trigger point injections[4]; the third is on facet and sacroiliac joint injections and associated topics including vaccine and anticoagulants (in preparation); and the fourth is on neuraxial injections.

The guidelines are not intended to limit or deny care nor affect the rights of patients or providers, nor do they define the standard of care. They are not intended to replace clinical judgment. In the imperfect setting of heterogeneous data, limited data, controversial topics, and bias inherent to expert opinion, compliance with the recommendations may not result in improved outcomes compared with personalized medicine.

DEVELOPMENT OF THE PRACTICE GUIDELINE

The Corticosteroid Safety Work Group consisted of experts who have written on the subject. The Work Group decided on the topics for the PGs and recruited additional experts to develop SRs. The project was sponsored by the ASRA PM, and the participating societies included the American Academy of Pain Medicine (AAPM), American Society of Interventional Pain Physicians, North American Spine Society, and International Pain and Spine Intervention Society. The American College of Rheumatology (ACR), American Academy of Orthopedic Surgeons (AAOS), and the American Academy of Physical Medicine and Rehabilitation identified members with content expertise (JF, JR, and AN, respectively) who helped create the SRs, participated in the discussions, and voted on the SRs.

In this PG, the joints covered include shoulder, elbow, hip, knee, hand, wrist, and small joints. Each member of the Writing Committee was assigned a topic, extensively searched the literature using PubMed, EMBASE, and/or Cochrane clinical trials with appropriate Medical Subject Headings (see online supplemental appendix), and initially formulated statements and recommendations (SRs) using a modified US Preventive Services Task Force (USPSTF) levels of evidence. Statements and recommendations were created and evaluated based on the USPSTF methodologies[5] noted in tables 1 and 2. A grade was assigned to each recommendation based on the obtainable evidence (table 1). The level of certainty regarding the net benefit was based on the available literature as outlined in table 2.

The SRs were modified after several discussions involving all the participants, using a modified Delphi process[6 7] and unanimously approved after four rounds of voting. Subsequently, the

Table 1 Modified US Preventive Services Task Force (USPSTF) grades and suggestions for practice

Grade	Definitions	Suggestions for practice
A	The Multisociety Corticosteroid Safety Work Group recommends the service. There is high certainty that the net benefit is substantial.	Offer or provide this service.
B	The Multisociety Corticosteroid Safety Work Group recommends the service. There is high certainty that the net benefit is moderate, or there is moderate certainty that the net benefit is moderate to substantial.	Offer or provide this service.
C	The Multisociety Corticosteroid Safety Work Group recommends selectively offering or providing this service to individual patients based on professional judgment and patient preferences. There is at least moderate certainty that the net benefit is small.	Offer or provide this service for selected patients depending on individual circumstances.
D	The Multisociety Corticosteroid Safety Work Group recommends against the service. There is moderate or high certainty that the service has no net benefit or that the harms outweigh the benefits.	Discourage the use of this service.
I	The Multisociety Corticosteroid Safety Work Group concludes that the current evidence is insufficient to assess the balance of benefits and harms of the service. Evidence is lacking, of poor quality, or conflicting, and the balance of benefits and harms cannot be determined.	Read the clinical considerations section of the USPSTF Recommendation Statement. If the service is offered, patients should understand the uncertainty about the balance of benefits and harms.

Table 2 Modified US Preventive Services Task Force levels of certainty regarding net benefit

Level of certainty	Description
High	The available evidence usually includes consistent results from well-designed, well-conducted studies in representative care populations with joint pain. These studies assess the effects of the service on health outcomes. This conclusion is therefore unlikely to be strongly affected by the results of future studies. Examples: randomized controlled trials or large-scale observational studies with control groups.
Moderate	The available evidence is sufficient to determine the effects of the intervention on health outcomes, but confidence in the estimate is constrained by such factors as follows: ► The number, size, or quality of individual studies. ► Inconsistency of findings across individual studies. ► Limited generalizability of findings to individuals with joint pain. ► Different etiologies and phenotypes in the study subjects with joint pain. ► Lack of coherence in the chain of evidence. As more information becomes available, the magnitude or direction of the observed effect could change, and this change may be large enough to alter the conclusion. Examples: a single large-scale observational study without control groups (multisite or single-site); multiple (>2) large retrospective studies (>20 subjects) or cohort studies.
Low	The available evidence is insufficient to assess effects on health outcomes. Evidence is insufficient because of the following: ► The limited number or size of studies. ► Important flaws in study design or methods. ► Inconsistency of findings across individual studies. ► Gaps in the chain of evidence. ► Findings not generalizable to individuals with joint pain, or generalizable only to a small proportion of those with joint pain. ► Lack of information on important health outcomes. More information may allow estimation of effects on health outcomes. Examples: case series or case reports or consensus-based recommendations from other sources.

The USPSTF defines certainty as 'likelihood that the USPSTF assessment of the net benefit of a service is correct.' The net benefit is defined as benefit minus harm of the service as implemented in a general, primary care population. The USPSTF assigns a certainty level based on the nature of the overall evidence available to assess the net benefit of a service.

SRs were approved by the Board of Directors of the participating societies.

INDICATIONS AND COMPOSITION OF CORTICOSTEROID INJECTIONS

Joint pain can be debilitating and limit a patient's mobility, activity, and quality of life. IACS injections are employed for the management of pain related to arthropathy due to osteoarthritis (OA), rheumatoid arthritis (RA), and other inflammatory arthritis (eg, crystalline, psoriatic, or spondyloarthropathy); hemophilic arthropathy; or post-traumatic arthritis. In addition, these injections may also be used for recalcitrant soft tissue injuries, tendinosis/tendinitis, and bursitis. Conventional conservative management, including exercise, weight loss, physiotherapy, and anti-inflammatory medications, is usually undertaken for joint pain. IACS injections are usually employed when non-pharmacological treatment and analgesics fail to provide adequate relief of the symptoms. A review of more focused (usually single joint) clinical PGs noted the recommendations of higher-quality PGs: guidelines that scored at least 60% for domains 3 (rigor of development), 6 (editorial independence), plus one other criterion in the International Appraisal of Guidelines, Research and Evaluation (AGREE) II tool.[8] These prior PGs consistently recommended education, exercise, and weight management, non-steroidal anti-inflammatory drugs (NSAIDs) for hip and knee OA, and IACS for knee. Other recommendations were less consistent; these included paracetamol, IACS for hip OA, hyaluronic acid for knee OA, and acupuncture. Arthroscopy was consistently recommended against.[8] An update of the EULAR PG added appropriate footwear, assistive devices, modifying work-related factors, and behavioral changes to the previous recommendations.[9]

Hip and knee IACS practice recommendations from organizations

Indications for IACS and other soft tissue musculoskeletal injections include pain relief and improved function. In 2019, the ACR updated their 2019 recommendations for hip and knee IACS.[10] In patients with knee and hip OA, a strong recommendation was made for IACS (table 3). The AAOS updated their advice from 'unable to recommend (knee)'[11 12] to 'could be considered' in their most recent version.[13 14] The EULAR recommended the injection of a long-acting glucocorticoid for acute exacerbation of knee pain, especially if accompanied by effusion.[15] For hip OA, they changed their original advice from 'not recommended'[16] to 'maybe considered in patients with flare that is unresponsive to analgesic or NSAID.'[17] This was prompted by a randomized controlled trial (RCT) that showed better results with IACS compared with local anesthetic alone, and two uncontrolled trials showed some short-term (3 months) pain reduction from IACS injection.[17] The Osteoarthritis Research Society International (OARSI)[18] conditionally recommended IACS for knee OA, but no pharmacological treatment was conditionally recommended for hip OA, partly because of the lack of hip-specific RCTs.[18]

Table 3 Recommendations of national organizations on the usefulness of hip and knee intra-articular corticosteroid injections

Organization	Knee	Hip
American College of Rheumatology	Recommended	Recommended
American Academy of Orthopedic Surgeons	Could be considered	Could provide short-term relief
European League Against Rheumatism	Recommended	May be considered
Osteoarthritis Research Society International	Conditionally recommended	Not commented

Box 1 Absolute and relative contraindications to intra-articular and soft tissue corticosteroid injections

Absolute contraindications
⇒ Overlying skin infection
⇒ (Suspected) infectious arthritis
⇒ Fracture site
⇒ (Suspected) bacteremia
⇒ Hypersensitivity or allergic reactions to previous corticosteroid injectables.

Relative contraindications
⇒ Previous lack of efficacy
⇒ Severely immunocompromised status
⇒ Coagulopathy
⇒ Joint prosthesis
⇒ Poorly controlled diabetes

General statements and contraindications for IACS

IACS are usually injected with local anesthetic. One study compared local anesthetic with or without methylprednisolone (MP) in patients with lateral epicondylitis.[19] The recovery rate, in terms of pain relief and recovery of function, was significantly better in the corticosteroid and local anesthetic group throughout the 12-week follow-up.

The absolute and relative contraindications to intra-articular (IA) and soft tissue CSIs are listed in box 1.

CHOICE OF CORTICOSTEROID FOR INTRA-ARTICULAR JOINT INJECTIONS

There is little evidence to guide the selection of one IACS over another. A 1994 survey of the ACR membership, with a 62% response rate, reported that 87% of respondents used either methylprednisolone acetate (MPA), triamcinolone hexacetonide (TH), or triamcinolone acetonide (TA).[20] The authors noted a strong correlation for the type of corticosteroid selected with the region where the respondent had trained, with MPA in the mid-Atlantic, New England, and the Southeast; TH in the Midwest and Southwest; and TA in the West.[20]

OBSERVATIONAL AND RETROSPECTIVE STUDIES COMPARING TRIAMCINOLONE ACETONIDE AND TRIAMCINOLONE HEXACETONIDE

In a retrospective study of 85 patients with juvenile RA, 227 joint injections, and time to relapse, as assessed by the attending physician, were analyzed using the Cox proportional hazards model.[21] Doses were standardized by joint. Mean time to relapse was shorter for TA-injected than TH-injected joints, 8 vs 10 months ($p<0.0001$).

In a prospective study, patients with oligoarticular juvenile idiopathic arthritis, 115 knees and 15 ankles from 85 patients were treated with 1 mg/kg of either TH (n=70) or TA (n=60) based on drug availability.[22] The patients were similar based on age, disease duration, gender, antinuclear antibody positivity, type of joint, inflammatory markers, and current meds. Patients treated with TA relapsed sooner than patients treated with TH when analyzed by either Cox proportional hazard (HR 2.7) or time point (6, 12, 24 months) with risk rate of relapse approximately 2 for the different time points. All results were statistically significant.

RANDOMIZED CONTROLLED TRIALS COMPARING DIFFERENT CORTICOSTEROIDS

In a small study on knee OA, 57 patients were randomized to either TH 20 mg or MPA 40 mg.[23] The patients in the TH group had a statistically greater reduction in pain (visual analog scale (VAS)) than did the MPA group at week 3. The authors concluded that MPA was slower in onset and less efficacious than TH. No differences between the groups were noted as assessed by the Lequesne index, a questionnaire that assesses pain, walking distance, and difficulties of daily life. A review noted that TH may be associated with faster onset, but there were no significant differences in long-term outcomes.[24]

In another small single-blind study, 42 patients with knee OA were randomized to either TH 20 mg or the combination of 6 mg betamethasone acetate and betamethasone disodium phosphate.[25] TH had superior clinical benefits at week 1. Treatment failure, defined as a patient's need for a new injection or other therapy, was more common in the betamethasone group (n=12) vs the TH group (n=5).

In a randomized study, 100 patients with inflammatory knee arthritis (89 with RA) were randomized to receive either TA 80 mg or MPA 80 mg.[26] No differences were noted in the time to relapse, pain, swelling, range of movement, or adverse effects (AEs) at 4, 12, or 24 weeks after the treatments. Research to date has not demonstrated long-term superiority of any corticosteroid preparation for IA knee injections.

EXTENDED-RELEASE CORTICOSTEROID PREPARATIONS

TA extended-release preparation results in steadier, longer triamcinolone plasma levels (lasting weeks rather than days) than TA.[27 28] A phase IIb report studied TA extended-release 32 mg vs TA extended-release 16 mg vs placebo (approximately 100 per group) in patients with knee OA.[29] Although the primary end point (average daily pain intensity) was not met, secondary end points (improvement in average daily pain) were met, and trends favored the extended-release 32 mg dose group. A separate phase III study compared a 1:1:1 randomized trial of knee IACS: TA extended-release 32 mg vs TA 40 mg vs placebo (approximately 161 subjects per group). For average daily pain (primary end point), TA extended-release was superior to placebo, but no different than TA 40 mg. Secondary and exploratory clinical end points favored the extended-release preparation but not significantly.[30]

In a small phase II study, 32 patients with knee OA and diabetes were randomized to either TA extended-release 32 mg vs TA 40 mg and underwent blood glucose monitoring.[31] Patients receiving the extended-release preparation mg had statistically and clinically meaningful lower blood glucose during the 48 hours post-IACS injection. A review noted that TA extended-release provides longer plasma levels and less alteration in blood glucose than TA.[24]

It should be noted that studies of TA extended-release IACS have been limited to knee and glenohumeral joint injections and funded by the drug manufacturer. Whether the results apply to other joints has not been studied at this time. For SRs on corticosteroid pharmacology and adverse events in IACS, see box 2.

Box 2 Statements and recommendations on corticosteroid pharmacology

Choice of corticosteroid

Statements

1. The three most used corticosteroid preparations for intra-articular injection are methylprednisolone acetate, triamcinolone hexacetonide, and triamcinolone acetonide.
   Level of certainty: moderate
2. Various corticosteroid preparations have similar effectiveness but may differ in their duration of action.
   Level of certainty: moderate
3. Extended-release corticosteroid preparations have not demonstrated clinical superiority to standard preparations except for improved blood glucose stability in populations with diabetes.
   Level of certainty: moderate

Recommendation

⇒ There is insufficient evidence to recommend one preparation of intra-articular corticosteroid over another.
Grade I

Relief from corticosteroid injections

Statement

⇒ Corticosteroid joint injections can provide short-term pain relief and improvement in function.
Level of certainty: moderate

Recommendation

⇒ Corticosteroid joint injections can be used for short-term relief in patients with symptomatic inflammatory or degenerative arthritis.
Grade C

Pharmacokinetic and pharmacodynamic studies of IACS injections

Pharmacokinetic studies were done after knee and glenohumeral joint injections. A pharmacokinetic study after knee IACS[27] compared TA with TA extended-release. They showed the median time to achieve peak plasma concentration (T_{max}) of triamcinolone after TA injection to be 6.5 (range 2, 360) hours and the median terminal half-life ($T_{1/2}$) to be 663.8 (range 18, 2067) hours (663 hours=27 days) after knee IACS. Another pharmacokinetic study looked at the triamcinolone levels after knee IACS injection of extended-release TA.[28] One study showed maximum synovial fluid concentration at week 1, when the sample was obtained, and maximum plasma levels at 24 hours that declined over weeks 6–12 for synovial fluid and weeks 12–20 for plasma levels.[28]

Another pharmacokinetic study compared standard TA with an extended-release form after glenohumeral joint IACS.[32] Lower peak levels and systemic levels of TA were noted after TA extended-release compared with TA. For TA, the T_{max} was 4 (1–57 hours) (median, range) and remained very high at 3–5 days after which it declined. The $t_{(1/2)}$ was 613 (287–1026) hours.[32] It should be noted that the plasma levels remained high up to day 15; $T_{1/2}$ ranged from 287 (12 days) to 1026 hours (42 days); and duration of measurable plasma levels was 839 hours (35 days).

Regarding pain relief after knee IACS, a study noted relief at 1 week that extended up to their 12-week follow-up, with both immediate-release triamcinolone and extended-release TA.[33] The above studies suggest that pain relief from IACS injections can last from a few weeks up to 3 months.

For SRs on corticosteroid pharmacology and AEs in IACS, see box 2.

FREQUENCY OF INJECTIONS AND CUMULATIVE DOSE: RESULTS OF SURVEY OF ORTHOPEDIC SURGEONS

The optimal frequency and the total number of corticosteroid joint injections for OA continue to be controversial. An American Association of Hip and Knee Surgeons survey of common injection practices yielded 537 members' responses.[34] Most used a 3-month minimum interval between repeat IACS in the same joint, although some respondents preferred a longer interval. The survey showed great variability in the number of injections allowed per year. Based on the available pharmacokinetic and pharmacodynamic data,[27 28 32 33] we suggest a *minimum* interval of 2–3 weeks, up to 3 months. The series of injections should be stopped when there is complete or acceptable pain relief or when the relief has plateaued, taking into consideration the maximum cumulative dose. Similar to other injections, the decision when to repeat the injection is between the patient and the physician, taking into consideration the pain and quality of life of the patient and specific patient characteristics that may put them at higher risk for adverse events.

Injections prior to a planned orthopedic surgery were common. Almost all responders used a local anesthetic mixture with the CSI. There were no distinctly defined yearly or lifetime limits. There was a strong consensus for a 3-month corticosteroid-free preoperative interval. There was a near consensus that the efficacy of serial injections decreases over time (as arthritis progresses).[34]

LANDMARK-BASED TECHNIQUES, ROLE OF FLUOROSCOPY, AND ULTRASOUND: GENERAL COMMENTS

Studies indicate that a landmark injection technique may be sufficient for accurate trochanteric bursa injections and that SASDB injections have been performed under landmark guidance. Some investigators advised that image-guided injections should be reserved for diagnostic arthrocentesis or for cases where complication risk is higher, for example, in patients with morbid obesity,[35] patients on anticoagulants, or after a previous landmark-based injection or aspiration failure.[35 36] In contrast, the accuracy of landmark-assisted glenohumeral, acromioclavicular joint, and SASDB injections has been questioned (see sections on glenohumeral and SASDB injections image-guided versus landmark guidance).

Our literature search did not show a study that compared fluoroscopy with landmark-based injection. Overall, studies showed improved accuracy of US-guided (USG) over landmark-based injections. One review showed the US to have improved accuracy over fluoroscopy in glenohumeral joint injections, but it did not reach statistical significance.[37] Two other studies showed comparable results in accuracy, pain relief, and functional outcomes between USG and fluoroscopy-guided glenohumeral joint injections.[38 39] A study showed significantly better accuracy with US compared with fluoroscopy in injections around the long head of the biceps, but there were no differences in pain relief or complications.[40]

Accuracy and outcomes of US-guided corticosteroid joint injections

Studies on the accuracy and outcomes of landmark and image-guided injections are discussed in the specific joint sections;

Box 3 Statements and recommendations on the role of imaging in intra-articular corticosteroid injections

Role of imaging

Statements

1. Ultrasound-guided techniques result in more accurate intra-articular needle placement than landmark-based techniques.
   Level of certainty: high
2. There are no significant differences in accuracy between ultrasound-guided and fluoroscopy-guided peripheral joint corticosteroid injections.
   Level of certainty: low
3. Compared with landmark-based techniques, use of image guidance may be associated with less pain on injection, improved patient satisfaction, and better short-term clinical outcomes.
   Level of certainty: low
4. Use of imaging guidance may be associated with fewer adverse events, including damage to periosteum and intravascular injection, after diagnostic or therapeutic arthrocentesis.
   Level of certainty: low

Recommendation

1. Image-guided techniques may be preferred for accuracy of intra-articular corticosteroid injections, especially in individuals with morbid obesity.
   Grade C

studies that involved several joints are discussed here. An RCT compared US with landmark-based injection in the wrist, hand, or ankle of 114 patients with chronic inflammatory arthritis including RA, psoriatic arthritis, or other spondyloarthritis.[41] The study showed better short-term outcomes, measured by functional and clinical scores, with the use of US guidance. A separate RCT of 184 patients with similar chronic inflammatory arthritis across shoulder, elbow, wrist, knee, and ankle found that USG injections had higher accuracy but showed similar clinical outcomes.[42]

A systematic review of 17 studies confirmed greater accuracy of USG IACS, compared with anatomic guidance, into the shoulder, elbow, wrist, hip, knee, or ankle joints and demonstrated better short-term clinical outcomes.[43] However, there were no differences in long-term outcome measures with either technique. A recent review noted increased accuracy of USG injections regardless of location, with the exception of the hip (due to a lack of comparative studies).[44]

For SRs on the role of imaging in IACS, see box 3. Discussions supporting the SRs on the role of imaging are noted in the section on specific joints.

Chronic shoulder joint pain: etiologies

The shoulder joint consists of the primary articulations of the acromioclavicular joint, between the clavicle and the acromion of the scapula; the glenohumeral joint, between the glenoid cavity of the scapula and the humerus; and the scapulothoracic articulation. The etiologies of chronic shoulder pain include acromioclavicular glenohumeral and OA, rotator cuff disorders, adhesive capsulitis (AC), and instability.[45]

Acromioclavicular osteoarthritis

The clinical presentation of acromioclavicular joint OA includes superior shoulder pain, joint tenderness, and a painful body cross adduction test. In the body cross test, the affected arm is elevated to 90 degrees; pain is reproduced in the acromioclavicular joint when the examiner takes the patient's elbow and adducts the arm across the body.[46] Patients with acromioclavicular OA usually present with gradual pain and loss of motion or a history of dislocation or subluxation.[45] Imaging studies are indicated when the diagnosis is not clear. MRI shows degenerative changes in the joint, osteophytes and/or hypertrophy of the clavicle and acromion, and joint edema.[47] As noted previously, IACS is recommended when there is no improvement with the initial conservative management.[48] Non-surgical management includes suprascapular nerve blocks.[49] There has been no dose-response study on IACS for the AC joint, although a dose of 40 mg MP has been injected under fluoroscopy.[46]

Adhesive capsulitis and glenohumeral joint disease

Disorders of and around the glenohumeral joint are multifactorial, resulting in frequent shoulder pain, with a lifetime prevalence as high as 67%, and significant functional impairment during and long after the initial painful episode.[50]

AC ('frozen shoulder') is a syndrome thought to involve the capsule of the glenohumeral joint, featuring characteristics of shoulder pain, stiffness with reduced range of active and passive motion, and otherwise negative radiographic findings.[51] ACs have been proposed to be a fibroproliferative disease[52] and may be either idiopathic or associated with trauma, tear, surgery, immobilization, or medical diseases (such as diabetes, stroke, thyroid disorders, or Parkinson's disease). Treatments include conservative analgesic management, physical therapy (PT), short-wave diathermy, IACS, intracapsular hydrodistension, manipulation under anesthesia, and arthroscopic release.

Glenohumeral instability is caused by trauma, repetitive motion of the shoulder (eg, throwing), high demand shoulder activities (eg, push-ups, bench presses), or loose ligaments leading to chronic shoulder instability. Treatment is conservative[48 53]; surgery is performed in recalcitrant cases.[54]

Tendinitis of the long head of the biceps

The long head of the biceps tendon is susceptible to trauma, instability, impingement, inflammation of the tendon sheath, instability, and degeneration, resulting in anterior shoulder pain. Patients with biceps tendinitis or tendinosis complain of a deep, throbbing ache in the anterior shoulder.[55] Repetitive overhead motion of the arm initiates or exacerbates the symptoms. A common isolated finding in biceps tendinitis is tenderness over the bicipital groove with the arm in 10 degrees of internal rotation.[55] Tests to diagnose tendinitis of the long head of the biceps include the Speed, Yergason, and upper cut tests. These maneuvers are considered positive when pain is elicited in the bicipital groove. A comparison of the tests concluded that the upper cut test should be used as the screening test and the Speed and Yergason tests as confirmatory tests for confirming disorders of the biceps tendon.[56] MRI can help differentiate between an isolated tear or inflammation of the biceps tendon and other shoulder pathology.

Similar to other causes of shoulder pain, treatment is conservative: rest, medications, and PT. Patients with tendinitis and tenosynovitis who do not respond to conservative treatment may benefit from USG CSIs into the biceps tendon sheath.

Scapulothoracic bursitis

Symptomatic scapulothoracic disorders include scapulothoracic crepitus and scapulothoracic bursitis, collectively called 'snapping scapula syndrome.'[57] Scapulothoracic crepitus is disruption of the normal gliding of the scapula over the thorax; inflammation of the bursa occurs when there is repetitive movement of the scapula over the thoracic wall (eg, baseball, swimming). Plain X-ray may show osseous lesions while CT or MRI reveal bursitis. Treatment is conservative,[58 59] with NSAIDs, activity modification, and rehabilitation. Landmark scapulothoracic bursa injection, between the serratus anterior and the lateral chest wall, has been described.[60 61] Surgery includes removal of masses or impinging osseous lesions, bursectomy, or scapulothoracic fusion.[57 59 62]

SHOULDER CORTICOSTEROID INJECTIONS

The non-surgical treatment of persistent shoulder pain is similar regardless of the etiology.[48 49 63 64] The initial treatment consists of activity modification and oral medications including NSAIDs, acetaminophen, corticosteroids, antidepressants, and opioids.[48 49 63 64] If there is no relief, heat modalities and PT focused on the specific etiology are instituted.

Injections of the shoulder are for either general shoulder pain or more specifically, adhesive capsulitis, rotator cuff disease/subacromial bursitis, OA of the glenohumeral and acromioclavicular joints, tendinitis of the long head of the biceps tendon, and for scapulothoracic disorders.

IACS and subacromial subdeltoid bursa corticosteroid injection

CSI for shoulder pain can be IA or subacromial (in or around the SASDB). IACS are done for acromioclavicular and glenohumeral joint pain and ACs, while SASDB are usually conducted for subacromial bursitis, rotator cuff disorders, and/or impingement syndrome (figure 1).[65]

The location target for CSI (IACS vs SASDB) for treatment of ACs has been studied. Chen *et al* conducted a meta-analysis of seven articles comparing IACS with SASDB for frozen shoulder and found that IACS reduced pain to a greater degree for up to 3 months compared with SASDB injection.[66] A review and a meta-analysis observed no difference between the two approaches and recommended that either approach can be used for ACs.[65 67]

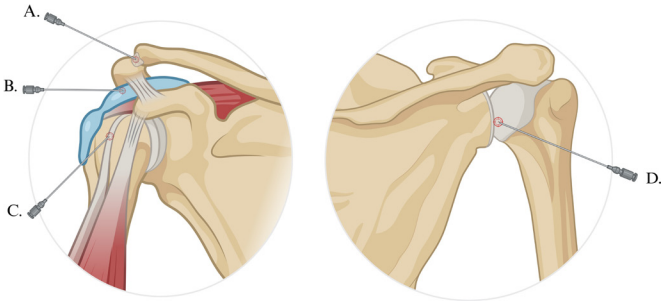

Figure 1 Injection sites for shoulder pain. A—acromioclavicular joint; B—subacromial subdeltoid bursa; C—long head of the biceps tendon; D—glenohumeral joint. Note that the injection is around the biceps tendon or tendon sheath. Image courtesy of Sebastian Encalada, MD, Mayo Clinic, Jacksonville, Florida.

In an RCT of 58 subjects with moderate-to-severe post-stroke shoulder pain and associated rotator cuff or biceps tendon disease, SASDB injection with corticosteroid conferred pain relief and range of motion (ROM) improvement in shoulder flexion for up to 8 weeks compared with lidocaine.[68]

Acromioclavicular and glenohumeral IACS: image-guided versus landmark guidance

A retrospective study showed that IACS USG injection for the treatment of painful acromioclavicular joint due to OA produced better pain and function outcomes than did landmark-guided IACS at 6 months.[69] A 2012 Cochrane review on shoulder IACS that included a meta-analysis of RCTs and non-RCTs showed better pain outcomes at 6 weeks with image-guided (US) over landmark-guided injections in three out of five trials.[70] However, the difference was no longer significant when trials with inadequate blinding and allocation concealment were removed.[70] A recent double-blind RCT between USG and landmark-guided injections for adhesive capsulitis did not show a difference in pain or functional outcomes despite greater accuracy of the USG injections.[71] This was confirmed in another study.[37]

For glenohumeral joint injections, there have been issues on the accuracy of landmark guidance.[72] For this reason, IACS injection into the glenohumeral joint under fluoroscopy was recommended.[48] One review showed the US to have improved accuracy over fluoroscopy in glenohumeral joint injections, but it did not reach statistical significance.[37] Two other studies noted comparable results in accuracy, pain relief, and functional outcomes between US-guided and fluoroscopy-guided glenohumeral joint injections.[38 39]

Subacromial subdeltoid bursa corticosteroid injections: landmark approaches

SASDB injections using landmark approaches can be administered via an anterior, lateral, or posterior approaches. An RCT including 50 subjects, which evaluated landmark-based mid-lateral (a variant of the lateral approach) versus the posterior subacromial approach, conferred greater accuracy for mid-lateral approach (92% vs 68%). However, there was no difference in functional clinical outcomes.[73] A similar RCT in 80 subjects with subacromial impingement syndrome showed no difference in Shoulder Pain and Disability Index (SPADI), night pain, or shoulder function for up to 12 weeks between posterior versus lateral approaches.[74] These results were confirmed in a review of five RCTs and three trials; however, they did not determine superiority of specific approaches in subacromial impingement syndrome.[75]

US-guided versus landmark injection subacromial subdeltoid bursa corticosteroid injections

SASDB may require less precision in view of its size (largest bursa in the body) and the superficial location of the subacromial space. A study showed similar accuracy between landmark and USG SASDB injections; the injection was located in the bursa in all cases. However, the injections were performed by either an experienced orthopedic surgeon or an experienced musculoskeletal radiologist.[36] A study questioned the accuracy of landmark techniques.[76] In this study, the investigators noted 76% (13 of 33 patients) accuracy with the posterior approach and 69% (10 of 33) accuracy with the anteromedial approach.[76] Most important, only the injection into the SASDB resulted in a significant reduction of pain and an improvement in the functional scores.

Two reviews compared the outcomes of USG versus landmark-based SASDB injection.[77 78] Some analyses favored USG based on 4-week outcomes.[77 79] A 2015 review of seven papers (445 patients) showed significantly greater improvement in pain and function with USG.[77] Such improved efficacy was not shown in a 2020 review of four papers (234 patients).[78] Some of the differences were based on study selection, but differences were also due to interpretation of the data. Analyses were complicated by multiple study outcomes (pain, function, ROM, or other global scores), heterogeneity across studies, and greater risk of bias (for the more inclusive meta-analyses). The sample sizes of all the primary RCTs included were small (fewer than 50 subjects per group).

Two other reviews on USG versus landmark injections looked at papers that included both SASDB and IACS. One group noted that while there was a statistically significant improvement, the clinical benefit was questionable and may not represent 'clinically useful differences'[80]; the other group showed a benefit for USG.[78] Overall, the studies showed that accuracy improved with USG injections, compared with landmark approaches in SASDB and IACS injections.

Dose-response studies after shoulder IACS and SASDB injections

An RCT in 60 patients with full-thickness rotator cuff tears compared a single IACS of TA 40 mg (one vs two vs no injections), 21 days apart.[51] Night pain and activity-related pain were improved among the CSI groups at 1 and 3 months. Long-term Constant-Murley shoulder score (a scale that assesses shoulder function based on pain, activities of daily living, strength, and ROM) was similar with treatment versus no treatment at 3–6 months. The two-injection steroid dose provided no benefit over the single-dose injection.

An RCT showed no difference in efficacy, measured by SPADI between 20 mg, 40 mg, and 80 mg TA IACS injected into the glenohumeral joint; all doses showed a reduction of SPADI at the 6-month follow-up.[81]

There is limited evidence on the use of biologic agents and inconclusive results for hyaluronic acid in glenohumeral joint injections.[64]

Two RCTs on IACS for adhesive capsulitis and shoulder joint stiffness showed no difference between 20 mg and 40 mg TA.[82 83] In one triple-blind placebo-controlled study in patients with adhesive capsulitis, the two doses were noted to be equally effective in terms of SPADI, VAS, and ROM at the shoulder up to the 12-week follow-up of the study.[82] Another RCT showed equal efficacy between the two doses in patients with shoulder stiffness.[83] Measures included VAS, ROM, and the American Shoulder and Elbow Surgeons score; relief lasted up to the 12-month follow-up.

Another RCT of 79 subjects with primary OA and full-thickness rotator cuff tear compared USG SASDB injection using TA 20 mg vs TA 40 mg vs placebo with follow-up at 8 weeks.[84] The SASDB injections improved pain VAS and active ROM for both doses over placebo throughout the study, but no difference between the TA doses.

In another RCT of SASDB for shoulder pain, 62 subjects were randomized to one of four groups by preparation (MPA vs TA) and dose (20 mg vs 40 mg). All groups' pain and function improved from baseline, but there were no differences between any of the four groups by either preparation or dose.[85]

A systematic review showed equal efficacy between NSAIDs and corticosteroids in SASDB injections.[86]

Biceps tendon sheath injection

A study showed that as much as 43% of patients with anterior shoulder pain presumed to have originated from the biceps tendon had normally appearing biceps tendon.[87] The others had tendinosis, tenosynovitis, or both, or tendon tear.

An RCT noted the accuracy (location of contrast in the tendon sheath confirmed by CT) of USG to be 87% compared with 27% for landmark technique.[88] Another RCT showed significantly better pain relief with USG injection than 'free-hand injection' without US, and significantly greater improvement in the Constant-Murley score at 31–34 weeks follow-up.[89] A later RCT compared the superior accuracy of US over palpation-guided injection into the bicipital groove (100% vs 68%) with less discomfort.[90] Pain relief and improvement in QuickDASH scores at the 4 weeks and 6 months follow-up were significantly better with US. An additional benefit of US is that it permits visualization of the anterior circumflex artery in proximity to the tendon and potentially avoid it.

Fluoroscopy-guided injections were noted to be effective in relieving the pain from biceps tendinitis.[91] However, this retrospective study only looked at six patients. US was noted to be more accurate than fluoroscopy-guided biceps tendon sheath injection. A 10-year retrospective review noted that the first-pass rate (91% for US vs 74% for fluoroscopy) and final-pass rate (98% vs 90%) were better for US, with no difference in pain relief or complications.[40] An additional benefit of US is the visualization of abnormalities of the biceps tendon.

The commonly used doses are triamcinolone 40 mg in 9 mL bupivacaine[90] or 40 mg TA in 1 mL lidocaine (reduced to 20 mg in patients with diabetes).[89] There are no dose-response studies.

Biceps tendon rupture is usually due to degenerative changes and to trauma.[92] Tendon rupture can be a consequence of CSI (see section on adverse events cartilage, ligament and tendon health).[92–94] Interestingly, peritendinous CSI has been used as treatment for partial biceps tendon tear.[92] Vardakas *et al* described seven cases of partial tear; four of the seven had 'at least one injection of steroid' as treatment. They did not state the effect of CSI but rather discussed the surgical technique that followed.[92] Lee *et al* discussed 21 patients with biceps tendinitis and partial rupture who were treated with CSI (USG injection of TA 40 mg in 1 mL NS and 2 mg ropivacaine into the tendon sheath): 10 patients with biceps tendinosis had good to excellent results, while three patients with partial tear had good to excellent results.[95]

Scapulothoracic bursa injection

Landmark scapulothoracic bursa injections have been described. The patient is in prone position, with the affected arm in extension, internal rotation, and adduction, attempting to reach the upper spine, in what is known as the 'chicken wing' position.[60 61] The spinal needle is inserted midway between the spine of the scapula and the inferior angle of the scapula and three to four fingerbreadths from the vertebral border of the scapula. This is not frequently done because of the risk of pneumothorax. A USG subscapularis muscle injection has been described, with the insertion site at the lateral border of the scapula.[61] TA 40 mg subscapularis muscle injection provided equal relief for up to 3 months, compared with subscapularis bursa injection. Either TA 40 mg in 4 mL lidocaine or TA 40 mg plus hyaluronate resulted in significant relief of pain of up to 3 months.[60 61]

Comparison of corticosteroids versus other therapeutic modalities or agents in shoulder injections

A meta-analysis of single CSI versus conservative management with NSAIDs for shoulder pain (ACs, subacromial impingement syndrome, nonspecific pain, tendinitis) was performed and included eight RCTs involving 465 subjects.[96] CSI showed favorable benefit over NSAIDs for improved function (Disabilities of the Arm, Shoulder, and Hand (DASH) and Oxford Shoulder Score) at 4–6 weeks (primarily seen for ACs and painful shoulder rather than shoulder impingement) but no benefit in pain relief. No differences in complication rates were noted.[96]

A meta-analysis including six RCTs (301 subjects) compared CSI with PRP for pain associated with rotator cuff lesions (tears, tendinosis, impingement). The analysis found short-term (3–6 weeks) benefits in pain relief and function for the CSI group, but no clinical differences at either intermediate (8–12 weeks) or long-term outcomes (over 12 weeks).[97]

A review and meta-analysis of three studies noted that, in patients with subacromial impingement syndrome, SASDB conferred short-term functional improvement compared with PT at 6–7 weeks, but otherwise there were no differences in pain, function, or ROM up to 12 months.[98] However, there may be an additive benefit of combining PT (specifically resistance band training) to SASDB to improve ROM and reduce the need for retreatment of subacromial bursitis after SACS.[99]

Adverse effects of shoulder corticosteroid injections

A review of RCTs evaluating guidance-based shoulder CSI directed to the glenohumeral joint, the subacromial subdeltoid space, or tendon sheaths compared landmark-guided versus image-guided (fluoroscopy or US). There was a trend towards lower AEs (all mild) for image-guided CSI, although not significant.[79]

In 1979, 13 cases of tendon rupture were reported after corticosteroid injection, seven of which involved the long head of the biceps.[93] Triamcinolone 40 mg in procaine was injected in the cases. The interval from injection to rupture ranged from 3 days to 5 months. Treatment was conservative; three required surgical repair.[93] A case report noted the progression of a partial tear of the biceps tendon to complete tear after a *palpation-guided* corticosteroid injection.[94] As noted previously, peritendinous CSI has been reported in patients with partial biceps tendon tear.[92 95]

AEs related to CSIs are discussed in the section on general AEs.

Comments

In this section, we discussed different shoulder injections: IA, SASDB, and biceps tendon sheath. SRs specific to these approaches are presented in box 4. General comments, not noted in the SRs, include the following:

Studies and reviews had conflicting results and conclusions. Overall, US improved the accuracy of acromioclavicular and glenohumeral joint, SASDB, and biceps tendon sheath injections. This did not translate into better functional outcomes in acromioclavicular joint or SASDB injections.

Peritendinous CSI into the biceps tendon has been reported to be effective in patients with biceps tendinosis and in patients with partial tear of the biceps.

Peritendinous CSI injection is controversial in view of possible tendon rupture when the injection is made into the tendon. For this reason, we did not create an SR. The clinician is advised to make an informed decision with the patient.

Box 4 Statements and recommendations on intra-articular corticosteroid injections in shoulder and elbow

Shoulder joints

Statements

1. Lower corticosteroid doses equivalent to 20 mg triamcinolone or methylprednisolone in IACS and SASDB shoulder injections are equally effective as higher corticosteroid doses.
   Level of certainty: moderate
2. Corticosteroid injection (CSI) of the shoulder provides short-term improvement (up to 8 weeks) in pain and disability over no treatment or placebo for painful shoulder disorders and should be considered for adhesive capsulitis (AC) and other painful disorders of the shoulder (subacromial subdeltoid impingement syndrome, subacromial subdeltoid bursitis, biceps tendinopathy).
   Level of certainty: high
3. Physical therapy or home exercise, in conjunction with CSI of the shoulder, is beneficial for painful shoulder disorders, including AC and subacromial bursitis.
   Level of certainty: moderate

Recommendations

1. The recommended initial CSI can be performed with corticosteroid equivalent not exceeding 20 mg triamcinolone or methylprednisolone.
   Grade B
2. Shoulder CSI should be offered for short-term pain relief of moderate-to-severe pain, disability from shoulder impingement syndrome, bursitis, rotator cuff tendonitis, or tendinopathy if no other conservative treatment options are available or successful.
   Grade B
3. Physical therapy or home exercises should be offered in conjunction with shoulder CSI.
   Grade B

Tendinitis/Tendinosis of the long head of the biceps

Statements

1. For biceps tendon injections, ultrasound (US)-guided injections improve accuracy, pain relief, and functional outcomes compared with landmark techniques.
   Level of certainty: high
2. US-guided injections provide higher accuracy of injections than fluoroscopy-guided injections, with similar analgesic benefit.
   Level of certainty: low

Recommendations

1. US guidance is recommended over landmark technique for peritendinous injection of the long head of the biceps.
   Grade A
2. Fluoroscopy guidance is recommended over landmark technique for peritendinous injection of the long head of the biceps.
   Grade B

Elbow joint

Statements

1. Extra-articular CSI are effective in the short term for treatment of lateral epicondylosis.
   Level of certainty: low
2. There is no evidence to support long-term benefit for CSI for epicondylosis compared with conservative management

Continued

Box 4 Continued

or PT. The long-term improvement may reflect the natural history of the condition.
Level of certainty: low

3. For non-septic olecranon bursitis, aspiration followed by CSI is safe and may result in earlier improvement in symptoms compared with aspiration alone or compression with bandaging.
Level of certainty: low

Recommendations

1. An administration of CSI may be considered for short-term treatment of pain due to *lateral epicondylosis* unless contraindicated.
Grade C
2. Aspiration with injection of corticosteroid may be offered for non-septic olecranon bursitis.
Grade B

There is insufficient data to create a position statement regarding the preferred CSI approach for SASDB injections (anterior, lateral, posterior) to improve pain, function, or safety for painful shoulder disorders.

We *suggest a minimum interval of 2–3 weeks*, up to 3 months, between injections. A repeat injection is based on a shared decision between the patient and the physician, balancing the intensity of the recurring pain and the adverse events associated with CSI.

ELBOW INJECTIONS

Medial and lateral epicondylitis/epicondylosis

Painful syndromes in the elbow, including lateral epicondylitis/epicondylosis (LE) and medial epicondylitis/epicondylosis (ME) when refractory to conservative management (including PT), are sometimes treated with CSI. LE, commonly known as 'tennis elbow,' presents with lateral elbow pain reproduced with extension of the wrist. ME, commonly known as 'golfer's elbow,' presents with medial elbow pain reproduced with flexion or pronation at the wrist. ME can also be reproduced with provocative maneuvers enhancing this motion or with valgus stress testing.

Injection treatment for lateral epicondylosis

A study noted similar results in terms of pain relief and functional outcomes after USG or palpation-guided betamethasone injection of the lateral epicondyle.[100] As noted previously, a study showed significantly better efficacy of combined corticosteroid and local anesthetic, compared with local anesthetic alone, in patients with lateral epicondylitis.[19]

Several systematic reviews have examined CSI for LE.[101–106] An early review found the role of CSI for LE to be mostly inconclusive, but CSI for LE might provide benefit in short-term (2–6 weeks) relief.[106] Another early systematic review of CSI for elbow and shoulder tendonitis[105] found short-term (<8 weeks) benefit of CSI, without long-term benefit compared with pooled other comparators (placebo, PT, NSAIDs). Another review identified 12 studies and characterized the findings as indicative of strong support for the efficacy of CSI in the short term compared with no intervention, NSAIDs, PT, and orthoses.[104] However, CSI was found to be less efficacious, in terms of reduction of pain, than no interventions at 26 and 52 weeks.[104] A review of therapies for LE favored CSI for short-term improvements in pain, function, and global improvement over placebo, local anesthetic, orthoses, PT, and oral anti-inflammatories.[107] However, PT and NSAIDs were more effective in the long term. Furthermore, CSI was associated with more frequent LE recurrence compared with PT alone.[107] A later review identified 10 clinical trials assessing CSI for pain due to lateral epicondylosis, seven of which were published after 2000. CSI conferred analgesic benefit for up to 8 weeks after an injection for LE.[102] Overall, the reviews noted short-term (<8 weeks) relief from CSI.

An RCT (not described in the identified systematic reviews noted above) compared NSAID therapy, PT, and CSI for treatment of 60 patients with LE. Patients receiving PT showed modest improvement in grip strength at 2 weeks and improved pain at 2 weeks and 4 weeks compared with the CSI and NSAID.[108]

A recent RCT compared stretching and splinting therapies, deep friction massage, and CSI for the treatment of LE (n=41) and found improvement (decrease in VAS score) for those patients treated with CSI at 6 and 12 weeks (from 45.4 to 31.4) as well as improvement in grip strength (from 46.7 to 60.5 pounds).[109] However, similar clinical improvement was also seen in the traditional therapy and deep friction massage groups at early follow-up, with no statistical difference among the steroid, therapy, and massage groups. Neither the CSI nor the stretching and splinting group sustained improvement in VAS score at 6-month follow-up, and only the deep friction massage group experienced improved pain (6.7 to 1.3, p=0.002) and function (disability of the arm, shoulder, and hand; DASH—a 30-item questionnaire based on the patient's ability to perform specific activities related to daily living and recreation, and weakness and stiffness of arm, shoulder, or hand score increase from 48.6 to 10.3) at 6 months.

In the studies reviewed above, TA or MPA were mostly used, with betamethasone and dexamethasone used in very few investigations. Doses of TA employed the whole range (20, 40, 80 mg), 20 and 40 mg for MP, 6 mg for betamethasone, and 4 mg for dexamethasone; 1–2 mL volumes were injected.

Corticosteroid injections versus platelet-rich plasma and autologous blood for LE

Other reviews have compared CSI for LE with PRP[110] and autologous blood. A review and meta-analysis comparing the safety and efficacy of injection of autologous blood products with corticosteroids for the treatment of LE identified a total of 10 studies with 509 patients.[101] CSI was more effective in the short term, but autologous blood products provide more pain relief and improved function in the intermediate and long term. The study described high recurrence rates of LE following CSI, 72% at 6 weeks and 37% at 6 months.

Another meta-analysis compared CSI with PRP and autologous blood in terms of improved function and pain.[111] Of the 10 studies analyzed, comparisons between PRP, autologous blood, and CSI focused on three studies with results from within 2 months. These studies favored PRP and autologous blood in terms of improved function and pain pressure threshold. However, CSI had a more favorable AE profile compared with autologous blood.[111]

Finally, a meta-analysis showed limited favorability for CSI over PRP in the short term (4–8 weeks), but no difference in the long term (24 weeks).[110]

AEs from CSI in lateral epicondylosis

Common AEs include postinjection flare, minor rash, transient pain (around 11%), skin atrophy, and depigmentation

(4%).[105 107] In one study, the rate of pain following CSI was substantially higher compared with injection of local anesthetic (50% vs 11%).[112] No serious AEs such as tendon rupture or infection were identified in the reviews. There is a statistically higher risk of local pain and skin reaction after injection of autologous blood compared with CSI but not between PRP and CSI or PRP and autologous blood.[111]

Injection for medial epicondylosis

There is a paucity of studies investigating CSI for ME. Injection of 40 mg MPA in 1 mL lidocaine provided better short-term benefit at 6 weeks over lidocaine and saline injection.[113] However, there was no difference in effect at 3 months and 1 year. The authors believed that the improvement reflected the natural history of the condition.

Intra-articular elbow joint injection

Pain associated with the elbow joint may be due to OA, RA, or crystalline arthropathies.[114 115] Few publications have focused on IACS for the elbow, and there were no pharmacokinetic studies after elbow IACS injections. When the elbow was studied, it was one of several joints included in the study.

Injection for olecranon bursitis

A 2016 RCT evaluated the resolution of non-septic olecranon bursitis comparing 90 patients randomly assigned to either NSAIDs (and compression bandaging), aspiration, or aspiration with CSI (n=90; 40 mg TA in 1 mL lidocaine) for the treatment of non-septic olecranon bursitis.[116] The proportions of patients experiencing resolution (by VAS score) by week 4 were similar among the three groups. CSI with aspiration was associated with the earliest mean resolution at 2.3 weeks compared with aspiration alone (3.2 weeks) or NSAIDs with compression bandaging (3.2 weeks). There were no AEs or complications reported.

In summary, CSI confers short-term (up to 8 weeks) pain relief for LE. Further research is required on the utilization of CSI for ME and olecranon bursitis. For this reason, no SR is provided for medial epicondylosis. For SRs on IACS in shoulder and elbow, see box 4.

Hip pain

Hip pain is most commonly caused by OA or other inflammatory arthritis (such as autoimmune or crystalline disease) of the femoral-acetabular joint, and by greater trochanteric pain syndrome (GTPS). Other reasons for hip pain include osteonecrosis, femoral acetabular impingement, or labral tear.[117 118] CSIs are used for patients who fail to respond to pharmacological and non-pharmacological managements, or for patients who are looking for short-term pain relief where hip surgery is either not an option or delayed.[10 18 118–120]

As noted earlier, the recommendations from different organizations regarding IACS into the hip are listed in table 3.[10–12 16–18 121]

General comments on image-guided hip injections

IACS injections can be performed using landmark technique, fluoroscopy, US, or CT.[69 122 123] Fluoroscopically guided hip injections were noted to be more accurate than non-image-guided hip injections.[124] For diagnostic purposes only, one study showed comparable accuracy between USG and fluoroscopy-guided injections in obtaining arthrography of the hip joint,[125] while another study noted similar accuracy, less pain, and better patient preference in USG injections.[126] A review noted the absence of comparative data to show increased accuracy with US or X-ray guidance in IA hip injections.[17]

INTRA-ARTICULAR HIP CORTICOSTEROID INJECTIONS

An RCT compared 40 mg IACS TH versus saline (both with bupivacaine).[123] Significant improvements in Western Ontario and McMaster Universities Osteoarthritis (WOMAC, a questionnaire on pain, stiffness, and physical functioning of the joints) index were noted at 1-month and 2-month follow-up for the IACS group. Open-label follow-up showed continued improved outcomes at 3 months (but not 6 months). The authors concluded that IA corticosteroid hip injection can be an effective treatment of pain in patients with hip OA, 'with benefits lasting up to 3 months in many cases.'

Corticosteroid versus non-corticosteroid anti-inflammatory intra-articular injections

A retrospective comparative study showed no difference in efficacy between IA 40 mg triamcinolone and 30 mg ketorolac in patients with hip OA; the verbal numeric pain scores did not show differences at 1, 3, and 6 months.[127] A double-blind RCT study examined comparative effectiveness of USG IACS injection with IA ketorolac injection in patients with symptomatic hip OA.[128] IA injections with either ketorolac or triamcinolone produced significant improvements in patient-reported outcome measures, with the largest improvements at 1 week, which decreased over time. There were no significant differences between ketorolac and triamcinolone. There were no significant side effects from either intervention. Ketorolac could therefore be considered in patients at risk for steroid AEs, as a low-cost option.[69 128]

An RCT examined the comparative efficacy of IA hip injections of hyaluronic acid, corticosteroid, and normal saline in patients with hip OA.[129] Patients treated with 40 mg triamcinolone experienced greater improvement 28 days after IACS injection than did patients assigned to the hyaluronic acid group. The outcome domains were pain on walking and at rest, WOMAC, and Lequesne index. There was no difference in the patients' global assessment of pain. Hyaluronic acid had a considerable effect on patients without effusion but had no effect in the patients with effusion. On the contrary, corticosteroids influenced both patients with and without effusion. The peak effect of the CSI was observed 2 weeks postinjection. The improvement from normal saline injection was insignificant.[129] Another prospective RCT produced a similar result.[130] Patients with hip OA were randomized to one of four groups, including non-interventional care (no injection) group and three groups receiving injections: normal saline, hyaluronic acid, and MP. The CSIs were found to be highly efficacious, specifically pain, WOMAC pain, and function improved significantly for the steroid group alone.[130] The corticosteroid response was maintained for 8 weeks.

Three systematic reviews compared IACS with placebo (saline), PRP, and hyaluronic acid. The studies were heterogeneous in the degree of OA, all trials with different sample sizes, medications used, and timing of follow-up. The most used dose was 40 mg triamcinolone or MP. All reviews showed improvement in pain and function with IACS that lasted 4 or 6 months.[131–133] IACS showed better results than hyaluronic acid.[131–133] In a network meta-analysis (with the same above limitations), despite no mean statistical differences across treatments (including saline), IACS was rated as the most favorable treatment by surface under the cumulative ranking curve (a score that represents numeric ranking of treatments, with a greater value indicating greater

efficacy) analysis at 2–4 months (both pain and function), whereas HA and PRP had favored rating at 6 months.[133]

Two recent systematic reviews compared the clinical outcomes, in terms of pain and function, between NSAID injection and IACS in hip OA. One review noted no difference[86]; both groups showed significant improvement for 3–6 months. The other concluded that IACS injections were more effective.[134]

Volume of injectate and dose of corticosteroid

The reported volumes of IA hip injection vary from 3 mL to 12 mL. In one randomized study, patients were given either 40 mg triamcinolone and 2 mL bupivacaine or 6 mL of sterile water injection. There was no significant statistical or clinical difference in functional scores between the two groups at 3 months. Since there is no detriment to using a larger volume of injectate, the investigators recommended that practitioners use total volumes between 3 and 9 mL.[135]

As noted in the above studies, the most commonly used dose for hip IACS is 40 mg triamcinolone or MP.

For statements and recommendations on IACS in hip and knee injections, see box 5.

Peri-articular hip injections: greater trochanteric bursitis, gluteus tendinopathy, snapping hip syndrome

GTPS is characterized by pain around the greater trochanter and may radiate distally over the lateral aspect of the thigh. It is more common in women. GTPS can be caused solely or by a combination of trochanteric bursitis, gluteus medius or minimus tendinopathy, or snapping hip (palpable or audible snapping with active hip motion).[136] The current thinking is that GTPS is mostly caused by gluteal tendinopathy.

Greater trochanteric bursitis

There are four bursae around the greater trochanteric prominence: subgluteus maximus bursa, subgluteus medius bursa, subgluteus minimus bursa, and gluteofemoral bursa.[137] The subgluteus maximus bursae, located lateral to the great trochanter, are the largest and most incriminated in trochanteric bursitis. Greater trochanteric bursitis is denoted by pain over the buttock and lateral aspect of the thigh that may radiate down the leg to the proximal tibia, at the level of the insertion of the iliotibial tract.[137] The patient has pain when lying on the affected side, pain in the area when climbing or descending stairs, or when rising from a seated position. Physical examination shows pain on pressure on the greater trochanter; Jump sign is positive (table 4). There is anechoic fluid in the greater trochanter on US.[138] MRI shows high signal intensity of the bursa on fluid-sensitive sequences.[137] Greater than 50% relief after CSI (40 mg TA in 6 mL local anesthetic) under US has been used to diagnose trochanteric bursitis.[137] Greater trochanteric bursitis as a cause of GTPS is lower than previously thought. A US study of 877 patients with GTPS noted 50% had gluteal tendinosis, 0.5% with gluteal tendon tears, and 28.5% with thickened iliotibial band. Only 20% had trochanteric bursitis.[138]

Gluteus medius/minimus tendinopathy

Gluteus medius/minimus tendinopathy is characterized by lateral hip pain localized to the greater trochanter. There is discomfort with walking and stair climbing and pain lying on the affected side. Signs include tenderness at the greater trochanter and localized lateral hip pain with flexion, abduction, and external rotation testing. The hip-lag sign and the Ossendorf and Lequesne tests are positive (table 4). There is pain with resisted

Box 5 Statements and recommendations on intra-articular corticosteroid (IACS) injections in hip and knee joints

Hip injections

Statements

1. IACS hip injections are commonly performed procedures that can be used as a diagnostic tool in pain due to hip osteoarthritis or as a treatment modality for short-term (4–12 weeks) pain relief.
   Level of certainty: high
2. Potential adverse effects of standard doses of IACS hip injections may include accelerated cartilage loss, subchondral insufficiency fractures, osteonecrosis, and rarely rapid joint destruction.
   Level of certainty: moderate
3. Pre-injection/screening X-ray of the hip joint may help to verify baseline pathology, for example, osteonecrosis with preserved femoral head, that would preclude corticosteroid injection.*
   Level of certainty: moderate
4. Education and exercise, in conjunction with IACS, result in better global improvement than IACS alone in patients with greater trochanter pain syndrome at 1 year postintervention. Pain relief is similar after both interventions.
   Level of certainty: low
5. Safety and accuracy of greater trochanteric bursa corticosteroid injections are similar across injections performed using landmarks, fluoroscopy, or ultrasound.
   Level of certainty: moderate

Recommendations

1. Caution should be taken with intra-articular hip injections using high-dose corticosteroids and multiple injections. Consider using the lowest effective dose of corticosteroids for IACS of the hip while extending the time interval between repeat CSI.
   Grade B
2. Consider using a 40 mg dose of triamcinolone or comparable dose of another corticosteroid for IACS hip injection.
   Grade B
3. Pre-injection/Screening X-ray of the hip joint should be performed prior to IACS hip injection to verify baseline pathology including osteonecrosis.*
   Grade B
4. Patient education and home physical therapy exercises should be offered in conjunction with or prior to CSI for greater trochanter pain syndrome.
   Grade B
5. Hip trochanteric bursa injections can be performed using landmark guidance.
   Grade B

Knee injections

Statements

1. The lowest effective dose for triamcinolone acetate and methylprednisolone acetate is 40 mg. TA and MPA are non-superior in comparison with each other; both are similarly effective for the clinical treatment of knee arthritis.
   Level of certainty: high

Continued

Box 5 Continued

2. Repeat IACS are associated with small volume cartilage loss, with the effect likelihood and size increasing with higher doses and/or extended duration of therapy.*
   Level of certainty: high

Recommendations

1. IACS for knee osteoarthritis should use the lowest effective doses of corticosteroids while increasing the time interval between repeat injections when possible.
   Grade A
2. The recommended initial maximum intra-articular knee triamcinolone acetonide dose is 40 mg, or another particulate corticosteroid equivalent.
   Grade A

*Some of the studies supporting statements and recommendations related to harmful developments are discussed in the section on adverse events Accelerated joint space narrowing and osteonecrosis, and Cartilage, ligament, and tendon health.

hip abduction and with resisted hip internal rotation.[139] MRI (increased signal intensity or tendinitis, soft tissue edema, tear) and US (tears, absence of tendon fibers, muscle wasting) can document the presence of gluteal tendinopathy and tears.[140]

Snapping hip syndrome

Snapping hip syndrome, also called 'coxa saltans,' is characterized by a perceptible or audible snap in the hip area and may be accompanied by pain.[141] It occurs in two forms: internal or medial (ISHS) secondary to the iliopsoas tendon movement, and external or lateral (ESHS) commonly due to the iliotibial band.[141]

ISHS is generated by movement of the iliopsoas tendon, and an audible snap is noted in the anterior portion of the hip. Etiologies include anatomic variabilities of the iliopsoas tendon, or acetabular cup malposition or anterior protrusion of the screws after THR. Physical examination findings include tenderness to palpation and positive Thomas and Stinchfield tests (table 4).[142 143] Both tests rely on hip flexion and strain the iliopsoas. MRI may show edema around the iliopsoas, while US may reveal evidence of tendinopathy (abnormal foci of hypoechogenicity or thickening of the tendon), bursitis (peritendinous fluid collection) and increased blood flow around or within the iliopsoas tendon.[144]

ESHS is more prevalent, characterized by pain in the lateral aspect of the thigh. It is ascribed to the movement of the iliotibial band over the greater trochanter, seen during deep hip flexion or rotation. Etiologies include iliopsoas tightness or bursitis or hypertrophy of the psoas tendon. Tests include the Ober and hula-hoop tests (table 4).[141 142 145] MRI may show edema, increased signal, or tears in the iliotibial band. Treatment includes PT, NSAIDs, or CSI into the trochanteric bursa.[144] Surgery is performed in refractory cases: release of iliotibial band or endoscopic gluteus maximus tendon release. The proximal iliotibial band syndrome should not be confused with the distal IT band friction syndrome at the knee (see below).

Use of imaging in peri-articular hip injections

Earlier reports suggested that peri-articular hip injections (figure 2) can be performed using landmarks, fluoroscopy, or US.[35 146–149] A cadaveric study of 24 hip specimens (body mass index unknown) compared the accuracy between landmark-guided and USG greater trochanteric bursa injections.[150] The accuracies (intrabursal injection) were 67% for landmark vs 92% for USG, with no statistically significant difference (p=0.25), although the study may be underpowered to detect a statistical difference. Using landmark guidance, a clinical study showed attainment of a bursagram in 45% of the patients on the first attempt, 23% on the second attempt, and 23% on the third attempt.[147] In a subsequent study, the same investigators noted similar positive bursagram and similar functional outcomes (Oswestry scores, 36-Item Short Form Survey, patient satisfaction) between fluoroscopy and landmark-guided trochanteric bursa corticosteroid injection (60 mg MPA plus 2.5 mL local anesthetic).[148] In patients with obesity, trochanteric bursa injections under fluoroscopy significantly reduced immediate and 1-week postinjection pain scores.[151]

Table 4 Clinical tests in greater trochanteric pain syndrome

Diagnosis	Test	Description
Greater trochanteric bursitis	Jump sign	Severe sensitivity and intense pain on pressure over the most prominent ridge of the greater trochanter that the patient wants to 'jump off' the bed.
Gluteus medius/minimus tendinopathy	FABER test	Ipsilateral hip pain with flexion, abduction, and external rotation.
	Ossendorf test	Patient in lateral position, the knee of the tested side is flexed to 45°, and the hip passively abducted and the leg passively elevated by the investigator. The patient is asked to bring his knee in the direction of the examination table. The test is regarded as positive if no internal rotation is possible, the maneuver is painful, or groin pain is elicited.
	Hip lag sign	Patient in lateral position, with the affected leg up. The examiner positions one arm under this leg, whereas the other hand stabilizes the pelvis. The hip is passively extended to 10°, abducted, and rotated internally as far as possible, while the knee remains in a flexed position. The patient is asked to hold the leg actively in this position. The test is positive if the patient is not able to keep the leg in the abducted, internally rotated position, and the foot drops >10 cm.
Internal snapping hip (iliopsoas tendon/bursa)	Thomas test	Patient lies supine and pulls the unaffected knee to the chest. The test is positive if the patient is unable to keep the affected limb fully extended on the examination table or feels a stretch in the groin.
	Stincfield test	Patient lies supine with the hip at 30° and is asked to fully flex the hip against resistance; the test is positive when internal snapping is reproduced.
External snapping hip (iliotibial band)	Ober test	Patient lies on the non-painful side and raises the knee up and down with the knee at a right angle; the test is positive when there is anterior groin pain with visible or audible snapping.
	Hula-hoop test	Patient stands with adduction and circumduction of the affected hip; a positive test is the presence of a snap over the greater trochanter.

Ossendorf test and Hip Lag Sign are tests of hip abductor muscle (gluteus medius/minimus) tear, rupture, or damage. Thomas test and Stincfield test rely on hip flexion.

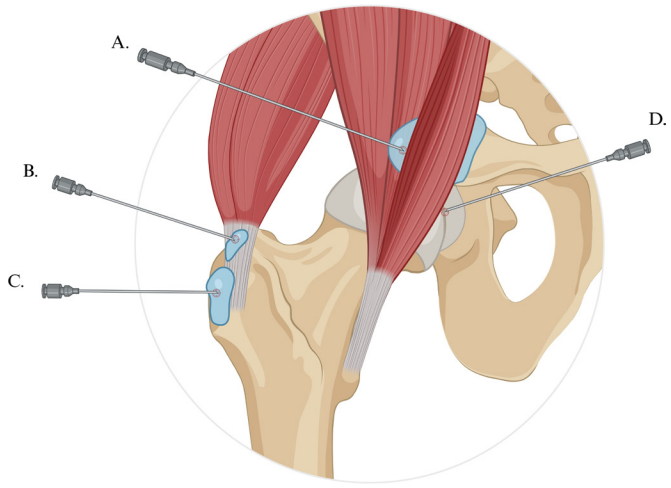

Figure 2 Injection sites for hip pain. A—iliopsoas bursa; B—gluteus medius/minimus tendon sheath; C—greater trochanter bursa; D—hip joint. Note that the injection is around the gluteus medius/minimus tendon or tendon sheath. Image courtesy of Sebastian Encalada, MD, Mayo Clinic, Jacksonville, Florida.

There has been no study that compared US and landmark injections; most studies used US guidance, and two involved fluoroscopy.[148 151] While studies showed no statistically significant benefit with imaging (fluoroscopy or US), the use of fluoroscopy or US is recommended in patients with obesity where palpation of the greater trochanter can be difficult or when landmark-based injections have failed.

US guidance has been recommended for tendon sheath injections and iliopsoas bursa injections.[152] There has been no study that compared landmark with US in gluteus medius/minimus tendon injections. Visualization of the tendon with US is an obvious advantage to prevent intratendon injection and possible rupture.

There has been no study comparing iliopsoas injection with image-guided (US or fluoroscopy) versus landmark-guided techniques. Fluoroscopy-guided iliopsoas bursa CSI (TA 40 mg in 5 mL lidocaine) has been described with the center of the acetabular roof as the target area and confirmed by injection of contrast.[153] The study of 39 patients showed 49% had 'clinically relevant improvement' at 1-month follow-up. A cadaver study noted 90% accuracy with USG injection, with the injectate covering 50%–100% of the iliopsoas tendon.[154]

Treatment of GTPS, efficacy of injections

Treatments of GTPS include PT, analgesics, NSAIDs, injections; surgery is performed in recalcitrant cases.

Trochanteric bursa injection

Small observational studies suggested that local CSI may be beneficial in the management of trochanteric bursitis.[155 156] CSI using 60 mg MPA in 2.5 mL lidocaine, performed either with fluoroscopy or landmarks, resulted in >50% pain relief at 1 month (61% of patients) and at 3 months (44% of patients), with a perceived positive global effect.[148] TA 20 mg in 3 mL local anesthetic under fluoroscopy significantly reduced the pain at 1-week follow-up.[151] A review noted that injection into the 'greater trochanteric bursa' (specifically, the subgluteus maximus bursa) in patients with trochanteric bursitis resulted in longer pain reduction compared with injection into the gluteus medius bursa or extrabursal sites. Additionally, image-guided injections resulted in maintained lower pain scores for up to 6 months.[157]

Two randomized trials compared CSI into the greater trochanter with other modalities.[158 159] An RCT showed CSI (25 mg prednisolone in 4 mL mepivacaine) into the point of maximal tenderness or swelling in the greater trochanter to be more effective than home training (progressive repetitive exercises) or shock wave therapy at 1 month but not at 4 months or 15 months.[159] Another RCT showed that CSI (40 mg TA in lidocaine) into the point of maximal tenderness in the greater trochanter provided more pain relief at 3 months follow-up than usual care (analgesics, physical therapy), but there was no difference at 12 months.[158]

A randomized double-blind placebo-controlled (normal saline) trial investigated the efficacy of CSI (1 mL betamethasone in 4 mL lidocaine) in GTPS (lateral hip pain reproduced by palpation of the greater trochanter).[160] Under US guidance, the injection was made either within the peri-trochanteric bursa (if visualized) or at the surface of the distal gluteus medius tendon near its insertion at the postero-lateral facet of the greater trochanter. There was no difference in pain relief after 1 month, although there was a trend towards improvement in pain scores in favor of the corticosteroid ($p=0.08$). There were no significant differences at 3 or 6 months.[160] The investigators concluded that CSI for trochanteric bursitis is of limited benefit, that glucocorticoid injections are of no greater efficacy than the injection of normal saline solution in patients with GTPS. It is important to note that the injection of saline for trochanteric bursitis is not truly a sham procedure (relief may be due to washout of inflammatory mediators).

Extra-trochanteric bursa injections

Needle manipulation with or without injectate injection or aspiration is one of the treatment options for GTPS. In one study, the diagnosis of GTPS was the presence of pain 'anywhere from the iliac crest to the mid-iliotibial band.'[161] This RCT of CSI (80 mg MPA in 8 mL local anesthetic into the point of maximal tenderness in the greater trochanter) versus dry needling in patients with GTPS showed non-inferiority of dry needling for pain and function scores at 6 weeks.[161] In this study, the site of dry needling was determined by the therapist but usually involved trigger points in the gluteus maximus/medius/minimus, piriformis, or tensor fascia lata.[161] Another RCT showed that the efficacy of USG CSI (80 mg MPA in 7 mL local anesthetic) and extracorporeal shock wave therapy were similar at 3 months, with shock wave therapy being more effective at 12 months.[162] In this study, the inclusion criteria were characteristic of trochanteric bursitis, but the injection was made into the 'target bursae and tendon insertions.'

A recent systematic review and meta-analysis compared CSI with PRP.[136] In the review, studies included both greater trochanteric bursitis and gluteus tendinopathy, and the specific site of injection was not noted in one study. The authors concluded that CSI and PRP are useful options in GTPS and that the superiority of one over the other is not clear.

Gluteus medius/minimus tendon injection

An RCT demonstrated that a USG intratendinous injection of PRP produced significantly better outcomes (pain and function) than CSI at their 12-week follow-up.[163] Celestone chronodose in saline was injected into the 'affected tendon' under US. At 12 weeks follow-up, PRP gave better results (Harris hip score, minimally important clinical difference) than CSI. To determine

the duration of pain relief, a study by the same investigators demonstrated that USG intratendinous PRP injections produced sustained clinical outcomes at 2 years, whereas the improvement from CSI was maximal at 6 weeks and was not maintained beyond 24 weeks.[164]

A multicenter single-blinded RCT on patients with gluteal tendinopathy compared CSI with education on load management plus exercise and a wait-and-see approach. Either 1 mL betamethasone or 1 mL TA (40 mg) in 2 mL local anesthetic was injected under US into the trochanteric bursa. (Note that the injection was into the trochanteric bursa when the diagnosis was gluteal tendinopathy, even though the muscles insert into the superior aspect of the bursa.) Education plus exercise was better than CSI (USG bursa injection per published protocol),[165 166] or the no-treatment approach at 8 months follow-up. At the 52-week follow-up, education plus exercise led to better global improvement, with no difference in pain relief, than CSI.[166]

Snapping hip syndrome

Treatment of iliotibial band syndrome includes PT, NSAIDs, or CSI into the iliopsoas bursa. USG CSI (TA 40 mg in 4 mL lidocaine) into the iliopsoas bursa resulted in pain relief: 29 of 40 patients (72%) had complete or partial relief.[144] The authors noted a good correlation between pain relief after CSI with results of surgery (arthroscopic iliopsoas tendon release or arthroscopic debridement of labral tears), with a minimum follow-up of 12 months.[144]

Corticosteroid doses

Corticosteroid doses in trochanteric bursa injections were 40 mg TA or MPA, 80 mg TH, or 1 mL betamethasone.[136 158–160] For injections around the tendons of the gluteus medius or gluteus minimus, doses of 40 mg TA and 1 mL betamethasone were employed.[165 166] TA 40 mg in 4 mL lidocaine has been injected into the iliopsoas bursa.[144]

Comments, statements, and recommendations for pericapsular hip injections

In the previously cited studies, the site of pericapsular hip injections was not clear. In some studies, the injection was made into the site of maximal tenderness or swelling, peritrochanteric bursa if visualized or landmark-guided insertion of the gluteus medius tendon into the greater trochanter, per discretion of the provider (surgeon or physician assistant), or the site of injection was not noted. In one study, the diagnosis was gluteus tendinopathy, but the injection was into the trochanteric bursa. This is partly explained by the varied etiologies of pericapsular hip pain and the inclusion of various etiologies in studies. *Owing to this heterogeneity, we are not providing statements or recommendations related to pericapsular hip injections. However, in view of the better efficacy of CSI over home training, usual care, or shock wave therapy shown in some studies, it is reasonable to initiate therapy with CSI in pericapsular hip pain.*

Iliotibial band friction syndrome

Iliotibial band friction syndrome results from repetitive friction between the iliotibial band and the lateral femoral condyle. It is usually seen in runners and cyclists and has been reported after knee cementoplasty. The syndrome is characterized by lateral knee pain, aggravated by knee flexion and relieved by full knee extension. Treatments include rest, reduced running, NSAIDs; surgery is performed in refractory cases. An RCT compared CSI with MPA 40 mg and local anesthetic with local anesthetic injection into the point of maximal tenderness in the lateral femoral condyle.[167] The decrease in pain during running was significantly better with the CSI at the 7 and 14 days follow-up. There were no complications, although only 18 patients were studied.[167] There is a case report of iliotibial band rupture 2 months after several CSIs (three CSIs—40 mg TA in 8 mL local anesthetic) every 2 months) in a patient with iliotibial band friction syndrome.[168]

KNEE INJECTIONS

The recommendations of the different organizations (AAOS, ACR, EULAR, OARSI) regarding knee IACS are noted in table 3.[10–12 16 18]

Landmark versus image-guided knee injections

A prospective study compared the accuracy of different approaches with the landmark-based needle IACS into the knee. There was a 75% accuracy rate with the anteromedial approach and a 93% accuracy rate with the lateral midpatellar approach.[169]

A prospective randomized study examined differences in patient satisfaction, functionality, and the quality of life in adult patients receiving USG versus landmark-guided knee aspiration followed by IA CSI.[170] It was noted that USG injections resulted in greater improvement in pain indexes and better patient satisfaction and quality of life scales after 4–6 weeks compared with landmark techniques.[170] USG knee joint aspiration and injection resulted in significantly less procedural pain, greater synovial fluid yield, and more complete joint decompression. The same positive outcome measures, plus improved clinical outcomes were noted in another knee study.[171] A recent review of 12 published clinical studies, seven of which directly compared US with landmark-guided knee injections, all noted better accuracy with US in each of the seven studies.[172]

Comparative effects of different corticosteroids and dose-response studies

Studies comparing different corticosteroids, including extended-release preparation, were mostly done in knee injections (see section ‘extended-release corticosteroid preparations’). As noted earlier, research to date has not demonstrated long-term superiority of one corticosteroid preparation for IA knee injections.[24]

Dose-response studies and long-term efficacy of knee IACS

In a 12-week double-blind RCT, 80 mg of IA TA was compared with 40 mg of TA.[173] Of the two doses, 80 mg was not found to be superior to 40 mg for IA in terms of pain relief or functional improvement.

Neither IA injections of corticosteroid nor hyaluronic acid provided sustained symptom relief over 2 years.[174] A clinical evidence synopsis concluded, with low-quality evidence, that IACS for knee OA may be associated with moderate improvement in pain and a small improvement in physical function up to 6 weeks after injection.[175] A systematic review and meta-analysis confirmed the short-term (up to 6 weeks) superiority of IACS in the knee, while long-term follow-up (24 weeks or longer) showed a trend towards superiority of controls (IA hyaluronic acid, IA NSAID, PT).[176] A systematic review of guidelines also noted the short-lived improvement (<4 weeks) with IACS into the knee joint.[177] A recent systematic review noted no difference in outcomes between IACS and NSAID injection into the knee joint; both showed improvement at 1 and 3 months.[86]

We previously discussed the pharmacokinetic and pharmacodynamic studies after knee IACS (see section ‘pharmacokinetics

and timing of responses'). In summary, pain relief is noted at 1–2 weeks after injection. Such relief extended to 12 weeks.[33] The timing of these responses coincided with the T_{max} and $T_{1/2}$ concentrations of the corticosteroid.[27 28 33] For this reason, we *suggest* follow-up at 2 weeks to 3 months after injection.

Postinjection protocol to optimize efficacy and safety

After a CSI into a joint, it is common for physicians to limit activity to minimize possible chondrotoxic effects, systemic absorption, and potentially improve outcome. In a survey, 29% of rheumatologists did not restrict weight bearing after a corticosteroid knee injection, while 8% of rheumatologists restricted weight bearing for up to 1 week.[20] In another survey, 42% of respondents recommended avoidance of weight-bearing after knee joint steroid injection. There was an increased likelihood that rheumatologists (71%) would recommend limited weight-bearing for 1 or 2 days as compared with general practitioners (57%) and orthopedic surgeons (3%).[178] A Cochrane review found low-quality evidence to support splinting/resting a knee in this population after injection, but not the wrist.[179] In one trial, there was significant improvement in pain, stiffness, knee circumference, and walking time in the rested group (no point estimates were provided).[180] In pediatric patients, a retrospective observational study of two pediatric hospitals showed no clear benefit of rest/splinting postinjection after knee IACS.[181] In fact, patients who had postinjection splinting had a trend toward more arthritis recurrence (38% vs 26%, p=0.14).

Adverse events related to knee joint corticosteroid injections

The local AEs for the knee include joint destruction, avascular necrosis, and Nicolau syndrome (ie, variable degrees of skin and underlying tissue necrosis).[182–184] Discussion on cartilage health and systemic adverse events are included in the section of general adverse events.[185]

In summary, USG IACS knee injections are more efficacious (less procedural pain, greater aspirate volume, and better short-term outcomes) than landmark-assisted injections. There is no long-term superiority between the different corticosteroids. Triamcinolone at a dose of 40 mg is as effective as 80 mg. Relief from IACS is short-term (up to 6 weeks). For SRs on IACS in hip and knee joints, see box 5. In view of the pharmacokinetic and pharmacodynamic studies on knee IACS, we suggest a *minimum* 2-week interval between injections.

SMALL JOINTS, WRIST, AND HAND JOINTS

Wrist and hand corticosteroid injections

CSI of the joints of the wrist, hand, and small joints have been reported for treatment of both inflammatory and non-inflammatory arthritis.[186–197] In a prospective open-label study, 30 subjects with RA had USG CSIs into wrist and/or hand joints, using 40 mg TA for the wrist joints and 20 mg TA for metacarpophalangeal (MCP) and proximal interphalangeal joints. There was a statistically significant improvement in visual analog pain scores, swelling, tenderness, synovial hyperplasia, and power Doppler signal scores at 4–12 weeks postprocedure as compared with baseline for all joints.[187]

While select individual RCTs have shown efficacy of corticosteroids over placebo in IA injections in osteoarthritic interphalangeal joints for treatment of pain, this has not held true when data are analyzed in aggregate.[196] A systematic review of 13 RCTs showed no overall benefit for CSI over placebo.[195] One trial showed no improvement in pain after CSI in the carpometacarpal joint for the treatment of OA.[198] Another trial demonstrated significantly less pain during movement, but not at rest, in patients with interphalangeal OA; the authors concluded that this isolated finding requires confirmation.[199] Another systematic review demonstrated with low-to-moderate quality data that IA saline is superior to CSI in trapeziometacarpal (so-called 'thumb base') OA when confirmed with radiography using pain and function as end points.[197] The ACR provided a conditional recommendation for IACS in hand OA.[10]

Beneficial effect of US-guided injection

The use of US guidance for wrist and hand CSIs appears to be beneficial.[171 186 187 200] USG IACS into the distal radioulnar joint were significantly more accurate than landmark-guided IACS (100% vs 75.8%, respectively).[201] Of note, the study demonstrated no significant difference in clinical outcomes between the USG CSI and the landmark injection technique groups.[201]

A meta-analysis of four studies comparing USG wrist and hand CSIs with landmark-guided injections showed that the USG injection technique was more likely to result in decreased pain and increased function at a 6-week follow-up interval.[200] In one study, USG injections for patients with RA demonstrated improvement in pain and function as compared with landmark-guided injections and an 8% reduction in cost. It should be noted that in this study, only 3% of the joints injected were 'small joints.'[188]

Postinjection management after wrist injections: rest versus activity

Unlike knee IACS injection, there appears to be no benefit with rest after wrist injection. A trial noted an increase in relapse rate, with no difference in pain relief, wrist function, grip strength, or ROM in the patients who had 48 hours of rest using elastic wrist orthoses, compared with the non-rested group.[202]

Trigger finger

Stenosing tenosynovitis, known as 'trigger finger,' is snapping or locking of a finger or thumb, usually at the MCP joint. It is caused by the disproportion of the volume of the tendon sheath and its contents, inhibiting the straightforward gliding of the tendon through the digital pulley (structure that holds the tendon against the finger bone). A dose-response study showed significantly better results with 20 mg TA compared with 5 and 10 mg at 3 and 6 months of follow-up. However, there were no differences at 9 and 12 months.[203] A 2018 systematic review found moderate evidence for the benefit of CSI in the short term (0–3 months) for the treatment of trigger finger.[204]

A prospective case-control study evaluated USG and palpation-guided trigger finger injections with corticosteroids and found no differences at 6 weeks or 6 months in terms of clinical efficacy. There was a significant increase in procedural time and effort with US.[205]

De Quervain's tenosynovitis

De Quervain's disease is non-inflammatory thickening of the ligament overlying the tendons in the first dorsal compartment of the wrist, impeding the gliding of the adductor pollicis longus and extensor pollicis brevis tendons. This hinders the function of the thumb and produces pain in the thumb side of the wrist. A systematic review evaluating CSI versus placebo and acupuncture for De Quervain's tenosynovitis showed moderate benefit for CSI in the short term (0–3 months). The review also demonstrated that there is moderate evidence that

a thumb splint added to a CSI leads to effective treatment in the short term and intermediate term (0–3 and 4–6 months, respectively).[204]

Plantar fasciitis

The terms 'plantar fasciitis,' 'heel pain,' and 'plantar heel pain' are often used interchangeably in the medical literature.[206 207] Etiologies include biochemical (extreme pronation of the talar joint), anatomic (flat foot), and chronic disease (diabetes, obesity). Pathophysiology can either be inflammatory, secondary to immune system activation and vasodilatation, or non-inflammatory from fibroblastic hypertrophy.[208] Deposition of corticosteroids in or near the origin of the plantar fascia has been used as a treatment for plantar heel pain for decades.[209] A 2017 Cochrane review evaluated 42 studies (36 were RCTs) to assess the efficacy of CSIs in the treatment of plantar fasciitis. The data supported the use of CSIs over placebo or no treatment but only up to 1 month.[206] A 2019 systematic review, comprisingd 47 trials, concluded that CSIs for plantar heel pain were more effective than autologous blood or foot orthoses in reducing pain and more efficacious than PT in improving function, but only in the short term (up to 6 weeks). Notably, CSI was not more effective than placebo in terms of pain relief or in improving function.[207] The authors noted that in the long term (13–52 weeks), PRP injections and dry needling were superior to CSIs.[207] The majority of trials were small (mean size 28 subjects) and had significant risk of bias (most frequently due to lack of blinding) resulting in low or very low quality of evidence. Another 2019 systematic review and meta-analysis based on 31 RCTs demonstrated that there was no difference in outcomes for plantar heel pain between CSIs, oral NSAIDs, therapeutic exercise, orthoses, or extracorporeal shockwave therapy.[210]

An important distinction is the treatment of plantar heel pain associated with rheumatological inflammatory arthritis, especially spondyloarthritis. Enthesitis, or inflammation, at the site of attachment of tendons and ligaments to bones, is characteristic of spondyloarthritis. A systematic review of the treatment of this subset of plantar heel pain associated with rheumatological inflammatory diseases included five studies. All studies demonstrated efficacy and safety of USG CSI.[211]

The corticosteroids used in the above studies were MP, triamcinolone, betamethasone, and dexamethasone. There were no dose-response studies; the doses ranged from 20 to 80 mg for MP and TA, 6 mg for betamethasone, and 4 to 8 mg for dexamethasone. In the studies that noted the repeat injections, the interval between injections was 2, 3, and 6 weeks, and 3 months.[206]

Known complications of plantar fascia injections with corticosteroids include fascial rupture and fat pad atrophy.[206 212 213] A longitudinal cohort study followed 174 patients for 5–15 years, where the patients received USG steroid injections of the plantar fascia for 5–15 years. At follow-up, the mean fat pad thickness in the patients who received USG CSI was 9.0 mm (95% CI 7.0 to 10.9 mm) compared with 9.4 mm (95% CI 7.2 to 11.6 mm) in the patients without an injection ($p=0.66$).[209] The decrease in thickness could be due to age/aging or the corticosteroid, which reduces edema by decreasing inflammation. In this study, no patient experienced a fascial rupture.

For SRs on small joint injections, see box 6.

Similar to corticosteroid joint injections, clinicians should limit the use of IACS injections into the small joints of the wrist, hand, and foot. Repeat injections should be based on the patient's response.

Box 6 Statements and recommendations on small joint injections

Statements

1. Ultrasound (US) guidance is superior to landmark-based guidance when performing small joint injections.
   Level of certainty: high
2. The use of intra-articular corticosteroid (IACS) injection in the treatment of *osteoarthritis* of *the carpometacarpal joints* of the hands and wrists does not result in short-term or long-term improvement in pain or function. IACS results in less pain with movement in patients with *interphalangeal joints of the hand*.
   Level of certainty: moderate
3. The use of IACS in the treatment of *rheumatoid arthritis* of the joints of the hands and wrists results in short-term (12 weeks) or long-term (12 months) improvement in pain, function, and inflammation.
   Level of certainty: high
4. Trigger finger corticosteroid injection (CSI) confers a short-term to intermediate-term (3–6 months) benefit in resolving symptoms.
   Level of certainty: moderate
5. Triamcinolone, 20 mg, is superior to 5 mg and 10 mg for trigger finger injections.
   Level of certainty: low
6. De Quervain's tenosynovitis improves with CSI in the short term, and the addition of a thumb splint to the steroid injection leads to intermediate-term improvement.
   Level of certainty: moderate
7. Plantar fascia injections with corticosteroids are not superior to placebo injections in *non-inflammatory* plantar heel pain.
   Level of certainty: moderate
8. In rheumatic *inflammatory diseases* such as spondyloarthritis, plantar fascia injections with corticosteroids are beneficial in the treatment of pain and inflammation.
   Level of certainty: low

Recommendations

1. Clinicians should preferably offer US guidance when performing injections into the small joints of the wrists, hands, feet, and ankles, as it may provide benefit (eg, reduced procedural pain) over landmark-based guidance.
   Grade C
2. In patients with active *rheumatoid arthritis* in the small joints of the wrists and hands, IACSCSI may be used as an adjunct therapy to decrease pain, improve function, and reduce signs and symptoms of inflammation.
   Grade C
3. Clinicians should perform CSI for *trigger finger* with 20 mg triamcinolone/methylprednisolone corticosteroid equivalent rather than 5 or 10 mg.
   Grade C
4. Clinicians should offer thumb splints in conjunction with CSI for De Quervain's tenosynovitis.
   Grade C
5. Clinicians may perform plantar fascia injections with corticosteroids for *rheumatic inflammatory heel pain* not responsive to conservative measures.
   Grade C
6. Avoid plantar fascia injections with corticosteroids for *non-inflammatory plantar heel pain*.
   Grade D

SAFETY, ADVERSE EVENTS, AND MONITORING

IACS and other CS injections provide symptomatic relief for patients with a relatively low risk of AEs.[214–216] As with other injections, risks include superficial bleeding or hemarthrosis and temporary worsening of pain. Specific to joints, joint swelling, superficial or joint infection, temporary facial flush, lipoatrophy, or pigment loss around the injection site, interphalangeal calcification, and acute postinjection inflammatory arthritis may occur.[122 217–226] Systemic effects from CSI may include hyperglycemia, decreased bone marrow density, and adrenal suppression (though no cases of clinical adrenal insufficiency have been described).

Bleeding

In a retrospective study of 514 patients on therapeutic anticoagulation with warfarin who underwent a total of 640 joint injections and/or arthrocentesis, a single incident of clinically significant bleeding in an anticoagulated patient (international normalization ratio (INR) 2.3) was found (rate of 0.2%).[227] A total of 456 procedures were performed when INR was >2.0, and 184 procedures were performed with INR <2.0. Another single-center retrospective study of adult patients on novel oral anticoagulants found no incidents of bleeding among 1050 consecutive procedures, with the authors concluding that holding oral anticoagulation prior to joint injections is not warranted.[228]

The ASRA PM recommends that patients on anticoagulant and antiplatelet medications without additional complicating coagulopathic conditions (advanced liver disease or cirrhosis, advanced renal disease, old age, history of bleeding/hemophilia, or multiple anticoagulant medications) may continue their anticoagulant or antiplatelet treatments without interruption for low bleeding risk procedures (such as peripheral joint injection) as the risk for stopping these medications likely outweighs the low risk of bleeding for those on therapeutic dose.[229] Indeed, even patients with knee pain due to hemophilic arthropathy have been shown to derive benefit from IACS, and knee injections have been shown to be performed safely in this population with use of US and power Doppler.[230]

Cartilage, ligament, and tendon health

One of the concerns with IACS for the knee is the potential AE of IACS on cartilage health. Potential detrimental effects include catabolic effects on cartilage proteins including aggrecan, type II collagen, and proteoglycans, chondrocyte availability, and gross cartilage morphology.[231–234] Animal studies investigated the effects of corticosteroids on cartilage with inconsistent and conflicting results.[231 232 235–237] Some of these studies demonstrated cartilage disruption, while others showed cartilage preservation during acute inflammatory events. For commonly employed corticosteroid preparations, such as MP, betamethasone, and triamcinolone, basic science and animal studies have demonstrated a dose-dependent detrimental effect on cartilage.

A 2-year randomized placebo-controlled, double-blind trial of IA TA versus saline for symptomatic knee arthritis in 140 patients using annual knee MRIs, IACS resulted in greater cartilage volume loss than saline injection.[238] In this study, the intervention (saline or 40 mg triamcinolone without IA local anesthetic administration) was administered every 12 weeks for 2 years. Patients received MRIs at 0 (baseline), 12, and 24 months, and mean cartilage thickness was computed. The cartilage loss was more significant with the corticosteroid, and a corresponding response with pain improvements did not occur, raising concern about the value of frequent repeat IACS for the knee.

As noted previously, cases of tendon rupture were reported after injection into the biceps tendon or into the iliotibial band.[93 94 168] The long-term risks of repeated injections of the tendon sheath have not been reported, but in vitro studies indicated damage to chondrocyte viability after exposure to MP.[239] Single doses of USG injections of the biceps tendon do not appear to cause changes in tendon elasticity.[240] Practitioners may choose to exercise caution in performing repeated CSIs of the biceps tendon or iliotibial band.

Accelerated joint space narrowing and osteonecrosis

An IACS knee RCT study (40 mg IA TA injections administered every 3 months vs saline placebo for up to 2 years) used X-rays (rather than MRI) to examine radiological progression of joint space narrowing.[241] The study was powered (34 patients per group) to detect a difference of 0.125 mm progression of joint space narrowing between the two treatment groups at 2 years. No difference between the groups was detected at either 1-year or 2-year follow-up.

A study used radiographic findings to assess progression of joint space narrowing or joint destruction (semi-quantitative 0–4 scale) in 30 individuals with OA and 35 with RA who underwent a minimum of 15 knee CSIs over a 4-year period and a maximum of 167 injections over a 12-year period.[242] Fifty percent (36) knees showed no or minimal progression between radiographs (duration not described). Ten knees showed marked deterioration (marked narrowing with some collapse of a condyle and/or lateral subluxation). Two knees (same patient) revealed gross deterioration (Charcot's type joint), over 7 years after 82 and 85 IACS provided for each knee. However, there was no correlation between the number of injections and the rating of joint deterioration. Again, follow-up radiographs were done for clinical indications (not by protocol) with variable follow-up (not described). The total number of injections rather than frequency per year were described; laterality was not addressed. The authors concluded that repeated IACS do not lead to rapid joint destruction.

An updated Cochrane review of IACS for knee OA found that corticosteroids had no effect on joint space narrowing compared with control interventions (SD −0.02; 95% CI −0.49 to 0.46).[243]

Two retrospective studies showed progression of OA with IACS (based on Kellgren-Lawrence radiographic grading of OA) compared with non-injected controls. One is a small retrospective study with hip OA, and[244] the other is a bigger multi-institutional study of 684 patients with knee OA.[245] The retrospective study of 70 patients with hip OA compared with a matched control group showed that 44% (31 of 70) of patients who were given injections of corticosteroids with local anesthetics had radiographic progression of their OA, and 17% (12 of 70) experienced collapse of the articular surface.[244] The two radiologists, blinded to receipt of hip injection, found osteonecrosis in eight to nine images prior to injection and new osteonecrosis in 16–19 images postinjection. There was a very high prevalence of X-ray defined osteonecrosis in both the IACS group (37%) and comparator group (24%).[244] The larger multicenter longitudinal observational study followed 684 propensity-score matched participants. Using either an increase in the Kellgren-Lawrence grade by >1 or a decrease in joint space by >0.7 mm for knee rapid OA progression, the authors noted an association between IACS and knee radiographic OA progression.

Finally, there is also a case report of collapse of the superior femoral head articular surface after IACS administration in

a patient with osteonecrosis but with preserved femoral head contours.[122] This progression has to be kept in mind since patients with painful non-collapsed osteonecrosis of the femoral head are frequently referred for IACS. The case also demonstrates value in radiographic imaging before IACS hip injections.

The risk factors for osteonecrosis include a history of BMD compromise; chronic corticosteroid exposure; and underlying disorders, such as renal insufficiency, organ transplantation, graft versus host disease, inflammatory bowel disease, HIV, and acute lymphoblastic leukemia.[122 246] Bisphosphonate therapy may mitigate this risk.[247]

Accelerated OA progression

Rapid progressive OA (RPOA), also called rapid destructive hip disease or rapid destructive OA, is a rare condition with rapid loss of joint space on X-rays that is beyond the anticipated rate; defined as a joint space loss of >2 mm within a 12-month period.[122]

A report of 307 patients undergoing hip IACS noted 23 patients (7%) developed RPOA, and of the 152 patients undergoing knee IACS, 6 (4%) were observed to experience RPOA.[122] This study was limited by retrospective review of the clinical care. Radiographic follow-up was incomplete, obtained only when clinically indicated, and this would result in conservative estimates. Selection bias (referral to the radiology department for image-guided injections) may have been selected for patients with more progressive OA (independent of IACS).

A recent two-part study documented an association between hip CSI and RPOA.[248] In the case-control portion, the authors showed an association between CSI and RPOA, with the risk increased with higher dosage and number of injections. The risk was low with a single 40 mg triamcinolone injection and higher with higher doses (80 mg or higher) and multiple (two or more) injections. The minimum effective dose is 40 mg TA (see box 7). In the retrospective portion, the investigators noted a rate of 5.4% (37 of 688 cases) after injection. Diagnosis occurred at an average of 5 months after injection and was characterized by rapid narrowing of the joint space, osteolysis, and collapse of the femoral head.

SYSTEMIC EFFECTS OF CS INJECTIONS

Blood glucose

An IA corticosteroid is known to elevate blood glucose in patients with and without diabetes mellitus, although not necessarily with adverse clinical consequences in patients without diabetes. Shoulder IACS (triamcinolone 40 mg) for the treatment of ACs elevated fasting blood glucose (FBG) by 17 mg/dL in both patients with and without diabetes, resulting in higher levels at day 1 (attributable to higher baseline FBG); FBG was observed to remain above baseline up to 2 weeks following injections for both groups.[249] Among 60 patients with diabetes mellitus who received IACS, fasting and postprandial blood glucose were observed to be elevated up to 3 days after injection among the entire cohort.[250] However, when analyzed according to site, upper extremity injections were not found to be associated with increased fasting or postprandial blood glucose, knee injections were associated with significantly elevated fasting and postprandial blood glucose, and paradoxically, injections at multiple sites were not associated with elevated fasting or postprandial blood glucose on days 1 through 7. In multivariate analyses, high baseline glycosylated hemoglobin (HbA1c) was significantly associated with elevated blood glucose following IACS, while factors including body mass index, insulin use, and

Box 7 Statements and recommendations on adverse events from intra-articular corticosteroid (IACS) injections

Statements

1. Clinically significant increases in blood glucose may follow IACS injection, particularly in patients with diabetes mellitus. These effects are noted within hours of IACS, but peak blood glucose may be delayed for up to 2 days after IACS.
   Level of certainty: high
2. Extended-release corticosteroid preparations may mitigate the impact of IACS on systemic blood glucose in patients with diabetes.
   Level of certainty: moderate
3. Adrenal suppression may follow an intra-articular corticosteroid injection.
   Level of certainty: moderate
4. For warfarin, in patients with an international normalization ratio (INR) in the therapeutic range (2.0–3.0), the risks of withholding anticoagulation prior to IACS related to the development of a thromboembolic event are greater than the risks of bleeding
   Level of certainty: low
5. When there is strict adherence to standard infection control practices, the risk of infection due to IACS is low.
   Level of certainty: moderate
6. There is an increased risk of postoperative deep joint infection when IACS is administered within 3 months prior to that joint replacement surgery, especially if IACS is performed within 1 month of surgery.
   Level of certainty: moderate
7. There is a trend toward increased risk of postoperative deep joint infection when IACS is administered within 3 months prior to that joint replacement surgery.
   Level of certainty: low

Recommendations

1. Patients with diabetes mellitus should be advised to monitor blood glucose carefully postinjection for at least 48 hours, until blood glucose normalizes (possibly up to 7 days).
   Grade A
2. Monitoring of cortisol levels pre-IACS or post-IACS is not recommended routinely.
   Grade D
3. In the right clinical setting, adrenal crisis should be considered as a possible etiology in the hypotensive patient in the days or weeks following IACS.
   Level of certainty: low
4. For patients on chronic stable warfarin therapy with good control (no bleeding symptoms), anticoagulation therapy need not be withheld for IACS; patients on warfarin may be in therapeutic INR range.
   Grade A
5. Providers should adhere to standard infection control practices, including strict aseptic technique when performing IACS.
   Grade A
6. Avoid IACS within 3 months of planned total replacement of that joint, notably within 1 month of planned surgery.
   Grade D
7. Discuss with the surgeon the risks/benefits when considering IACS in a joint planned for replacement surgery within 3 months.
   Grade C

corticosteroid dose were not associated with elevated blood glucose. In this study, one patient had FBG as high as 493 mg/dL, but no patient experienced diabetic ketoacidosis.[250] A study of 23 patients with diabetes undergoing IACS shoulder injection reported similar findings, namely no significant elevation of blood glucose above baseline following injection.[251] One RCT of patients with diabetes on oral agents undergoing IA knee CSI compared extended-release with standard formulations of triamcinolone (32 mg) vs standard triamcinolone preparations (40 mg).[31] The mean increase in blood glucose from preinjection (days −3 to −1) to postinjection (days 1–3) was 37 mg/dL and significantly >8.2 mg/dL in the extended-release group (p=0.04); blood glucose after standard 40 mg triamcinolone was noted to peak 6 hours after the injection, with mean blood glucose of 252 mg/dL.[31] A systematic review of patients with diabetes mellitus undergoing IACS identified seven studies (n=72) showing a clinically significant rise in blood glucose up to 1 week after injection, with many patients experiencing this effect within 48–72 hours after injection but not necessarily immediately following the procedure.[252] In a study evaluating the effects of TH versus TA on blood glucose following IACS in patients with diabetes and symptomatic knee OA (n=12 in each cohort and n=6 in a hyaluronic acid cohort), patients experienced median elevated blood glucose >200 mg/dL following IASC, (median peak 239.5 at 32.5 hours in the TH group, 288 at 24.5 hours in the TA group) returning to normal within approximately 4 days.[253] All study subjects had HbA1c <7.0. A separate small study following six patients with controlled diabetes after IACS with betamethasone to the knee joint showed a mean peak blood glucose of 322.5±67.75 mg/dL, with most patients returning to baseline within 48 hours following the injection.[254]

Bone mineral density

Chronic and/or high-dose corticosteroid exposure is known to affect BMD, particularly in patients with conditions requiring long-term oral medication. Excessive use of epidural CSIs has been associated with compromised BMD.[255–258] Kerezoudis *et al* noted significant reductions in BMD were associated with a cumulative dose of 200 mg over a 1-year period and 400 mg over 3 years, and at least 3 g for healthy men. Reductions in BMD were not seen in doses of <200 mg of MP equivalents for postmenopausal women.[255] Their conclusions were questioned in view of the small and underpowered studies that they reviewed.[256] In a subsequent narrative review of additional studies, Stout *et al* recommended consideration of a maximum cumulative whole-body triamcinolone/MP dose of 200 mg/year and 400 mg per 3 years in postmenopausal women and potentially men over 50 years of age.[258] They cautioned that these relative limits should be weighed against functional benefits. Additionally, another study of 352 postmenopausal women concluded that there was no association between epidural CSIs and decreased BMD or fracture risk.[257] These studies are discussed in more detail in our upcoming neuraxial steroid PG.

Regarding IACS, a retrospective study in patients with RA (n=208 patients, receiving one (101 patients), two to three (51 patients) or four (56 patients)) did not find any statistically significant relationship between the number of IACS and BMD over the course of 1 year.[259]

A recent cohort study by Sytsma *et al* was published after we developed the SRs.[260] This study is notable for the large number of injections and the variety of CSIs. The investigators evaluated the association between the risk of fracture and 33 864 CSIs into joints (large, medium, small), spine (facet, epidural, sacroiliac), nerve blocks, trigger points, and tendon or ligament. They did not see an association between higher fracture risk based on cumulative corticosteroid dose, with a mean cumulative dose of 141.8 mg TA equivalents (range: 2.7–2140.3 mg). Sytsma *et al* also noted the lack of associated higher fracture risk in the non-high-risk or osteoporosis subgroups.[260] This supports the findings of the study by Kerezoudis *et al*, in which BMD was not decreased at doses of <200 mg of MPA/TA equivalents per year for postmenopausal women.

The recommendations of Kerezoudis *et al* and Stout *et al* were made after a careful review of the literature. Balancing the recommendations of Kerezoudis *et al* and Stout *et al* with the results of the recent study by Sytsma *et al*, we suggest that the clinician *consider* a maximum cumulative whole-body triamcinolone dose equivalent of 200 mg/year and 400 mg per 3 years in postmenopausal women. Note that the average and maximum TA equivalent cumulative dose was higher in the study by Kerezoudis *et al* (average of 80–81 309 mg in the eight studies) compared with the Sytsma *et al* study (2140.3 mg). We arrived at this suggestion to err on the side of safety, as we wait for additional studies. These limits are achievable without compromising efficacy. Routine series of injections should not be performed; subsequent injections should be repeated after observation of the patient's response and after recurrence of the pain. The minimum effective doses of CSIs in the joints and in the spine should be administered; CS should not be added in sympathetic nerve blocks, TPIs, and most peripheral nerve blocks. We echo the recommendation by Stout *et al* that providers should discuss the potential of BMD loss after glucocorticoid injections with patients, especially when receiving multiple injections.

Adrenal suppression

Adrenal suppression has been documented after single IA doses of corticosteroids.[261–263] Clinically meaningful adrenal insufficiency occurs when a sufficient stress requires an adrenal surge in the setting of adrenal suppression; it is an uncommon but important clinical condition that may occur more commonly or be expected in the hospital setting.

An RCT compared patients who received a single knee IACS (MPA 80 mg) with a group that received 6 mL IA sodium hyaluronate. This was followed by a low-dose adrenocorticotropic hormone (ACTH) stimulation test. The authors noted that 25% of subjects in the steroid group experienced secondary adrenal insufficiency (<7 μg/dL increase in serum cortisol level and absolute levels of <18 μg/dL 30 min after the ACTH stimulation test), observed 2–4 weeks following injection versus none in the control group.[264] A systematic review and meta-analysis noted that the percentages of adrenal insufficiency ranged from 4% with intranasal administration to 52% from IA injection.[265]

Septic arthritis

The incidence of septic arthritis following IACS outside of the context of joint replacement surgery is rare, but patient morbidity can be devastating.

Risk factors for septic arthritis include immunosuppression, intravenous drug use, alcoholism, previous steroid injections, and cutaneous ulcers. Patients commonly present with local warmth and/or swelling, fever, and night pain, and the most involved joints include the knee and hip.

A retrospective review of 10 patients diagnosed with acute septic arthritis following knee injection found that three out of 10 patients had undergone recent injection with 'cortisone' (five with hyaluronic acid, two unknown).[266] All patients presented

with joint pain and swelling; three had decreased ROM, two had fever, and one had erythema. The mean incubation period was 11.9 days. Inflammatory markers were elevated (mean erythrocyte sedimentation rate, 52.6 mm/hour; mean C reactive protein, 10.3 mg/dL). Only half of the 10 patients had an organism identified in culture (three *Streptococcus mitis*, two oral flora). Comorbidities included hypertension (four patients), diabetes mellitus (two patients), and chronic kidney disease (one patient). Patients had received a variable number of injections prior to admission (0–1 in four patients, 2–3 in four patients, 4–5 in two patients). All 10 patients underwent arthrocentesis with cell culture and were treated surgically (three patients required more than one incision and drainage). Of the patients, eight were treated with antibiotics for 21 days (seven with parenteral antibiotics), and six were dismissed to a rehabilitation facility. With a broader assessment of risk factors associated with these infections, the authors concluded that the facility performing the injections had poor adherence to standard infection control protocols.

Sterile inflammatory arthritis may occur after IA injection and can be confused with septic arthritis. A systematic review identified 19 patients among 18 studies (n=286) with postinjection swelling without clinical evidence for infection consistent with synovitis.[267–269] Postinjection inflammation may be due to exacerbation of calcium pyrophosphate dihydrate crystals, which has been best described after sodium hyaluronate injection.[270]

Safety of IACS prior to joint replacement surgery

IACS in the pre-operative joint replacement setting raises concern for prosthetic joint infection (PJI). Guidance from professional societies and federal agencies is vague. The AAOS states that there is limited evidence to suggest that IA injections may have a time-dependent association for increased risk of PJI and that the overall event rate is low.[13] The US Centers for Disease Control and Prevention cited low-quality evidence precluding recommendations about preoperative IACS.[271] The 2017 ACR/American Association of Hip and Knee Surgeons (AAHKS) Guideline for Perioperative Management did not include comments or recommendations about the timing of preoperative IACS.[272] In a survey of AAHKS members, 93% cited that a 3-month interval should be the minimum interval between IACS and joint replacement surgery.[34]

The literature review and manual search resulted in articles that fell into three principal methodologies: (1) small single-institution cohorts, (2) administrative data reviews, and (3) systematic literature reviews.

Large administrative database analyses—knee

Given the infrequent outcome of PJI, the majority of the patient-derived data came from analyses of large administrative datasets. All knee analyses[273–276] were derived from the PearlDiver National Insurance Claim Database, which captures data from Humana, United Healthcare, and Medicare.[277] There are variations in (1) the dates of patients sampled, (2) the granularity of the pre-operative IACS window, (3) the definition of infection (superficial vs deep), and (4) postoperative follow-up (6 vs 12 months) across the studies. A single study evaluated the difference between CSI versus hyaluronate injection.[274] Three large administrative analyses reported statistically significant increases in PJI risk when total knee arthroplasty (TKR) closely followed an IACS. Infection risk in the comparator group without preceding injection ranged from 1% to 2.7% depending partly on the length of post-TKR observation. All studies reported statistically significant increased multivariate OR or HR for the time periods

Table 5 Minimum effective and commonly used doses of intra-articular, bursa, and tendon corticosteroid injections

Study	Joint/Bursa/Tendon	Steroid, dose	Indication
Minimum effective dose (based on dose-response studies)			
Onks *et al* Yoon *et al* Kim *et al*[81–83]	IACS, glenohumeral joint	TA, 20 mg	Glenohumeral arthritis; adhesive capsulitis
Hong *et al*[84]	SASDB	TA, 20 mg	Rotator cuff tear
Carroll *et al*[85]	SASDB	TA, 20 mg; MPA 20 mg	Shoulder pain
Popma *et al*[173]	Knee joint	TA, 40 mg	Knee osteoarthritis
Kosiyatrakul *et al*[203]	Trigger finger	TA, 20 mg	Trigger finger
Commonly used doses			
Hanson *et al* Zhang *et al* Yiannakopoulos *et al*[32 89 90]	Long head of biceps	TA, 40 mg TA, 20 mg in patients with diabetes	Tendinitis of the long head of the biceps
Qian *et al* Krogh *et al* Bisset *et al* Coombes *et al* Gaujoux-Viala *et al* Assendelft *et al* Bisset *et al*[101–107]	Lateral epicondyle	TA, 20, 40, 80 mg MPA, 20, 40 mg Betamethasone, 6 mg Dexamethasone, 4 mg	Lateral epicondylosis
Stahl *et al*[113]	Medial epicondyle	MPA, 40 mg	Medial epicondylosis
Kim *et al*[116]	Olecranon bursa	TA, 40 mg	Olecranon bursitis
Lambert *et al* Park *et al* Jurgensmeier *et al* Qvistgaard *et al* Atchia *et al* Young *et al*[123 127–130 135]	Hip joint	TH, 40 mg TA, 40 mg MPA, 40 mg	Hip joint osteoarthritis
Migliorini *et al* Brinks *et al* Rompe *et al* Nissen *et al*[136 158–160]	Greater trochanteric bursa	MPA, 40 mg TA, 40 mg TH, 80 mg Prednisolone, 25 mg Betamethasone, 1 mL (5 mg/mL betamethasone dipropionate and 2 mg/mL betamethasone sodium phosphate)	Greater trochanteric bursitis
Mellor *et al* Mellor *et al*[165 166]	Gluteus medius/minimus tendon	TA, 40 mg Betamethasone, 5.7 mg (1 mL)	Gluteus medius/minimus tendinopathy
Wang *et al* Kroon *et al*[187 196]	Wrist joint	TA, 40 mg	Arthritis of joint
Nam *et al*[201]	Distal radioulnar joint	TA, 20 mg	Arthritis of joint
Wang *et al*[187]	Metacarpophalangeal joint	TA, 20 mg	Arthritis of joint
Wang *et al* Kroon *et al*[187 196]	Interphalangeal joint	TA, 20 mg TH, 4–6 mg	Arthritis of joint
Kroon *et al* Meenagh *et al*[196 198]	Carpometacarpal joint	TA, 10 mg, 20 mg, 40 mg Betamethasone, 6 mg (1 mL), 3 mg (0.5 mL) TH, 5 mg	Arthritis of joint
Huisstede *et al*[204]	Tendon, thumb side of wrist	TA, 10 mg, 20 mg MPA, 40 mg Betamethasone, 6 mg (1 mL)	De Quervain's (radial styloid) tenosynovitis
David *et al* Whittaker *et al* Hansen *et al* Babatunde *et al* Abdelghani *et al*[206 207 209–211]	Plantar fascia	TA, 20, 40, 80 mg* MPA, 20, 40, 80 mg Betamethasone, 6 mg Dexamethasone, 4, 8 mg	Plantar fasciitis

*Plantar fasciitis, TA, and MPA: no dose-response studies but a 20 mg dose shown to be effective.
IACS, intra-articular corticosteroid injection; MPA, methylprednisolone acetate; SASDB, subacromial subdeltoid bursa; TA, triamcinolone acetonide; TH, triamcinolone hexacetonide.

closest to surgery. Bedard *et al* reported an increased risk for pre-operative injections done in a 6-month window preceding TKR; however, there was no detectable increased risk when injections were performed after 6 months.[275] By contrast, Cancienne *et al* noted an increased incidence of infection when steroids were injected within 3 months, with no increased risk when the surgery was done 3 months after injection.[276] In a study of 76 090 patients, Bhattacharjee *et al* found that the 0–2 week window for IACS had a significantly increased risk of infection with a trend for increased risk when injections were performed within 2–4 weeks of surgery.[273] The 4-week interval was reinforced in a later study by Bains *et al*.[278] They analyzed 9766 patients (4766 had IACS, 5000 without injection) and noted significant risk of surgical site infection when the IACS was done within 4 weeks prior to the TKA. There was no infection risk when the interval was beyond 4 weeks.

For the studies with multivariate analyses,[273 274 276] the presence of diabetes, obesity, inflammatory arthritis, or RA all carried significant risk of PJI (regardless of pre-operative IA injection).

Large administrative database analyses—hip

Two separate large administrative analyses focused on the risk of infection after total hip replacement (THR).[279 280] Both studies found that the IACS within the 3 months of THR resulted in higher rates of PJI. Both studies noted no increased infection risk for IACS given between 3 and 6 months or between 6 and 12 months.[279 280]

Three systematic literature reviews were identified (one hip from 2016, one knee from 2014, and one hip or knee from 2014). Charalambous *et al* concluded that pre-operative IACS was not associated with increased risk of PJI after THR or TKR, citing a non-significant trend for increased risk and lack of a clear mechanism of action for delayed PJI.[281] Marsland *et al* evaluated four level 3 evidence studies and expressed concern about observed trends, but described the data as insufficient to provide recommendations beyond awareness of the risk and optimization of known infection risk reduction peri-operative strategies.[282] Pereira *et al* analyzed eight retrospective studies and a single observational cohort (n=49) and found the level of evidence insufficient to provide a recommendation.[283] However, all authors noted the limitations of the studies and data analyzed. A 2023 review and meta-analysis evaluated 11 retrospective matched cohort or case-control studies and concluded that the risk of infection is increased when an IACS is performed within 3 months of THR.[284]

Intraoperative IA steroid injection—knee and hip

One systematic review identified a total of 12 studies (n=863) comparing the safety and efficacy of IACS administered intra-operatively during TKR/THR.[285] Results indicated that patients experienced superior analgesia and less postoperative nausea and vomiting in the immediate postoperative period with no difference in AEs compared with injection with saline. The authors speculated that the safety of intraoperative IACS may be due to the sterile environment of the operating room and careful post-operative monitoring.[285] Another study, however, showed an increased rate of infection after intraoperative ICAS in patients who had ankle arthroscopy.[286] The authors noted most infections occurred in the 65–79 years age group.

Comments on preoperative IACS and PJI

The literature evaluating PJI after pre-operative IACS is based on administrative databases, underpowered observational cohorts, variability in definition of PJI, and duration of follow-up. Providing IACS during the 3-month pre-operative period may carry increased risk of PJI, especially if done within 2–4 weeks of TKR.[273 278 284]

For SRs on adverse events, see box 7.

LIMITATIONS AND TIMELINE OF THIS PG

Limitations of our guideline include non-inclusion of stakeholders, for example, patient advocacy groups and incomplete adherence to the AGREE II recommendations,[287 288] similar to other guidelines.[289] This PG will be updated in 5 years, when adequate controlled trials and systematic reviews and meta-analyses are published necessitating revision of our recommendations.

SUMMARY

IACS and soft tissue musculoskeletal injections are employed in the management of joint pain related to arthritis, most commonly for OA and tendinosis/tendinitis and bursitis. Injections are usually performed when non-pharmacological treatment and systemic analgesics fail to provide relief of the symptoms. Our PG is the result of an extensive review of the literature and rigorous modified Delphi process.

The exact etiology of pain in the shoulder and in the hip should be identified, using the patient's history, physical examination including provocative tests, and the results of diagnostic studies including imaging. This is critical to proper treatment, including whether injection therapy is appropriate and the correct target for injection.

Image guidance, fluoroscopy, or US increases the accuracy of injections, although long-term outcomes (pain and function) did not show a difference. Some studies showed improved accuracy of US compared with fluoroscopy in some injections (biceps tendon injection), while others did not (hip joint, glenohumeral joint). US requires less equipment; there is no associated radiation; and patients appear to prefer it over fluoroscopy. US requires expertise; hence, the physician should employ the imaging modality with which they are most experienced and comfortable.

There is little evidence to guide the selection of one corticosteroid over another. A dose of 20 mg triamcinolone is as effective as 40 mg TA for shoulder IACS. The most commonly used dose for hip IACS was 40 mg TA or MPA. Triamcinolone 40 mg is as effective as 80 mg for knee IACS. The commonly used corticosteroid doses are noted in table 5. We suggest a *minimum interval* of 2–3 weeks between injections, up to 3 months. The series of injections can be stopped when there is complete or acceptable pain relief or when the relief has plateaued, taking into consideration the maximum cumulative dose. Overall, IACS results in short-term (4 weeks to 3 months) pain relief.

The AEs from IACS are related to the procedure as well as to local and systemic effects of the corticosteroid. These include an increase in blood glucose, adrenal suppression, detrimental effect on cartilage, reduction of BMD, and PJI. Identification of the patient at risk, injection of minimum effective doses, proper monitoring, and timing of injection in relation to planned total joint surgery should eliminate or mitigate most of these AEs. Adherence to the recommendations in this PG is a foremost step in the proper care of patients who need IACS, bursa, and tendon injections.

Author affiliations
[1]Anesthesiology, Northwestern University Feinberg School of Medicine, Chicago, Illinois, USA

[2]Pain Diagnostics and Interventional Care, Sewickley, Pennsylvania, USA
[3]PM&R, Medical University of South Carolina, Charleston, South Carolina, USA
[4]Pain Medicine, Summa Western Reserve Hospital, Cuyahoga Falls, Ohio, USA
[5]Anesthesiology, The University of Texas Health Science Center at San Antonio, San Antonio, Texas, USA
[6]Department of Anesthesiology and Perioperative Medicine, University of California, Irvine, Irvine, California, USA
[7]Department of Aerospace Medicine, Exploration Medical Capability, NASA Johnson Space Center, Houston, Texas, USA
[8]University of Wisconsin Madison School of Medicine and Public Health, Madison, Wisconsin, USA
[9]Department of Anesthesia, University of Chicago Medical Center, Chicago, Illinois, USA
[10]Anesthesiology, The University of Kansas Medical Center, Kansas City, Kansas, USA
[11]Anesthesiology and Critical Care Medicine, Johns Hopkins Medicine, Baltimore, Maryland, USA
[12]Anesthesiology, Naval Medical Center San Diego, San Diego, California, USA
[13]University of California, Irvine, Orange, California, USA
[14]Anesthesiology, Clement J Zablocki VA Medical Center, Milwaukee, Wisconsin, USA
[15]PM&R, Cleveland Clinic Neurological Institute, Cleveland, Ohio, USA
[16]American Society of Regional Anesthesia and Pain Medicine, Pittsburgh, Pennsylvania, USA
[17]Pain, The University of Texas MD Anderson Cancer Center, Houston, Texas, USA
[18]Anesthesiology, Pain Medicine Division; PM&R; Neurology; Psychiatry; Neurosurgery, Northwestern University Feinberg School of Medicine, Chicago, Illinois, USA
[19]Department of Interventional Radiology, Massachusetts General Hospital, Boston, Massachusetts, USA
[20]PM&R, Vanderbilt University Medical Center, Nashville, Tennessee, USA
[21]University of Louisville Health Sciences Center, Louisville, Kentucky, USA
[22]Radiology, Mayo Clinic, Rochester, Minnesota, USA
[23]Pain Medicine, University Hospitals Cleveland Medical Center, Cleveland, Ohio, USA
[24]Anesthesia, McMaster University, Hamilton, Ontario, Canada
[25]University of Pittsburgh Health Sciences, Pittsburgh, Pennsylvania, USA
[26]Endocrinology, Walter Reed Army Medical Center, Bethesda, Maryland, USA
[27]Orthopedic Surgery, LSUHSC, New Orleans, Louisiana, USA
[28]Anesthesiology—Pain Medicine, Mayo Clinic, Jacksonville, Florida, USA
[29]Medicine (Rheumatology), UCLA, Los Angeles, California, USA

Correction notice This article has been corrected since it published Online First. The title of the article has been updated.

X Maxim S Eckmann @eckmann_max, Ariana M Nelson @ANels_MD, Tina L Doshi @dr_tinadoshi, Shalini Shah @ShaliniShahMD, Samer Narouze @NarouzeMD and Harsha Shanthanna @harshamd5

Acknowledgements The figures are courtesy of Sebastian Encalada, MD, Mayo Clinic, Jacksonville, Florida. Copyediting and formatting were performed by Emma Hitt Nichols, PhD, on behalf of Nascent Medical. The suggestions of the reviewers greatly improved the paper.

Contributors All authors were involved in the modified Delphi process, approval of the statements and recommendations, and approval of the manuscript. The primary author, HTB, guarantees the contributorship statement.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests HTB: NIH NIAMS P30AR072579; DAP: consulting: Avanos, Boston Scientific, Medtronic, Nevro, and SI Bone; Research support: Avanos, Boston Scientific, Medtronic, Nevro; AN: speaker: Averitas Pharmaceuticals; Research: Saol Therapeutics; DS: Advisory Board, funded research: Scilex; speaker: AbbVie; MSE: funded research: SPR Therapeutics; consultant: Avanos, Abbott; MM: consultant: Juris Medicus; AA-E: consultant: Curonix; AC: research funding: NIH RM1NS128956; consultant: Swing Therapeutics, Scilex Pharmaceuticals; TLD: research support: Biohaven, NIH; consultant: Guidepoint Global; speaker honorarium: Remedy Health Media; CP: consulting: Mainstay Medical; royalties, UpToDate; SS: consultant: SPR Therapeutics, Allergan; AS: NIH R34AR080279; SPC: consulting (past 2 years): Avanos, Scilex, SPR, SWORD, Releviate (ended), Clearing (ended), Persica (inactive); research funds paid to institution: Scilex, Avanos; JAH: grants: Neiman Health Policy Institute (no number associated with this foundation grant); consulting (last 12 months): Medtronic, Relievant, Persica; DMC Chair: Balt, Rapid Medical, Arsenal; BS: consultant: State Farm, Carelon; TM: consultant, Interventional AnalgesiX; SN: consultant, Shiratonics; AW: investigator-initiated grant, Goodblends; TH: Acella: Advisory Board, speaker: Acella; CH: research grant: Nevro. The remaining authors declare no competing interests.

Patient consent for publication Not applicable.

Ethics approval Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplementary information.

ORCID iDs
Honorio T Benzon http://orcid.org/0000-0003-1376-8003
David Anthony Provenzano http://orcid.org/0000-0002-2147-3523
Ameet Nagpal http://orcid.org/0000-0001-5642-3465
Ariana M Nelson http://orcid.org/0000-0003-1575-1635
Andrea L Chadwick http://orcid.org/0000-0002-0570-9997
Tina L Doshi http://orcid.org/0000-0001-5011-3298
Carlos A Pino http://orcid.org/0000-0002-7560-8403
Hariharan Shankar http://orcid.org/0000-0002-1567-3887
Steven P Cohen http://orcid.org/0000-0001-5928-2127
Samer Narouze http://orcid.org/0000-0003-1849-1402
Harsha Shanthanna http://orcid.org/0000-0002-4105-4465
Christine Hunt http://orcid.org/0000-0002-0507-7889

REFERENCES

1 Ebell MH. Osteoarthritis: Rapid Evidence Review. *Am Fam Physician Apr* 2018;97:523–6.
2 Marcolina A, Vu K, Chang Chien G. Peripheral Joint Injections. *Phys Med Rehabil Clin N Am* 2022;33:267–306.
3 Havelin J, King T. Mechanisms Underlying Bone and Joint Pain. *Curr Osteoporos Rep* 2018;16:763–71.
4 Benzon HT, Elmofty D, Shankar H, *et al*. Use of corticosteroids for adult chronic pain interventions: sympathetic and peripheral nerve blocks, trigger point injections - guidelines from the American Society of Regional Anesthesia and Pain Medicine, the American Academy of Pain Medicine, the American Society of Interventional Pain Physicians, the International Pain and Spine Intervention Society, and the North American Spine Society. *Reg Anesth Pain Med* 2024.
5 Harris RP, Helfand M, Woolf SH, *et al*. Current methods of the US Preventive Services Task Force: a review of the process. *Am J Prev Med* 2001;20:21–35.
6 Benzon HT, Joshi GP, Gan TJ, *et al*. Development, Reporting, and Evaluation of Clinical Practice Guidelines. *Anesth Analg* 2019;129:1771–7.
7 Sinha IP, Smyth RL, Williamson PR. Using the Delphi technique to determine which outcomes to measure in clinical trials: recommendations for the future based on a systematic review of existing studies. *PLoS Med* 2011;8:e1000393.
8 Gibbs AJ, Gray B, Wallis JA, *et al*. Recommendations for the management of hip and knee osteoarthritis: A systematic review of clinical practice guidelines. *Osteoarthr Cartil* 2023;31:1280–92.
9 Moseng T, Vliet Vlieland TPM, Battista S, *et al*. EULAR recommendations for the non-pharmacological core management of hip and knee osteoarthritis: 2023 update. *Ann Rheum Dis* 2024;83:730–40.
10 Kolasinski SL, Neogi T, Hochberg MC, *et al*. 2019 American College of Rheumatology/Arthritis Foundation Guideline for the Management of Osteoarthritis of the Hand, Hip, and Knee. *Arthritis Rheumatol* 2020;72:220–33.
11 Rees HW. Management of Osteoarthritis of the Hip. *J Am Acad Orthop Surg* 2020;28:e288–91.
12 Jevsevar DS, Brown GA, Jones DL, *et al*. The American Academy of Orthopaedic Surgeons evidence-based guideline on: treatment of osteoarthritis of the knee, 2nd edition. *J Bone Joint Surg Am* 2013;95:1885–6.
13 AAOS. Diagnosis and prevention of periprosthetic joint infections evidence-based clinical practice guideline. Available: https://www.aaos.org/globalassets/quality-and-practice-resources/pji/diagnosisandpreventionofperiprostheticjointinfections-7-24-19.pdf [Accessed 08 Nov 2023].
14 American Academy of Orthopaedic Surgeons. Management of osteoarthritis of the hip. evidence-based clinical practice guideline. Available: www.aaos.org/oahguideline [Accessed 14 Nov 2024].
15 Uson J, Rodriguez-García SC, Castellanos-Moreira R, *et al*. EULAR recommendations for intra-articular therapies. *Ann Rheum Dis* 2021;80:1299–305.
16 Pendleton A, Arden N, Dougados M, *et al*. EULAR recommendations for the management of knee osteoarthritis: report of a task force of the Standing Committee for International Clinical Studies Including Therapeutic Trials (ESCISIT). *Ann Rheum Dis* 2000;59:936–44.
17 Zhang W, Doherty M, Arden N, *et al*. EULAR evidence based recommendations for the management of hip osteoarthritis: report of a task force of the EULAR Standing

Committee for International Clinical Studies Including Therapeutics (ESCISIT). *Ann Rheum Dis* 2005;64:669–81.
18 Bannuru RR, Osani MC, Vaysbrot EE, *et al*. OARSI guidelines for the non-surgical management of knee, hip, and polyarticular osteoarthritis. *Osteoarthr Cartil* 2019;27:1578–89.
19 Mardani-Kivi M, Karimi-Mobarakeh M, Karimi A, *et al*. The effects of corticosteroid injection versus local anesthetic injection in the treatment of lateral epicondylitis: a randomized single-blinded clinical trial. *Arch Orthop Trauma Surg* 2013;133:757–63.
20 Centeno LM, Moore ME. Preferred intraarticular corticosteroids and associated practice: a survey of members of the American College of Rheumatology. *Arthritis Care Res* 1994;7:151–5.
21 Eberhard BA, Sison MC, Gottlieb BS, *et al*. Comparison of the intraarticular effectiveness of triamcinolone hexacetonide and triamcinolone acetonide in treatment of juvenile rheumatoid arthritis. *J Rheumatol* 2004;31:2507–12.
22 Zulian F, Martini G, Gobber D, *et al*. Comparison of intra-articular triamcinolone hexacetonide and triamcinolone acetonide in oligoarticular juvenile idiopathic arthritis. *Rheumatology (Oxford)* 2003;42:1254–9.
23 Pyne D, Ioannou Y, Mootoo R, *et al*. Intra-articular steroids in knee osteoarthritis: a comparative study of triamcinolone hexacetonide and methylprednisolone acetate. *Clin Rheumatol* 2004;23:116–20.
24 Garg N, Perry L, Deodhar A. Intra-articular and soft tissue injections, a systematic review of relative efficacy of various corticosteroids. *Clin Rheumatol* 2014;33:1695–706.
25 Valtonen EJ. Clinical comparison of triamcinolonehexacetonide and betamethasone in the treatment of osteoarthrosis of the knee-joint. *Scand J Rheumatol Suppl* 1981;41:1–7.
26 Kumar A, Dhir V, Sharma S, *et al*. Efficacy of Methylprednisolone Acetate Versus Triamcinolone Acetonide Intra-articular Knee Injection in Patients With Chronic Inflammatory Arthritis: A 24-Week Randomized Controlled Trial. *Clin Ther* 2017;39:150–8.
27 Kivitz A, Kwong L, Shlotzhauer T, *et al*. A randomized, phase IIa study to assess the systemic exposure of triamcinolone acetonide following injection of extended-release triamcinolone acetonide or traditional triamcinolone acetonide into both knees of patients with bilateral knee osteoarthritis. *Ther Adv Musculoskelet Dis* 2019;11.
28 Kraus VB, Conaghan PG, Aazami HA, *et al*. Synovial and systemic pharmacokinetics (PK) of triamcinolone acetonide (TA) following intra-articular (IA) injection of an extended-release microsphere-based formulation (FX006) or standard crystalline suspension in patients with knee osteoarthritis (OA). *Osteoarthritis Cartilage* 2018;26:34–42.
29 Conaghan PG, Cohen SB, Berenbaum F, *et al*. Brief Report: A Phase IIb Trial of a Novel Extended-Release Microsphere Formulation of Triamcinolone Acetonide for Intraarticular Injection in Knee Osteoarthritis. *Arthritis Rheumatol* 2018;70:204–11.
30 Conaghan PG, Hunter DJ, Cohen SB, *et al*. Effects of a Single Intra-Articular Injection of a Microsphere Formulation of Triamcinolone Acetonide on Knee Osteoarthritis Pain: A Double-Blinded, Randomized, Placebo-Controlled, Multinational Study. *J Bone Joint Surg Am* 2018;100:666–77.
31 Russell SJ, Sala R, Conaghan PG, *et al*. Triamcinolone acetonide extended-release in patients with osteoarthritis and type 2 diabetes: a randomized, phase 2 study. *Rheumatology (Oxford)* 2018;57:2235–41.
32 Hanson P, Kivitz A, Mehra P, *et al*. Safety and Systemic Exposure of Triamcinolone Acetonide Following Ultrasound-Guided Intra-Articular Injection of Triamcinolone Extended-Release or Standard Triamcinolone Acetonide in Patients with Shoulder Osteoarthritis: An Open-Label, Randomized Study. *Drugs R D* 2021;21:285–93.
33 Bodick N, Lufkin J, Willwerth C, *et al*. An intra-articular, extended-release formulation of triamcinolone acetonide prolongs and amplifies analgesic effect in patients with osteoarthritis of the knee: a randomized clinical trial. *J Bone Joint Surg Am* 2015;97:877–88.
34 Blankstein M, Lentine B, Nelms NJ. Common Practices in Intra-Articular Corticosteroid Injection for the Treatment of Knee Osteoarthritis: A Survey of the American Association of Hip and Knee Surgeons Membership. *J Arthroplasty* 2021;36:845–50.
35 Mitchell WG, Kettwich SC, Sibbitt WL Jr, *et al*. Outcomes and cost-effectiveness of ultrasound-guided injection of the trochanteric bursa. *Rheumatol Int* 2018;38:393–401.
36 Rutten MJCM, Maresch BJ, Jager GJ, *et al*. Injection of the subacromial-subdeltoid bursa: blind or ultrasound-guided? *Acta Orthop* 2007;78:254–7.
37 Amber KT, Landy DC, Amber I, *et al*. Comparing the accuracy of ultrasound versus fluoroscopy in glenohumeral injections: a systematic review and meta-analysis. *J Clin Ultrasound* 2014;42:411–6.
38 Bae JH, Park YS, Chang HJ, *et al*. Randomized controlled trial for efficacy of capsular distension for adhesive capsulitis: fluoroscopy-guided anterior versus ultrasonography-guided posterolateral approach. *Ann Rehabil Med* 2014;38:360–8.
39 Ng AWH, Hung EHY, Griffith JF, *et al*. Comparison of ultrasound versus fluoroscopic guided rotator cuff interval approach for MR arthrography. *Clin Imaging* 2013;37:548–53.
40 Petscavage-Thomas J, Gustas C. Comparison of Ultrasound-Guided to Fluoroscopy-Guided Biceps Tendon Sheath Therapeutic Injection. *J Ultrasound Med* 2016;35:2217–21.
41 Gutierrez M, Di Matteo A, Rosemffet M, *et al*. Short-term efficacy to conventional blind injection versus ultrasound-guided injection of local corticosteroids in tenosynovitis in patients with inflammatory chronic arthritis: A randomized comparative study. *Joint Bone Spine* 2016;83:161–6.
42 Cunnington J, Marshall N, Hide G, *et al*. A randomized, double-blind, controlled study of ultrasound-guided corticosteroid injection into the joint of patients with inflammatory arthritis. *Arthritis Rheum* 2010;62:1862–9.
43 Gilliland CA, Salazar LD, Borchers JR. Ultrasound versus anatomic guidance for intra-articular and periarticular injection: a systematic review. *Phys Sportsmed* 2011;39:121–31.
44 Daniels EW, Cole D, Jacobs B, *et al*. Existing Evidence on Ultrasound-Guided Injections in Sports Medicine. *Orthop J Sports Med* 2018;6:2325967118756576.
45 Burbank KM, Stevenson JH, Czarnecki GR, *et al*. Chronic shoulder pain: part I. Evaluation and diagnosis. *Am Fam Physician* 2008;77:453–60.
46 Strobel K, Pfirrmann CWA, Zanetti M, *et al*. MRI features of the acromioclavicular joint that predict pain relief from intraarticular injection. *AJR Am J Roentgenol* 2003;181:755–60.
47 Rajagopalan D, Abdelaziz A, Ring D, *et al*. MRI findings of acromioclavicular joint osteoarthritis are the norm after age 40. *Orthop Traumatol Surg Res* 2023;109:103526.
48 Burbank KM, Stevenson JH, Czarnecki GR, *et al*. Chronic shoulder pain: part II. Treatment. *Am Fam Physician* 2008;77:493–7.
49 Al-Mohrej OA, Prada C, Leroux T, *et al*. Pharmacological Treatment in the Management of Glenohumeral Osteoarthritis. *Drugs Aging* 2022;39:119–28.
50 Luime JJ, Koes BW, Hendriksen IJ, *et al*. Prevalence and incidence of shoulder pain in the general population; a systematic review. *Scand J Rheumatol* 2004;33:73–81.
51 Gialanella B, Prometti P. Effects of corticosteroids injection in rotator cuff tears. *Pain Med* 2011;12:1559–65.
52 Challoumas D, Biddle M, McLean M, *et al*. Comparison of Treatments for Frozen Shoulder: A Systematic Review and Meta-analysis. *JAMA Netw Open* 2020;3:e2029581.
53 Stokes DJ, McCarthy TP, Frank RM. Physical Therapy for the Treatment of Shoulder Instability. *Phys Med Rehabil Clin N Am* 2023;34:393–408.
54 Scanaliato JP, Green CK, Sandler AB, *et al*. Establishing the Minimal Clinically Important Difference, Substantial Clinical Benefit, and Patient Acceptable Symptomatic State After Arthroscopic Posterior Labral Repair for Posterior Glenohumeral Instability. *Am J Sports Med* 2024;52:207–14.
55 Churgay CA. Diagnosis and treatment of biceps tendinitis and tendinosis. *Am Fam Physician* 2009;80:470–6.
56 Cardoso A, Amaro P, Barbosa L, *et al*. Diagnostic accuracy of clinical tests directed to the long head of biceps tendon in a surgical population: a combination of old and new tests. *J Shoulder Elbow Surg* 2019;28:2272–8.
57 Osias W, Matcuk GR Jr, Skalski MR, *et al*. Scapulothoracic pathology: review of anatomy, pathophysiology, imaging findings, and an approach to management. *Skeletal Radiol* 2018;47:161–71.
58 Manske RC, Reiman MP, Stovak ML. Nonoperative and operative management of snapping scapula. *Am J Sports Med* 2004;32:1554–65.
59 Conduah AH, Baker CL III, Baker CL Jr. Clinical Management of Scapulothoracic Bursitis and the Snapping Scapula. *Sports Health: A Multidisciplinary Approach* 2010;2:147–55.
60 Chang WH, Im SH, Ryu JA, *et al*. The effects of scapulothoracic bursa injections in patients with scapular pain: a pilot study. *Arch Phys Med Rehabil* 2009;90:279–84.
61 Chang WH, Kim YW, Choi S, *et al*. Comparison of the therapeutic effects of intramuscular subscapularis and scapulothoracic bursa injections in patients with scapular pain: a randomized controlled trial. *Rheumatol Int* 2014;34:1203–9.
62 Sharareh B, Hsu JE, Matsen FA, *et al*. Which Components of the Simple Shoulder Test Show Improvement After Scapulothoracic Fusion for Recalcitrant Scapular Winging? Clinical Results at a Minimum of 5 Years of Follow-up. *Clin Orthop Relat Res* 2023;481:2392–402.
63 Moskowitz RW, Blaine TA. An overview of treatment options for persistent shoulder pain. *Am J Orthop (Belle Mead NJ)* 2005;34:10–5.
64 Yamamoto N, Szymski D, Voss A, *et al*. Non-operative management of shoulder osteoarthritis: Current concepts. *J ISAKOS* 2023;8:289–95.
65 Shang X, Zhang Z, Pan X, *et al*. Intra-Articular versus Subacromial Corticosteroid Injection for the Treatment of Adhesive Capsulitis: A Meta-Analysis and Systematic Review. *Biomed Res Int* 2019;2019:1274790.
66 Chen R, Jiang C, Huang G. Comparison of intra-articular and subacromial corticosteroid injection in frozen shoulder: A meta-analysis of randomized controlled trials. *Int J Surg* 2019;68:92–103.
67 Prestgaard T, Wormgoor MEA, Haugen S, *et al*. Ultrasound-guided intra-articular and rotator interval corticosteroid injections in adhesive capsulitis of the shoulder: a double-blind, sham-controlled randomized study. *Pain* 2015;156:1683–91.
68 Rah UW, Yoon S-H, Moon DJ, *et al*. Subacromial corticosteroid injection on poststroke hemiplegic shoulder pain: a randomized, triple-blind, placebo-controlled trial. *Arch Phys Med Rehabil* 2012;93:949–56.

69 Park KD, Kim TK, Lee J, *et al*. Palpation Versus Ultrasound-Guided Acromioclavicular Joint Intra-articular Corticosteroid Injections: A Retrospective Comparative Clinical Study. *Pain Physician* 2015;18:333–41.
70 Zadro J, Rischin A, Johnston RV, *et al*. Image-guided glucocorticoid injection versus injection without image guidance for shoulder pain. *Cochrane Database Syst Rev* 2021;8:CD009147.
71 Cho CH, Min BW, Bae KC, *et al*. A prospective double-blind randomized trial on ultrasound-guided versus blind intra-articular corticosteroid injections for primary frozen shoulder. *Bone Joint J* 2021;103-B:353–9.
72 Sethi PM, Kingston S, Elattrache N. Accuracy of anterior intra-articular injection of the glenohumeral joint. *Arthroscopy* 2005;21:77–80.
73 Ganokroj P, Matrakool L, Limsuwarn P, *et al*. A Prospective Randomized Study Comparing the Effectiveness of Midlateral and Posterior Subacromial Steroid Injections. *Orthopedics* 2019;42:e44–50.
74 Ogbeivor C, Bandaru S, Milton C. A comparison of the effectiveness of lateral versus posterior approach to shoulder injection in patients with subacromial impingement syndrome: A pragmatic randomized controlled trial. *Musculoskeletal Care* 2019;17:257–68.
75 Ogbeivor C. Needle placement approach to subacromial injection in patients with subacromial impingement syndrome: A systematic review. *Musculoskeletal Care* 2019;17:13–22.
76 Henkus H-E, Cobben LPJ, Coerkamp EG, *et al*. The accuracy of subacromial injections: a prospective randomized magnetic resonance imaging study. *Arthroscopy* 2006;22:277–82.
77 Wu T, Song HX, Dong Y, *et al*. Ultrasound-guided versus blind subacromial-subdeltoid bursa injection in adults with shoulder pain: A systematic review and meta-analysis. *Semin Arthritis Rheum* 2015;45:374–8.
78 Ayekoloye CI, Nwangwu O. Ultrasound-Guided Versus Anatomic Landmark-Guided Steroid Injection of the Subacromial Bursa in the Management of Subacromial Impingement: A Systematic Review of Randomised Control Studies. *Indian J Orthop* 2020;54:10–9.
79 Soh E, Li W, Ong KO, *et al*. Image-guided versus blind corticosteroid injections in adults with shoulder pain: a systematic review. *BMC Musculoskelet Disord* 2011;12:137.
80 Sage W, Pickup L, Smith TO, *et al*. The clinical and functional outcomes of ultrasound-guided vs landmark-guided injections for adults with shoulder pathology--a systematic review and meta-analysis. *Rheumatology (Oxford)* 2013;52:743–51.
81 Onks C, Weaver L, Latorre J, *et al*. The most effective corticosteroid dose in the treatment of glenohumeral osteoarthritis: Feasibility pilot and protocol for double blinded randomized controlled trial. *Osteoarthr Cartil Open* 2024;6:100484.
82 Yoon SH, Lee HY, Lee HJ, *et al*. Optimal dose of intra-articular corticosteroids for adhesive capsulitis: a randomized, triple-blind, placebo-controlled trial. *Am J Sports Med May* 2013;41:1133–9.
83 Kim YS, Lee HJ, Lee DH, *et al*. Comparison of high- and low-dose intra-articular triamcinolone acetonide injection for treatment of primary shoulder stiffness: a prospective randomized trial. *J Shoulder Elbow Surg Feb* 2017;26:209–15.
84 Hong JY, Yoon SH, Moon DJ, *et al*. Comparison of high- and low-dose corticosteroid in subacromial injection for periarticular shoulder disorder: a randomized, triple-blind, placebo-controlled trial. *Arch Phys Med Rehabil Dec* 2011;92:1951–60.
85 Carroll MB, Motley SA, Smith B, *et al*. Comparing Corticosteroid Preparation and Dose in the Improvement of Shoulder Function and Pain: A Randomized, Single-Blind Pilot Study. *Am J Phys Med Rehabil Jun* 2018;97:450–5.
86 Rhim HC, Ruiz J, Taseh A, *et al*. Nonsteroidal Anti-Inflammatory Drug Injections versus Steroid Injections in the Management of Upper and Lower Extremity Orthopedic Conditions: A Systematic Review with Meta-Analysis. *J Clin Med* 2024;13:1132.
87 Geannette C, Williams D, Berkowitz J, *et al*. Ultrasound-Guided Biceps Tendon Sheath Injection: Spectrum of Preprocedure Appearances. *J Ultrasound Med* 2019;38:3267–71.
88 Hashiuchi T, Sakurai G, Morimoto M, *et al*. Accuracy of the biceps tendon sheath injection: ultrasound-guided or unguided injection? A randomized controlled trial. *J Shoulder Elbow Surg* 2011;20:1069–73.
89 Zhang J, Ebraheim N, Lause GE. Ultrasound-guided injection for the biceps brachii tendinitis: results and experience. *Ultrasound Med Biol* 2011;37:729–33.
90 Yiannakopoulos CK, Megaloikonomos PD, Foufa K, *et al*. Ultrasound-guided versus palpation-guided corticosteroid injections for tendinosis of the long head of the biceps: A randomized comparative study. *Skeletal Radiol* 2020;49:585–91.
91 Mitra R, Nguyen A, Stevens KJ. Fluoroscopically guided supraglenoid tubercle steroid injections for the management of biceps tendonitis. *Pain Pract* 2011;11:392–6.
92 Vardakas DG, Musgrave DS, Varitimidis SE, *et al*. Partial rupture of the distal biceps tendon. *J Shoulder Elbow Surg* 2001;10:377–9.
93 Ford LT, DeBender J. Tendon rupture after local steroid injection. *South Med J* 1979;72:827–30.
94 Carpenito G, Gutierrez M, Ravagnani V, *et al*. Complete rupture of biceps tendons after corticosteroid injection in psoriatic arthritis "Popeye sign": role of ultrasound. *J Clin Rheumatol* 2011;17:108.
95 Lee JH, Kim KC, Lee JH, *et al*. A Case Series of Symptomatic Distal Biceps Tendinopathy. *Clin Shoulder Elb* 2018;21:213–9.
96 Sun Y, Chen J, Li H, *et al*. Steroid Injection and Nonsteroidal Anti-inflammatory Agents for Shoulder Pain: A PRISMA Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Medicine (Baltimore)* 2015;94:e2216.
97 Wang C, Zhang Z, Ma Y, *et al*. Platelet-rich plasma injection vs corticosteroid injection for conservative treatment of rotator cuff lesions: A systematic review and meta-analysis. *Medicine (Baltimore)* 2021;100:e24680.
98 Burger M, Africa C, Droomer K, *et al*. Effect of corticosteroid injections versus physiotherapy on pain, shoulder range of motion and shoulder function in patients with subacromial impingement syndrome: A systematic review and meta-analysis. *S Afr J Physiother* 2016;72:318.
99 Zhu P, Liao B, Wang Z, *et al*. Resistance band training after triamcinolone acetonide injection for subacromial bursitis: A randomized clinical trial. *J Rehabil Med* 2021;53.
100 Malahias MA, Kaseta MK, Kazas ST, *et al*. Image-guided versus palpation-guided injections for the treatment of chronic lateral epicondylopathy: a randomized controlled clinical trial. *Handchir Mikrochir Plast Chir* 2018;50:348–52.
101 Qian X, Lin Q, Wei K, *et al*. Efficacy and Safety of Autologous Blood Products Compared With Corticosteroid Injections in the Treatment of Lateral Epicondylitis: A Meta-Analysis of Randomized Controlled Trials. *PM R* 2016;8:780–91.
102 Krogh TP, Bartels EM, Ellingsen T, *et al*. Comparative effectiveness of injection therapies in lateral epicondylitis: a systematic review and network meta-analysis of randomized controlled trials. *Am J Sports Med* 2013;41:1435–46.
103 Bisset L, Beller E, Jull G, *et al*. Mobilisation with movement and exercise, corticosteroid injection, or wait and see for tennis elbow: randomised trial. *BMJ* 2006;333:939.
104 Coombes BK, Bisset L, Vicenzino B. Efficacy and safety of corticosteroid injections and other injections for management of tendinopathy: a systematic review of randomised controlled trials. *Lancet* 2010;376:1751–67.
105 Gaujoux-Viala C, Dougados M, Gossec L. Efficacy and safety of steroid injections for shoulder and elbow tendonitis: a meta-analysis of randomised controlled trials. *Ann Rheum Dis* 2009;68:1843–9.
106 Assendelft WJ, Hay EM, Adshead R, *et al*. Corticosteroid injections for lateral epicondylitis: a systematic overview. *Br J Gen Pract* 1996;46:209–16.
107 Bisset L, Coombes B, Vicenzino B. Tennis elbow. *BMJ Clin Evid* 2011;2011:1117.
108 Mandiroglu S, Bal A, Gurcay E, *et al*. Comparison of the effects of non-steroidal anti-inflammatory drugs, steroid injection and physical therapy in lateral epicondylitis. *Turk J Phys Med Rehabil* 2007;53:104–7. Available: https://www.ftrdergisi.com/abstract.php?id=3242
109 Yi R, Bratchenko WW, Tan V. Deep Friction Massage Versus Steroid Injection in the Treatment of Lateral Epicondylitis. *Hand (New York, N, Y)* 2018;13:56–9.
110 Li A, Wang H, Yu Z, *et al*. Platelet-rich plasma vs corticosteroids for elbow epicondylitis: A systematic review and meta-analysis. *Medicine (Baltimore)* 2019;98:e18358.
111 Arirachakaran A, Sukthuayat A, Sisayanarane T, *et al*. Platelet-rich plasma versus autologous blood versus steroid injection in lateral epicondylitis: systematic review and network meta-analysis. *J Orthop Traumatol* 2016;17:101–12.
112 Price R, Sinclair H, Heinrich I, *et al*. Local injection treatment of tennis elbow--hydrocortisone, triamcinolone and lignocaine compared. *Br J Rheumatol* 1991;30:39–44.
113 Stahl S, Kaufman T. The efficacy of an injection of steroids for medial epicondylitis. A prospective study of sixty elbows. *J Bone Joint Surg Am* 1997;79:1648–52.
114 Soojian MG, Kwon YW. Elbow arthritis. *Bull NYU Hosp Jt Dis* 2007;65:61–71.
115 Cardone DA, Tallia AF. Diagnostic and therapeutic injection of the elbow region. *Am Fam Physician* 2002;66:2097–100.
116 Kim JY, Chung SW, Kim JH, *et al*. A Randomized Trial Among Compression Plus Nonsteroidal Antiinflammatory Drugs, Aspiration, and Aspiration With Steroid Injection for Nonseptic Olecranon Bursitis. *Clin Orthop Relat Res* 2016;474:776–83.
117 Anderson ES, Hodell E, Mantuani D, *et al*. Pilot study of ultrasound-guided corticosteroid hip injections by emergency physicians. *West J Emerg Med* 2014;15:919–24.
118 Lee YK, Lee GY, Lee JW, *et al*. Intra-Articular Injections in Patients with Femoroacetabular Impingement: a Prospective, Randomized, Double-blind, Cross-over Study. *J Korean Med Sci* 2016;31:1822–7.
119 McCabe PS, Maricar N, Parkes MJ, *et al*. The efficacy of intra-articular steroids in hip osteoarthritis: a systematic review. *Osteoarthr Cartil* 2016;24:1509–17.
120 Zhong H-M, Zhao G-F, Lin T, *et al*. Intra-Articular Steroid Injection for Patients with Hip Osteoarthritis: A Systematic Review and Meta-Analysis. *Biomed Res Int* 2020;2020:6320154.
121 Jordan KM, Arden NK, Doherty M, *et al*. EULAR Recommendations 2003: an evidence based approach to the management of knee osteoarthritis: Report of a Task Force of the Standing Committee for International Clinical Studies Including Therapeutic Trials (ESCISIT). *Ann Rheum Dis* 2003;62:1145–55.
122 Kompel AJ, Roemer FW, Murakami AM, *et al*. Intra-articular Corticosteroid Injections in the Hip and Knee: Perhaps Not as Safe as We Thought? *Radiology* 2019;293:656–63.
123 Lambert RGW, Hutchings EJ, Grace MGA, *et al*. Steroid injection for osteoarthritis of the hip: A randomized, double-blind, placebo-controlled trial. *Arthritis & Rheumatism* 2007;56:2278–87.

124 Diraçoğlu D, Alptekin K, Dikici F, *et al*. Evaluation of needle positioning during blind intra-articular hip injections for osteoarthritis: fluoroscopy versus arthrography. *Arch Phys Med Rehabil* 2009;90:2112–5.
125 Martinez-Martinez A, Garcia-Espinosa J, Ruiz-Santiago F, *et al*. Comparison of ultrasound and fluoroscopic guidance for injection in CT arthrography and MR arthrography of the hip [Comparacion de las tecnicas de inyeccion ecografica y radioscopica en artro-TC y artro-RM de cadera]. *Radiologia (Panama)* 2016;58:454–9.
126 Byrd JWT, Potts EA, Allison RK, *et al*. Ultrasound-guided hip injections: a comparative study with fluoroscopy-guided injections. *Arthroscopy* 2014;30:42–6.
127 Park KD, Kim TK, Bae BW, *et al*. Ultrasound guided intra-articular ketorolac versus corticosteroid injection in osteoarthritis of the hip: a retrospective comparative study. *Skeletal Radiol* 2015;44:1333–40.
128 Jurgensmeier K, Jurgensmeier D, Kunz DE, *et al*. Intra-articular Injections of the Hip and Knee With Triamcinolone vs Ketorolac: A Randomized Controlled Trial. *J Arthroplasty* 2021;36:416–22.
129 Qvistgaard E, Christensen R, Torp-Pedersen S, *et al*. Intra-articular treatment of hip osteoarthritis: a randomized trial of hyaluronic acid, corticosteroid, and isotonic saline. *Osteoarthritis Cartilage* 2006;14:163–70.
130 Atchia I, Kane D, Reed MR, *et al*. Efficacy of a single ultrasound-guided injection for the treatment of hip osteoarthritis. *Ann Rheum Dis* 2011;70:110–6.
131 Choueiri M, Chevalier X, Eymard F. Intraarticular Corticosteroids for Hip Osteoarthritis: A Review. *Cartilage* 2021;13:122S–131S.
132 Ferrara PE, Codazza S, Coraci D, *et al*. State of art in intra-articular hip injections of different medications for osteoarthritis: a systematic review. *BMC Musculoskelet Disord* 2021;22:997.
133 Gazendam A, Ekhtiari S, Bozzo A, *et al*. Intra-articular saline injection is as effective as corticosteroids, platelet-rich plasma and hyaluronic acid for hip osteoarthritis pain: a systematic review and network meta-analysis of randomised controlled trials. *Br J Sports Med* 2021;55:256–61.
134 Chang CY, Mittu S, Da Silva Cardoso M, *et al*. Outcomes of imaging-guided corticosteroid injections in hip and knee osteoarthritis patients: a systematic review. *Skeletal Radiol* 2023;52:2297–308.
135 Young R, Harding J, Kingsly A, *et al*. Therapeutic hip injections: is the injection volume important? *Clin Radiol* 2012;67:55–60.
136 Migliorini F, Kader N, Eschweiler J, *et al*. Platelet-rich plasma versus steroids injections for greater trochanter pain syndrome: a systematic review and meta-analysis. *Br Med Bull* 2021;139:86–99.
137 Zibis AH, Mitrousias VD, Klontzas ME, *et al*. Great trochanter bursitis vs sciatica, a diagnostic-anatomic trap: differential diagnosis and brief review of the literature. *Eur Spine J* 2018;27:1509–16.
138 Long SS, Surrey DE, Nazarian LN. Sonography of greater trochanteric pain syndrome and the rarity of primary bursitis. *AJR Am J Roentgenol* 2013;201:1083–6.
139 Bird PA, Oakley SP, Shnier R, *et al*. Prospective evaluation of magnetic resonance imaging and physical examination findings in patients with greater trochanteric pain syndrome. *Arthritis Rheum Sep* 2001;44:2138–45.
140 Kong A, Van der Vliet A, Zadow S. MRI and US of gluteal tendinopathy in greater trochanteric pain syndrome. *Eur Radiol* 2007;17:1772–83.
141 Sugrañes J, Jackson GR, Warrier AA, *et al*. Snapping Hip Syndrome: Pathoanatomy, Diagnosis, Nonoperative Therapy, and Current Concepts in Operative Management. *JBJS Rev* 2023;11.
142 Walker P, Ellis E, Scofield J, *et al*. Snapping Hip Syndrome: A Comprehensive Update. *Orthop Rev (Pavia)* 2021;13:25088.
143 Tramer JS, Holmich P, Safran MR. The Iliopsoas: Anatomy, Clinical Evaluation, and Its Role in Hip Pain in the Athlete: A Scoping Review. *J Am Acad Orthop Surg* 2024;32:e620–30.
144 Blankenbaker DG, De Smet AA, Keene JS. Sonography of the iliopsoas tendon and injection of the iliopsoas bursa for diagnosis and management of the painful snapping hip. *Skeletal Radiol* 2006;35:565–71.
145 Herrington L, Rivett N, Munro S. The relationship between patella position and length of the iliotibial band as assessed using Ober's test. *Man Ther* 2006;11:182–6.
146 Barratt PA, Brookes N, Newson A. Conservative treatments for greater trochanteric pain syndrome: a systematic review. *Br J Sports Med* 2017;51:97–104.
147 Cohen SP, Narvaez JC, Lebovits AH, *et al*. Corticosteroid injections for trochanteric bursitis: is fluoroscopy necessary? A pilot study. *Br J Anaesth* 2005;94:100–6.
148 Cohen SP, Strassels SA, Foster L, *et al*. Comparison of fluoroscopically guided and blind corticosteroid injections for greater trochanteric pain syndrome: multicentre randomised controlled trial. *BMJ* 2009;338:b1088.
149 Ladurner A, Fitzpatrick J, O'Donnell JM. Treatment of Gluteal Tendinopathy: A Systematic Review and Stage-Adjusted Treatment Recommendation. *Orthop J Sports Med* 2021;9:23259671211016850.
150 Mu A, Peng P, Agur A. Landmark-Guided and Ultrasound-Guided Approaches for Trochanteric Bursa Injection: A Cadaveric Study. *Anesth Analg* 2017;124:966–71.
151 Mao LJ, Crudup JB, Quirk CR, *et al*. Impact of fluoroscopic injection location on immediate and delayed pain relief in patients with greater trochanteric pain syndrome. *Skeletal Radiol* 2020;49:1547–54.
152 Payne JM. Ultrasound-Guided Hip Procedures. *Phys Med Rehabil Clin N Am* 2016;27:607–29.
153 Agten CA, Rosskopf AB, Zingg PO, *et al*. Outcomes after fluoroscopy-guided iliopsoas bursa injection for suspected iliopsoas tendinopathy. *Eur Radiol* 2015;25:865–71.
154 Dauffenbach J, Pingree MJ, Wisniewski SJ, *et al*. Distribution pattern of sonographically guided iliopsoas injections: cadaveric investigation using coned beam computed tomography. *J Ultrasound Med* 2014;33:405–14.
155 Ege Rasmussen KJ, bursitis FNT. Treatment by corticosteroid injection. *Scand J Rheumatol* 1985;14:417–20.
156 Shbeeb MI, O'Duffy JD, Michet CJ Jr, *et al*. Evaluation of glucocorticosteroid injection for the treatment of trochanteric bursitis. *J Rheumatol* 1996;23:2104–6.
157 Foxcroft B, Stephens G, Woodhead T, *et al*. What factors influence pain scores following Corticosteroid injection in patients with Greater Trochanteric Pain Syndrome? A systematic review. *BMC Musculoskelet Disord* 2024;25:149.
158 Brinks A, van Rijn RM, Willemsen SP, *et al*. Corticosteroid injections for greater trochanteric pain syndrome: a randomized controlled trial in primary care. *Ann Fam Med* 2011;9:226–34.
159 Rompe JD, Segal NA, Cacchio A, *et al*. Home training, local corticosteroid injection, or radial shock wave therapy for greater trochanter pain syndrome. *Am J Sports Med* 2009;37:1981–90.
160 Nissen MJ, Brulhart L, Faundez A, *et al*. Glucocorticoid injections for greater trochanteric pain syndrome: a randomised double-blind placebo-controlled (GLUTEAL) trial. *Clin Rheumatol* 2019;38:647–55.
161 Brennan KL, Allen BC, Maldonado YM. Dry Needling Versus Cortisone Injection in the Treatment of Greater Trochanteric Pain Syndrome: A Noninferiority Randomized Clinical Trial. *J Orthop Sports Phys Ther* 2017;47:232–9.
162 Heaver C, Pinches M, Kuiper JH, *et al*. Greater trochanteric pain syndrome: focused shockwave therapy versus an ultrasound guided injection: a randomised control trial. *Hip Int* 2023;33:490–9.
163 Fitzpatrick J, Bulsara MK, O'Donnell J, *et al*. The Effectiveness of Platelet-Rich Plasma Injections in Gluteal Tendinopathy: A Randomized, Double-Blind Controlled Trial Comparing a Single Platelet-Rich Plasma Injection With a Single Corticosteroid Injection. *Am J Sports Med* 2018;46:933–9.
164 Fitzpatrick J, Bulsara MK, O'Donnell J, *et al*. Leucocyte-Rich Platelet-Rich Plasma Treatment of Gluteus Medius and Minimus Tendinopathy: A Double-Blind Randomized Controlled Trial With 2-Year Follow-up. *Am J Sports Med* 2019;47:1130–7.
165 Mellor R, Grimaldi A, Wajswelner H, *et al*. Exercise and load modification versus corticosteroid injection versus "wait and see" for persistent gluteus medius/minimus tendinopathy (the LEAP trial): a protocol for a randomised clinical trial. *BMC Musculoskelet Disord* 2016;17:196.
166 Mellor R, Bennell K, Grimaldi A, *et al*. Education plus exercise versus corticosteroid injection use versus a wait and see approach on global outcome and pain from gluteal tendinopathy: prospective, single blinded, randomised clinical trial. *Br J Sports Med* 2018;52:1464–72.
167 Gunter P, Schwellnus MP. Local corticosteroid injection in iliotibial band friction syndrome in runners: a randomised controlled trial. *Br J Sports Med* 2004;38:269–72.
168 Pandit SR, Solomon DJ, Gross DJ, *et al*. Isolated Iliotibial Band Rupture After Corticosteroid Injection as a Cause of Subjective Instability and Knee Pain in a Military Special Warfare Trainee. *Mil Med* 2014;179:e469–72.
169 Jackson DW, Evans NA, Thomas BM. Accuracy of needle placement into the intra-articular space of the knee. *J Bone Joint Surg Am* 2002;84:1522–7.
170 Sheth T, Miranda OM, Johnson B. Assessment of patient satisfaction, functionality, and quality of life after ultrasound-guided knee intervention: a prospective study. *Clin Rheumatol* 2021;40:735–40.
171 Sibbitt WL Jr, Kettwich LG, Band PA, *et al*. Does ultrasound guidance improve the outcomes of arthrocentesis and corticosteroid injection of the knee? *Scand J Rheumatol* 2012;41:66–72.
172 Fang WH, Chen XT, Vangsness CT Jr. Ultrasound-Guided Knee Injections Are More Accurate Than Blind Injections: A Systematic Review of Randomized Controlled Trials. *Arthrosc Sports Med Rehabil* 2021;3:e1177–87.
173 Popma JW, Snel FW, Haagsma CJ, *et al*. Comparison of 2 Dosages of Intraarticular Triamcinolone for the Treatment of Knee Arthritis: Results of a 12-week Randomized Controlled Clinical Trial. *J Rheumatol* 2015;42:1865–8.
174 Liu S-H, Dubé CE, Eaton CB, *et al*. Longterm Effectiveness of Intraarticular Injections on Patient-reported Symptoms in Knee Osteoarthritis. *J Rheumatol* 2018;45:1316–24.
175 da Costa BR, Hari R, Jüni P. Intra-articular Corticosteroids for Osteoarthritis of the Knee. *JAMA* 2016;316:2671–2.
176 Najm A, Alunno A, Gwinnutt JM, *et al*. Efficacy of intra-articular corticosteroid injections in knee osteoarthritis: A systematic review and meta-analysis of randomized controlled trials. *Joint Bone Spine* 2021;88:105198.
177 Pavone V, Vescio A, Turchetta M, *et al*. Injection-Based Management of Osteoarthritis of the Knee: A Systematic Review of Guidelines. *Front Pharmacol* 2021;12:661805.
178 Charalambous C, Paschalides C, Sadiq S, *et al*. Weight bearing following intra-articular steroid injection of the knee: survey of current practice and review of the available evidence. *Rheumatol Int* 2002;22:185–7.

179 Wallen M, Gillies D. Intra-articular steroids and splints/rest for children with juvenile idiopathic arthritis and adults with rheumatoid arthritis. *Cochrane Database Syst Rev* 2006;2006:CD002824.
180 Chakravarty K, Pharoah PD, Scott DG. A randomized controlled study of post-injection rest following intra-articular steroid therapy for knee synovitis. *Br J Rheumatol* 1994;33:464–8.
181 Flanagan ER, Benham H, Figueroa J, *et al*. Retrospective review of immobilization vs. immediate resumption of activity in patients with Oligoarticular juvenile idiopathic arthritis following knee injections. *Pediatr Rheumatol Online J* 2019;17:42.
182 Cherasse A, Kahn MF, Mistrih R, *et al*. Nicolau's syndrome after local glucocorticoid injection. *Joint Bone Spine* 2003;70:390–2.
183 Habib GS, Saliba W, Nashashibi M. Local effects of intra-articular corticosteroids. *Clin Rheumatol* 2010;29:347–56.
184 Rozental TD, Sculco TP. Intra-articular corticosteroids: an updated overview. *Am J Orthop (Belle Mead NJ)* 2000;29:18–23.
185 Habib GS. Systemic effects of intra-articular corticosteroids. *Clin Rheumatol* 2009;28:749–56.
186 Young CM, Shiels WE II, Coley BD, *et al*. Ultrasound-guided corticosteroid injection therapy for juvenile idiopathic arthritis: 12-year care experience. *Pediatr Radiol* 2012;42:1481–9.
187 Wang S, Wang X, Liu Y, *et al*. Ultrasound-guided intra-articular triamcinolone acetonide injection for treating refractory small joints arthritis of rheumatoid arthritis patients. *Medicine (Abingdon)* 2019;98:e16714.
188 Sibbitt WL Jr, Band PA, Chavez-Chiang NR, *et al*. A randomized controlled trial of the cost-effectiveness of ultrasound-guided intraarticular injection of inflammatory arthritis. *J Rheumatol* 2011;38:252–63.
189 Haugeberg G, Morton S, Emery P, *et al*. Effect of intra-articular corticosteroid injections and inflammation on periarticular and generalised bone loss in early rheumatoid arthritis. *Ann Rheum Dis* 2011;70:184–7.
190 Jahangiri A, Moghaddam FR, Najafi S. Hypertonic dextrose versus corticosteroid local injection for the treatment of osteoarthritis in the first carpometacarpal joint: a double-blind randomized clinical trial. *J Orthop Sci* 2014;19:737–43.
191 Fowler A, Swindells MG, Burke FD. Intra-Articular Corticosteroid Injections to Manage Trapeziometacarpal Osteoarthritis—a Systematic Review. *Hand (New York, N,Y)* 2015;10:583–92.
192 Spaans AJ, van Minnen LP, Kon M, *et al*. Conservative treatment of thumb base osteoarthritis: a systematic review. *J Hand Surg Am* 2015;40:16–21.
193 Spolidoro Paschoal N de O, Natour J, Machado FS, *et al*. Effectiveness of Triamcinolone Hexacetonide Intraarticular Injection in Interphalangeal Joints: A 12-week Randomized Controlled Trial in Patients with Hand Osteoarthritis. *J Rheumatol* 2015;42:1869–77.
194 Trellu S, Dadoun S, Berenbaum F, *et al*. Intra-articular injections in thumb osteoarthritis: A systematic review and meta-analysis of randomized controlled trials. *Joint Bone Spine* 2015;82:315–9.
195 Kroon FPB, Rubio R, Schoones JW, *et al*. Intra-Articular Therapies in the Treatment of Hand Osteoarthritis: A Systematic Literature Review. *Drugs Aging* 2016;33:119–33.
196 Kroon FPB, Carmona L, Schoones JW, *et al*. Efficacy and safety of non-pharmacological, pharmacological and surgical treatment for hand osteoarthritis: a systematic literature review informing the 2018 update of the EULAR recommendations for the management of hand osteoarthritis. *RMD Open* 2018;4:e000734.
197 Hamasaki T, Laprise S, Harris PG, *et al*. Efficacy of Nonsurgical Interventions for Trapeziometacarpal (Thumb Base) Osteoarthritis: A Systematic Review. *Arthritis Care Res (Hoboken)* 2020;72:1719–35.
198 Meenagh GK, Patton J, Kynes C, *et al*. A randomised controlled trial of intra-articular corticosteroid injection of the carpometacarpal joint of the thumb in osteoarthritis. *Ann Rheum Dis* 2004;63:1260–3.
199 Spolidoro NDO, Machado FS, Oliveira HAV, *et al*. SAT0312 Interphalangeal Intra-Articular Injection with Triamcinolone Hexacetonide: Assessment of Effectiveness in Hand Osteoarthritis. *Ann Rheum Dis* 2013;72:A689.
200 Dubreuil M, Greger S, LaValley M, *et al*. Improvement in wrist pain with ultrasound-guided glucocorticoid injections: a meta-analysis of individual patient data. *Semin Arthritis Rheum* 2013;42:492–7.
201 Nam SH, Kim J, Lee JH, *et al*. Palpation versus ultrasound-guided corticosteroid injections and short-term effect in the distal radioulnar joint disorder: a randomized, prospective single-blinded study. *Clin Rheumatol* 2014;33:1807–14.
202 Weitoft T, Rönnblom L. Randomised controlled study of postinjection immobilisation after intra-articular glucocorticoid treatment for wrist synovitis. *Ann Rheum Dis* 2003;62:1013–5.
203 Kosiyatrakul A, Loketkrawee W, Luenam S. Different Dosages of Triamcinolone Acetonide Injection for the Treatment of Trigger Finger and Thumb: A Randomized Controlled Trial. *J Hand Surg Asian-Pac Vol* 2018;23:163–9.
204 Huisstede BM, Gladdines S, Randsdorp MS, *et al*. Effectiveness of Conservative, Surgical, and Postsurgical Interventions for Trigger Finger, Dupuytren Disease, and De Quervain Disease: A Systematic Review. *Arch Phys Med Rehabil* 2018;99:1635–49.
205 Cecen GS, Gulabi D, Saglam F, *et al*. Corticosteroid injection for trigger finger: blinded or ultrasound-guided injection? *Arch Orthop Trauma Surg* 2015;135:125–31.
206 David JA, Sankarapandian V, Christopher PR, *et al*. Injected corticosteroids for treating plantar heel pain in adults. *Cochrane Database Syst Rev* 2017;6:CD009348.
207 Whittaker GA, Munteanu SE, Menz HB, *et al*. Corticosteroid injection for plantar heel pain: a systematic review and meta-analysis. *BMC Musculoskelet Disord* 2019;20:378.
208 Rabadi D, Seo S, Wong B, *et al*. Immunopathogenesis, early Detection, current therapies and prevention of plantar Fasciitis: A concise review. *Int Immunopharmacol* 2022;110:109023.
209 Hansen L, Krogh TP, Ellingsen T, *et al*. Long-Term Prognosis of Plantar Fasciitis: A 5- to 15-Year Follow-up Study of 174 Patients With Ultrasound Examination. *Orthop J Sports Med* 2018;6:2325967118757983.
210 Babatunde OO, Legha A, Littlewood C, *et al*. Comparative effectiveness of treatment options for plantar heel pain: a systematic review with network meta-analysis. *Br J Sports Med* 2019;53:182–94.
211 Abdelghani KB, Rouached L, Fazaa A, *et al*. Efficacy of local injection therapy for heel pain in rheumatic inflammatory diseases: A systematic review. *Z Rheumatol* 2020;79:1033–9.
212 Sellman JR. Plantar fascia rupture associated with corticosteroid injection. *Foot Ankle Int* 1994;15:376–81.
213 Acevedo JI, Beskin JL. Complications of plantar fascia rupture associated with corticosteroid injection. *Foot Ankle Int* 1998;19:91–7.
214 Saltychev M, Mattie R, McCormick Z, *et al*. The Magnitude and Duration of the Effect of Intra-articular Corticosteroid Injections on Pain Severity in Knee Osteoarthritis: A Systematic Review and Meta-Analysis. *Am J Phys Med Rehabil* 2020;99:617–25.
215 Charlesworth J, Fitzpatrick J, Perera NKP, *et al*. Osteoarthritis- a systematic review of long-term safety implications for osteoarthritis of the knee. *BMC Musculoskelet Disord* 2019;20:151.
216 Pelletier JP, Raynauld JP, Abram F, *et al*. Intra-articular corticosteroid knee injection induces a reduction in meniscal thickness with no treatment effect on cartilage volume: a case-control study. *Sci Rep* 2020;10:13789.
217 Bentley G, Goodfellow JW. Disorganisation of the knees following intra-articular hydrocortisone injections. *J Bone Joint Surg Br* 1969;51:498–502.
218 Tiwari A, Karkhur Y, Keeney JA, *et al*. Rapid destructive osteoarthritis of the hip after intra-articular steroid injection. *Arthroplast Today* 2018;4:184–6.
219 Schindler C, Paessler L, Eckelt U, *et al*. Severe temporomandibular dysfunction and joint destruction after intra-articular injection of triamcinolone. *J Oral Pathol Med* 2005;34:184–6.
220 Northover JR, Williamson D, Rooker J, *et al*. Spontaneous peri-talar dislocation after steroid intra-articular injections: A case report. *Foot Ankle Surg* 2013;19:289–92.
221 Sohail MR, Smilack JD. Aspergillus fumigatus septic arthritis complicating intra-articular corticosteroid injection. *Mayo Clin Proc* 2004;79:578–9.
222 Job-Deslandre C, Menkes CJ. Complications of intra-articular injections of triamcinolone hexacetonide in chronic arthritis in children. *Clin Exp Rheumatol* 1990;8:413–6.
223 Li Q-X, Li Z-Y, Liu L, *et al*. Dexamethasone causes calcium deposition and degeneration in human anterior cruciate ligament cells through endoplasmic reticulum stress. *Biochem Pharmacol* 2020;175:113918.
224 Bernardoni ED, Frank RM, Gomoll AH. Looking Back: Safety of Current Treatments. *Oper Tech Sports Med* 2017;25:13–9.
225 Jalava S, Haapasaari J, Isomäki H. Periarticular calcification after intra-articular triamcinolone hexacetonide. *Scand J Rheumatol* 1980;9:190–2.
226 Kresse ME, Perry MT, Nacey NC. Inadvertent intraosseous injection during fluoroscopy-guided joint injection of two adult patients. *Clin Imaging* 2021;76:109–15.
227 Ahmed I, Gertner E. Safety of arthrocentesis and joint injection in patients receiving anticoagulation at therapeutic levels. *Am J Med* 2012;125:265–9.
228 Yui JC, Preskill C, Greenlund LS. Arthrocentesis and Joint Injection in Patients Receiving Direct Oral Anticoagulants. *Mayo Clin Proc* 2017;92:1223–6.
229 Narouze S, Benzon HT, Provenzano D, *et al*. Interventional Spine and Pain Procedures in Patients on Antiplatelet and Anticoagulant Medications (Second Edition): Guidelines From the American Society of Regional Anesthesia and Pain Medicine, the European Society of Regional Anaesthesia and Pain Therapy, the American Academy of Pain Medicine, the International Neuromodulation Society, the North American Neuromodulation Society, and the World Institute of Pain. *Reg Anesth Pain Med* 2018;43:225–62.
230 Martin EJ, Cooke EJ, Ceponis A, *et al*. Efficacy and safety of point-of-care ultrasound-guided intra-articular corticosteroid joint injections in patients with haemophilic arthropathy. *Haemophilia* 2017;23:135–43.
231 Murray RC, DeBowes RM, Gaughan EM, *et al*. The effects of intra-articular methylprednisolone and exercise on the mechanical properties of articular cartilage in the horse. *Osteoarthritis Cartilage* 1998;6:106–14.
232 Ishikawa K, Ohira T, Sakata H. Effects of intraarticular injection of halopredone diacetate on the articular cartilage of rabbit knees: a comparison with methylprednisolone acetate. *Toxicol Appl Pharmacol* 1984;75:423–36.
233 Moskowitz RW, Davis W, Sammarco J, *et al*. Experimentally induced corticosteroid arthropathy. *Arthritis Rheum* 1970;13:236–43.
234 Syed HM, Green L, Bianski B, *et al*. Bupivacaine and triamcinolone may be toxic to human chondrocytes: a pilot study. *Clin Orthop Relat Res* 2011;469:2941–7.

235 Gogia PP, Brown M, al-Obaidi S. Hydrocortisone and exercise effects on articular cartilage in rats. *Arch Phys Med Rehabil* 1993;74:463–7.
236 Pelletier JP, Martel-Pelletier J. Protective effects of corticosteroids on cartilage lesions and osteophyte formation in the Pond-Nuki dog model of osteoarthritis. *Arthritis Rheum* 1989;32:181–93.
237 Pelletier JP, Martel-Pelletier J. In vivo protective effects of prophylactic treatment with tiaprofenic acid or intraarticular corticosteroids on osteoarthritic lesions in the experimental dog model. *J Rheumatol* 1991;27:127–30.
238 McAlindon TE, LaValley MP, Harvey WF, *et al*. Effect of Intra-articular Triamcinolone vs Saline on Knee Cartilage Volume and Pain in Patients With Knee Osteoarthritis: A Randomized Clinical Trial. *JAMA* 2017;317:1967–75.
239 Beitzel K, McCarthy MB, Cote MP, *et al*. The Effect of Ketorolac Tromethamine, Methylprednisolone, and Platelet-Rich Plasma on Human Chondrocyte and Tenocyte Viability. *Arthroscopy: The Journal of Arthroscopic & Related Surgery* 2013;29:1164–74.
240 Hsu P-C, Chang K-V, Wu W-T, *et al*. Effects of Ultrasound-Guided Peritendinous and Intrabursal Corticosteroid Injections on Shoulder Tendon Elasticity: A Post Hoc Analysis of a Randomized Controlled Trial. *Arch Phys Med Rehabil* 2021;102:905–13.
241 Raynauld J-P, Buckland-Wright C, Ward R, *et al*. Safety and efficacy of long-term intraarticular steroid injections in osteoarthritis of the knee: a randomized, double-blind, placebo-controlled trial. *Arthritis Rheum* 2003;48:370–7.
242 Balch HW, Gibson JM, El-Ghobarey AF, *et al*. Repeated corticosteroid injections into knee joints. *Rheumatol Rehabil* 1977;16:137–40.
243 Jüni P, Hari R, Rutjes AWS, *et al*. Intra-articular corticosteroid for knee osteoarthritis. *Cochrane Database Syst Rev* 2015;2015:CD005328.
244 Simeone FJ, Vicentini JRT, Bredella MA, *et al*. Are patients more likely to have hip osteoarthritis progression and femoral head collapse after hip steroid/anesthetic injections? A retrospective observational study. *Skeletal Radiol* 2019;48:1417–26.
245 Zeng C, Lane NE, Hunter DJ, *et al*. Intra-articular corticosteroids and the risk of knee osteoarthritis progression: results from the Osteoarthritis Initiative. *Osteoarthr Cartil* 2019;27:855–62.
246 Weinstein RS. Glucocorticoid-induced osteonecrosis. *Endocrine* 2012;41:183–90.
247 Jensen TW, Hansen MS, Hørslev-Petersen K, *et al*. Periarticular and generalised bone loss in patients with early rheumatoid arthritis: influence of alendronate and intra-articular glucocorticoid treatment. Post hoc analyses from the CIMESTRA trial. *Ann Rheum Dis* 2014;73:1123–9.
248 Okike K, King RK, Merchant JC, *et al*. Rapidly Destructive Hip Disease Following Intra-Articular Corticosteroid Injection of the Hip. *J Bone Joint Surg Am* 2021;103:2070–9.
249 Akin-Takmaz S, Babaoglu G, Başar H, *et al*. Evaluation of the effects of intraarticular glucocorticoid injections on blood glucose levels in diabetes mellitus and nondiabetes mellitus patients with adhesive capsulitis of the shoulder. *Niger J Clin Pract* 2021;24:277–81.
250 Twu J, Patel N, Wolf JM, *et al*. Impact of Variation of Corticosteroid Dose, Injection Site, and Multiple Injections on Blood Glucose Measurement in Diabetic Patients. *J Hand Surg Am* 2018;43:738–44.
251 Habib GS, Abu-Ahmad R. Lack of effect of corticosteroid injection at the shoulder joint on blood glucose levels in diabetic patients. *Clin Rheumatol* 2007;26:566–8.
252 Choudhry MN, Malik RA, Charalambous CP. Blood Glucose Levels Following Intra-Articular Steroid Injections in Patients with Diabetes: A Systematic Review. *JBJS Rev* 2016;4:e5.
253 Habib GS, Miari W. The effect of intra-articular triamcinolone preparations on blood glucose levels in diabetic patients: a controlled study. *J Clin Rheumatol* 2011;17:302–5.
254 Habib G, Safia A. The effect of intra-articular injection of betamethasone acetate/betamethasone sodium phosphate on blood glucose levels in controlled diabetic patients with symptomatic osteoarthritis of the knee. *Clin Rheumatol* 2009;28:85–7.
255 Kerezoudis P, Rinaldo L, Alvi MA, *et al*. The Effect of Epidural Steroid Injections on Bone Mineral Density and Vertebral Fracture Risk: A Systematic Review and Critical Appraisal of Current Literature. *Pain Med* 2018;19:569–79.
256 Doshi TL, Cohen SP. Cracks in the Case against Epidural Steroids: Examining the Evidence for Vertebral Fracture Risk. *Pain Med* 2018;19:417–8.
257 Yi Y, Hwang B, Son H, *et al*. Low bone mineral density, but not epidural steroid injection, is associated with fracture in postmenopausal women with low back pain. *Pain Physician* 2012;15:441–9.
258 Stout A, Friedly J, Standaert CJ. Systemic Absorption and Side Effects of Locally Injected Glucocorticoids. *PM R* 2019;11:409–19.
259 Yoshii I, Sawada N. Efficacy and safety of intra-articular injection with triamcinolone acetonide for patients with rheumatoid arthritis. *Drugs Ther Perspect* 2020;36:404–12.
260 Sytsma TT, Thomas S, Fischer KM, *et al*. Corticosteroid Injections and Risk of Fracture. *JAMA Netw Open* 2024;7:e2414316.
261 Tan JW, Majumdar SK. Development and Resolution of Secondary Adrenal Insufficiency after an Intra-Articular Steroid Injection. *Case Rep Endocrinol* 2022;2022:4798466.
262 Duclos M, Guinot M, Colsy M, *et al*. High risk of adrenal insufficiency after a single articular steroid injection in athletes. *Med Sci Sports Exerc* 2007;39:1036–43.
263 Weitoft T, Rönnblom L. Glucocorticoid resorption and influence on the hypothalamic-pituitary-adrenal axis after intra-articular treatment of the knee in resting and mobile patients. *Ann Rheum Dis* 2006;65:955–7.
264 Habib G, Jabbour A, Artul S, *et al*. Intra-articular methylprednisolone acetate injection at the knee joint and the hypothalamic-pituitary-adrenal axis: a randomized controlled study. *Clin Rheumatol* 2014;33:99–103.
265 Broersen LHA, Pereira AM, Jørgensen JOL, *et al*. Adrenal Insufficiency in Corticosteroids Use: Systematic Review and Meta-Analysis. *J Clin Endocrinol Metab* 2015;100:2171–80.
266 Mohamed M, Patel S, Plavnik K, *et al*. Retrospective Analysis of Septic Arthritis Caused by Intra-Articular Viscosupplementation and Steroid Injections in a Single Outpatient Center. *J Clin Med Res* 2019;11:480–3.
267 Housman L, Arden N, Schnitzer TJ, *et al*. Intra-articular hylastan versus steroid for knee osteoarthritis. *Knee Surg Sports Traumatol Arthrosc* 2014;22:1684–92.
268 Lomonte ABV, de Morais MGV, de Carvalho LO, *et al*. Efficacy of Triamcinolone Hexacetonide versus Methylprednisolone Acetate Intraarticular Injections in Knee Osteoarthritis: A Randomized, Double-blinded, 24-week Study. *J Rheumatol* 2015;42:1677–84.
269 Shrestha R, Shrestha R, Thapa S, *et al*. Clinical Outcome following Intra-articular Triamcinolone Injection in Osteoarthritic Knee at the Community: A Randomized Double Blind Placebo Controlled Trial. *Kathmandu Univ Med J (KUMJ)* 2018;16:175–80.
270 Luzar MJ, Altawil B. Pseudogout following intraarticular injection of sodium hyaluronate. *Arthritis Rheum May* 1998;41:939–40.
271 Keely Boyle K, Rachala S, Nodzo SR. Centers for Disease Control and Prevention 2017 Guidelines for Prevention of Surgical Site Infections: Review and Relevant Recommendations. *Curr Rev Musculoskelet Med* 2018;11:357–69.
272 Goodman SM, Springer BD, Chen AF, *et al*. 2022 American College of Rheumatology/American Association of Hip and Knee Surgeons Guideline for the Perioperative Management of Antirheumatic Medication in Patients With Rheumatic Diseases Undergoing Elective Total Hip or Total Knee Arthroplasty. *Arthritis Care Res (Hoboken)* 2022;74:1399–408.
273 Bhattacharjee S, Wallace S, Luu HH, *et al*. Do We Need to Wait 3 Months After Corticosteroid Injections to Reduce the Risk of Infection After Total Knee Arthroplasty? *J Am Acad Orthop Surg* 2021;29:e714–21.
274 Richardson SS, Schairer WW, Sculco TP, *et al*. Comparison of Infection Risk with Corticosteroid or Hyaluronic Acid Injection Prior to Total Knee Arthroplasty. *J Bone Joint Surg Am* 2019;101:112–8.
275 Bedard NA, Pugely AJ, Elkins JM, *et al*. The John N. Insall Award: Do Intraarticular Injections Increase the Risk of Infection After TKA? *Clin Orthop Relat Res* 2017;475:45–52.
276 Cancienne JM, Werner BC, Luetkemeyer LM, *et al*. Does Timing of Previous Intra-Articular Steroid Injection Affect the Post-Operative Rate of Infection in Total Knee Arthroplasty? *J Arthroplasty* 2015;30:1879–82.
277 Alluri RK, Leland H, Heckmann N. Surgical research using national databases. *Ann Transl Med* 2016;4:393.
278 Bains SS, Chen Z, Sax OC, *et al*. Delaying Total Knee Arthroplasty More than 4 Weeks after Intra-Articular Knee Injection Does Not Further Decrease Risk of Septic Revision. *J Knee Surg* 2022;35:1511–7.
279 Schairer WW, Nwachukwu BU, Mayman DJ, *et al*. Preoperative Hip Injections Increase the Rate of Periprosthetic Infection After Total Hip Arthroplasty. *J Arthroplasty* 2016;31:166–9.
280 Werner BC, Cancienne JM, Browne JA. The Timing of Total Hip Arthroplasty After Intraarticular Hip Injection Affects Postoperative Infection Risk. *J Arthroplasty* 2016;31:820–3.
281 Charalambous CP, Prodromidis AD, Kwaees TA. Do intra-articular steroid injections increase infection rates in subsequent arthroplasty? A systematic review and meta-analysis of comparative studies. *J Arthroplasty* 2014;29:2175–80.
282 Marsland D, Mumith A, Barlow IW. Systematic review: the safety of intra-articular corticosteroid injection prior to total knee arthroplasty. *Knee* 2014;21:6–11.
283 Pereira LC, Kerr J, Jolles BM. Intra-articular steroid injection for osteoarthritis of the hip prior to total hip arthroplasty : is it safe? a systematic review. *Bone Joint J* 2016;98-B:1027–35.
284 Saracco M, Ciriello V, D'Angelo F, *et al*. Do prior intra-articular injections impact on the risk of periprosthetic joint infection in patients undergoing total hip arthroplasty? A meta-analysis of the current evidences with a focus on the timing of injection before surgery. *EFORT Open Rev* 2023;8:459–67.
285 Cui Z, Liu X, Teng Y, *et al*. The efficacy of steroid injection in total knee or hip arthroplasty. *Knee Surg Sports Traumatol Arthrosc* 2015;23:2306–14.
286 Werner BC, Cancienne JM, Burrus MT, *et al*. Risk of Infection After Intra-articular Steroid Injection at the Time of Ankle Arthroscopy in a Medicare Population. *Arthroscopy* 2016;32:350–4.
287 Brouwers MC, Kerkvliet K, Spithoff K, *et al*. The AGREE Reporting Checklist: a tool to improve reporting of clinical practice guidelines. *BMJ* 2016;352:i1152.
288 AGREE Next Steps Consortium. The agree ii instrument [Electronic version]. 2017. Available: http://www.agreetrust.org [Accessed 25 Apr 2019].
289 Mangione CM, Barry MJ, Nicholson WK, *et al*. Statin Use for the Primary Prevention of Cardiovascular Disease in Adults. *JAMA* 2022;328:746.