Are non-steroidal anti-inflammatory drug injections an alternative to steroid injections for musculoskeletal pain?: A systematic review

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ABSTRACT

Background: Given the potential side effect profile of steroids, the need for an alternative injectable anti-inflammatory is needed. The purpose of this systematic review was to compare corticosteroid injections with non-steroidal anti-inflammatory drug (NSAID) injections for musculoskeletal pain.

Methods: Reviewers with methodological and content expertise searched three databases: PUBMED, Medline and EMBASE. Two blinded reviewers searched, screened, and evaluated the data quality. Data was abstracted in duplicate. Agreement and descriptive statistics are presented.

Results: Four studies were included. All four studies found no statistically significant differences in improvements on the visual analog scale. The follow-up period within the four studies ranged between 2 weeks and 3 months. No statistically significant differences were demonstrated between the two groups with regards to functional outcomes.

Interpretation: The studies reviewed, while limited in quantity, show that compared with corticosteroids, NSAIDs provide equivalent, if not better, pain relief from the musculoskeletal ailments assessed. Further, there is weak evidence supporting a lower recurrence rate of symptoms with NSAIDs when compared to corticosteroids. There is a need for more long-term high-quality studies on this topic.

Level of evidence: Level II (Systematic review of Level II and III studies).

1. Introduction

Musculoskeletal pain is one of the most frequent chief complaints seen by family physicians, emergency physicians, and orthopedic surgeons across North America. Corticosteroids are used as a treatment method for a variety of these musculoskeletal pain conditions, varying from subacromial impingement to osteoarthritis.¹ Corticosteroids have anti-inflammatory properties that help to reduce pain. The use of corticosteroids is, however, associated with the risk of serious adverse events. The side-effect profile for corticosteroids consists of: immunosuppression, increased blood sugar for diabetics, facial swelling, weight gain, severe depression, mania, psychosis or other psychiatric symptoms, cataracts or glaucoma, steroid-induced osteoporosis, avascular necrosis, and hepatic steatosis.^{2–5}

Musculoskeletal corticosteroid injections may help mitigate these risks because they have been associated with fewer adverse events.⁶ Corticosteroids, as well as other medications, may be administered

through the intra-articular route to increase the intensity and duration of pain relief.⁷ Intra-articular injections of corticosteroids have demonstrated effective pain relief.^{7,8} Nevertheless, they have still been associated with decreased bone strength, tendon atrophy, and tendon rupture, particularly if used on Achilles tendonitis.^{4,9} In addition, post injection flare, skin depigmentation, subcutaneous atrophy, articular cartilage changes and increased blood glucose levels in diabetics make it difficult for diabetics to control their blood glucose, and as a result, systemic effects like osteoporosis may result.^{2–5,9–16} Due to the risk of these adverse events, many physicians limit the amount of corticosteroid injections a patient will receive in an affected area.^{14,15,17,18}

With these extensive side-effects and limitations of use, people may want an alternative. Oral non-steroidal anti-inflammatory drugs (NSAIDs) have been a mainstay of treatment for musculoskeletal pain due to their strong anti-inflammatory properties.¹⁹ When compared to intra-articular steroid injections, oral NSAIDs have demonstrated equal effectiveness in treating pain and movement restrictions in patients

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with adhesive capsulitis.²⁰ Although NSAIDs are associated with adverse events, such as the risk of gastrointestinal bleeding,³⁶ these risks may be minor and infrequent when administered via intra-articular injections, and may be less severe and less frequent than those experienced with steroid injections. Various authors have reported positive effects of intra-articular NSAID injections for a variety of musculoskeletal conditions.^{7,8,21–24} Therefore, intra-articular NSAID injections may potentially provide the same relief as corticosteroid injections, with less serious adverse events.

The purpose of this systematic review is to compare intra-articular NSAID and corticosteroid administrations and determine whether NSAID injections are a safer and more effective alternative.

2. Methods

2.1. Search strategy

Two blinded reviewers with methodological and content expertise searched three databases (PUBMED, Medline and EMBASE) for clinical studies involving injection of non-steroidal anti-inflammatory medications (NSAIDs) or corticosteroids for any musculoskeletal pathology. The following search terms were used: “NSAID” or “Non-steroidal anti-inflammatory”, “Corticosteroid” or “Steroid”, “Injection” or “injections”. MESH and Emtree headings were used in OVID and supplemented with free text to increase sensitivity. PUBMED was searched for articles e-published ahead of print. A reference search of relevant articles was conducted to ensure that all potential studies were included. Articles published from 1946 to April 2018 were included in this review. All identified titles and abstracts were reviewed independently and in duplicate. Disagreements regarding study inclusion were resolved by consensus discussion involving the senior author. Duplicate articles were manually excluded. Following the screening of titles and abstracts, both reviewers subsequently reviewed the full text of all studies identified during title and abstract screening, for meeting the inclusion/exclusion criteria.

2.2. Inclusion and exclusion criteria

Studies were included if they: 1) compared injection of anti-inflammatory medications and corticosteroids for any musculoskeletal application. There were no restrictions made with regards to type, dose or location of NSAID or steroid. Studies were excluded if they: 1) reported no outcomes, such as review articles, technique papers, or case reports; and 2) were not written in the English language.

2.3. Data extraction

Two reviewers abstracted data in duplicate and kept the records in a Microsoft Excel 2011 spreadsheet. The data included: year of publication, author, sample size, study design, level of evidence, location and dose of injection, duration of follow-up, study results, and recommendations. The outcome measures were baseline and follow-up measurements of the visual analog scale (VAS), functional outcome scores (if available), and number of patients with symptomatic resolution (Tables 1 and 2).

2.4. Statistical analysis

Descriptive statistics were calculated exploring the outcomes between injected NSAIDs and steroids. Inter-observer agreement for the reviewers' assessment of study eligibility was calculated with Cohen's kappa coefficient.²⁵ Based on the guidelines by Landis and Koch, a Kappa of 0–0.2 indicates slight agreement, 0.21 to 0.40 indicates fair agreement, 0.41 to 0.60 indicates moderate agreement, and 0.61 to 0.80 indicates substantial agreement. A value above 0.80 is considered almost perfect agreement.²⁶ Inter-observer agreement for assessments

of methodological quality was calculated with the Intraclass Correlation Coefficient (ICC). The Kappa and ICC were calculated using the SPSS software (SPSS Inc., Chicago, Illinois).

3. Results

3.1. Study identification

Our literature review yielded 2094 individual studies (384 from MEDLINE and EMBASE, 1710 from PUBMED). Following the removal of duplicates, 1871 individual studies were selected for screening. Of these, four studies met the inclusion and exclusion criteria and were included in this review.^{27–30} Detailed results of the included studies can be found in Fig. 1. Agreement between reviewers for eligibility of studies was high (Kappa = 0.89, 95% CI 0.72 to 0.98).

3.2. Study characteristics

A meta-analysis was not feasible due to the heterogeneity of the data. The mean quality assessment score for the four included studies was 10.5, which was considered moderate quality. The level of agreement between the two reviewers for quality assessment was ICC = 0.78 (95% CI: 0.42 to 0.92).

3.3. Study findings

Min et al.²⁷ conducted an RCT comparing Triamcinolone (40 mg) and Ketorolac (60 mg) injections in the subacromial joint space. They reported a mean improvement in pain on VAS by 0.9 in the steroid group and 1.83 in the NSAID group. They reported significant improvement in function on the UCLA shoulder rating scale for the NSAID group at 4 weeks ($p = 0.03$). They also reported significantly greater active abduction for the NSAID group at 4 weeks ($p = 0.03$). The only complication reported in the study was vasovagal syncope for the steroid group, in about 6.67% of participants.

Shakeel et al.²⁸ performed an RCT comparing Triamcinolone (20 mg) and Diclofenac (12.5 mg) in trigger finger. They reported no significant difference in functional scores at 3 months between the two groups. With regards to complications, 2% of participants in the steroid group had injection site pain and 18% had recurrence of symptoms. In the NSAID group, 4% had injection site pain, 6% had swelling, 4% had stiffness, and 2% had recurrence of symptoms.

Bellamy et al.²⁹ performed an RCT comparing Triamcinolone (80 mg) and Ketorolac (30 mg) in the setting of knee osteoarthritis with grade III Kellgren and Lawrence scale. They showed no statistically significant difference in improvement on the visual analog scale and no statistically significant difference in functional outcomes, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score at 2 week follow-up.

Aldrete et al.³⁰ performed a case controlled study comparing Indomethacin (1 and 2 mg) to Methylprednisolone (80 mg) in epidural space injection for post-laminectomy syndrome. They showed no statistically significant difference in the improvement on the visual analog scale in all three groups of methylprednisolone, indomethacin 1 mg and indomethacin 2 mg. They found no incidences of dural puncture or high sensory or motor block. They noted no typical side-effects of NSAID therapy such as rash, epigastric discomfort, or bruising.

4. Discussion

This unique systematic review compared corticosteroid and NSAID intra-articular injections for the treatment of musculoskeletal conditions. The results of this review demonstrate that: 1) In the short term (2–12 weeks) duration, intra-articular NSAID injections provide equivalent, if not better, pain relief from musculoskeletal ailments, when compared to intra-articular corticosteroid injections; 2) There is

Table 1
Characteristics of included studies.

Author/Year	Study Design	Sample size	Location/Dose/Type of Injection	Follow up	Level of Evidence
Min et al., 2013	RCT	Steroid N = 15 NSAID N = 17	Subacromial 1-Triamcinolone 40 mg 2-Ketorolac 60 mg	1 month	II
Shakeel et al., 2012	RCT	Steroid N = 50 NSAID N = 50	A1 pulley 1-Triamcinolone 20 mg 2-Diclofenac 12.5 mg	3 months	II
Bellamy et al., 2016	RCT	Steroid N = 20 NSAID N = 16	Knee 1- Triamcinolone 80 mg 2-Ketoralac 30 mg	2 weeks	II
Aldrete et al., 2003	pCCS	Steroid N = 84 NSAID (INM 1 mg) N = 64 NSAID (INM 2 mg) N = 60	Epidural Space Injection in Post-Laminectomy Syndrome 1-Methylprednisolone 80 mg 2- Indomethacin 1 mg 3-Indomethacin 2 mg	2 weeks	III

RCT – Randomized Controlled Trial.

pCCS – Prospective Case Controlled Study.

less recurrence of symptoms with the use of NSAID as opposed to corticosteroid injections; and 3) there is currently a lack of studies comparing intra-articular NSAID to corticosteroid injections for musculoskeletal conditions.

Results found by Shakeel et al. demonstrated comparable scoring on pain profiles, suggesting non-inferiority when treating with NSAID versus corticosteroid injections, at three months follow-up. Although symptom resolution was quicker with the corticosteroid injection, the authors explained that this result could be due to the inhibition of collagen, other extracellular matrix molecules, and granulation tissue at these sites in addition to the anti-inflammatory effect.²⁸ As a result, the authors recommended using NSAID injections for trigger finger in cases where steroid injections are not advisable for the patient, such as for patients with diabetes and difficulty controlling their blood glucose levels. This recommendation can further be supported with an article by Wang and Hutchinson, who reported that hyperglycemia, lasting for at least 5 days, can occur in diabetic patients administered intra-articular steroids via injection.⁵

Shakeel et al. also reported a lower recurrence rate of symptoms for the NSAID injection (2%) when compared to the corticosteroid injection (18%).²⁸ This could potentially be due to a longer lasting effect of NSAIDs. To our knowledge there are no studies to confirm this, although it has been reported by Dessery et al. that the effects of

corticosteroids disappear at 6 weeks.³¹ Therefore, the above finding could suggest that NSAIDs might be able to offer prolonged symptom relief compared to corticosteroids. Overall, the authors demonstrated that local NSAID injections appear to be safe for the treatment of trigger finger, with comparable effectiveness to that of steroid injections.²⁸

In the study by Min et al., the greater improvements in pain and function ($p = 0.03$) and reduced side effects found in the NSAID injection group demonstrate that NSAID injections may not only be equivalent to, but could potentially be superior to corticosteroid injections.²⁷

Bellamy et al.²⁹ and Aldrete et al.³⁰ also demonstrated non-inferiority with the NSAID injections when compared to corticosteroids in terms of visual analog pain scores and functional score improvement. This strengthens the argument for an alternative to the corticosteroid and prevention of the harmful effects of the steroids.

NSAIDs may provide an alternative injectable anti-inflammatory for those suffering from musculoskeletal ailments, where a corticosteroid injection is one of the treatment modalities. Unlike corticosteroid injections, current evidence does not limit the frequency of use of injectable NSAIDs.^{14,15} Corticosteroid injections have potential serious systemic side-effects and are known to locally inhibit collagen synthesis, cause tendon atrophy, delay tendon healing, and cause late tendon rupture.^{2,3,10,15,32–34} There is evidence to support the claim that a

Table 2
Results of included studies.

Author/Year	Pain Score	Functional Score	Complications
Min et al., 2013	Mean improvement in VAS steroid group: 0.9 Mean improvement in VAS NSAID group: 1.83 (p 0.23)	UCLA shoulder rating scale significantly better for NSAID group at 4 wks (p 0.03) Significantly greater active abduction in NSAID group at 4 wks (p 0.03)	N-1 steroid group: vasovagal
Shakeel et al., 2012	Not Applicable	No significant difference at 3 mths (p 0.21)	N-10 steroid group Injection site pain (1), recurrence (9) N-8 NSAID group Injection site pain (2), swelling (3), stiffness (2), recurrence (1)
Bellamy et al., 2016	Mean improvement in VAS steroid group: 1.6 (p 0.003) Mean improvement in VAS NSAID group: 1.7 (p 0.003)	Mean WOMAC score for both ketorolac and corticosteroid increased from baseline at 2 weeks, 4 points (p 0.003) and 15 points (p 0.003), respectively	Not Applicable
Aldrete et al., 2003	Mean improvement in VAS Steroid group: 1.34 (p < 0.05) Mean improvement in VAS NSAID (Indomethacin 1 mg) group: 1.16 (p < 0.05) Mean improvement in VAS NSAID group (Indomethacin 2 mg): 1.21 (p < 0.05)	Not applicable	There were no instances of apparent dual puncture or high sensory or motor block noted, nor were there any other untoward effects typical of NSAID therapy such as rash, epigastric discomfort, or bruising.

Fig. 1. Flow chart for the search strategy.

series of more than three preoperative injections of corticosteroids are associated with decreased suture pullout strength, weaker rotator cuff repair, and increased rate of failure of the rotator cuff repairs.^{14,15,17,18} Based on the association with decreased surgical success, the available evidence indicates that excessive subacromial corticosteroid injections are not recommended for conditions like rotator cuff tendinitis and should be limited to 3 injections.^{17,18}

Local injections of NSAIDs have not been associated with clinically significant changes in the cartilage or soft tissue, although studies on this subject are lacking.^{35,36} Various rat and rabbit studies in which NSAIDs were injected intra-articularly did not demonstrate any significant cartilaginous changes.^{35–38} We are unaware of any studies that have demonstrated clinically significant changes in tendon healing after NSAID injections. Studies investigating injectable NSAIDs, such as piroxicam for osteoarthritis of the knee, have shown that it may attenuate osteoarthritis progression.³⁶

4.1. Limitations

This systematic review highlights the need for further investigation addressing this topic. Prospective randomized trials with many participants and long-term follow-up would be ideal, although might not be feasible due to the resource intensive nature and methodological challenges of such trials.³⁹ Further, long-term RCTs with a large cohort of patients is warranted to examine and compare the long-term side-effects and effectiveness of intra-articular NSAIDs and corticosteroids.

The studies used in this review have a follow-up period of 2 weeks,^{29,30} 4 weeks²⁷ and 12 weeks.²⁸ Long-term side-effects of intra-articular corticosteroids on tendons and articular cartilage have been reported by Dean et al.⁴⁰ but the long-term side of intra-articular NSAIDs are unknown.

All four of the studies identified in this review did not have comparable outcome measures, which would have been optimal for more comprehensive comparisons across studies. They also did not contain the same treatment arms, and so, the results could not be combined to obtain a quantitative analysis.

All the studies included in this review failed to identify and/or control for whether any of the patients were concomitantly on any systemic anti-inflammatory medications.

Min et al. used clinical examinations for diagnostic purposes, and since rotator cuff tears were part of the exclusion criteria, participants were excluded from the study by this clinical examination for diagnosis, as opposed to diagnostic imaging. MRI has been the diagnostic modality of choice for diagnosing rotator cuff tears, with high sensitivity and specificity.^{41,42} The severity of symptoms prior to the injection were not described. These factors could have potentially biased the results.

Systemic NSAIDs are known to have gastrointestinal (GI) and cardiovascular (CV) side-effects⁴³ that have been shown to be reduced with topical NSAIDs.⁴⁴ It is assumed that intra-articular injections will have less severe side-effects, but none of the studies examined in this review identified or specifically reported an analysis about GI and CV side-effects.

None of the studies reported the physical activity status of their patient populations, pre- and post-injection.^{27–30} Dessery et al. reported that in patients with knee osteoarthritis who have undergone an intra-articular corticosteroid injection, the pain sensation may be optimized with the modulation of the intensity and duration of physical activity.³¹ Therefore, physical activity levels of the patients post injections could have potentially biased the results of the studies.

Rhon et al. has shown corticosteroids and physical therapy to be equivalent in symptomatic relief for subacromial impingement.⁴⁵ Min et al. did not report if any of the patients obtained physical therapy

concurrently,²⁷ which could have led to confounding and bias.

5. Conclusion

The intra-articular corticosteroid injection is a treatment modality often used in musculoskeletal ailments, however, with its serious side effect profile, an alternative should be considered. Intra-articular NSAID injections appear to have a less severe adverse-effect profile and may potentially offer a greater number of injections for treatment, as corticosteroid injections are commonly limited to about three injections. The studies reviewed, while limited in quantity, show that NSAIDs provide equivalent, if not better, pain relief from the musculoskeletal ailments assessed. Further, there is weak evidence supporting a lower recurrence rate of symptoms with NSAIDs when compared to corticosteroids. There is a scarcity in the literature regarding this comparison and further randomized control trials to assess this comparison is warranted.

Conflicts of interest

None.

References

- 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(12):1695–1706.
- Strom L. Trigger finger in diabetes. *J Med Soc NJ*. 1977;74:951–954.
- Anderson B, Kaye S. Treatment of flexor tenosynovitis of the hand with corticosteroids: a prospective study of the response to local injection. *Arch Intern Med*. 1991;151:153–156.
- Speed CA. Fortnightly review: corticosteroid injections in tendon lesions. *BMJ*. 2001;323:382–386.
- Wang A, Hutchinson D. The effect of corticosteroid injection for trigger finger on blood glucose level in diabetic patients. *J Hand Surg*. 2006;31A:979–981.
- Furtado RN, Oliveira LM, Natour J. Polyarticular corticosteroid injection versus systemic administration in treatment of rheumatoid arthritis patients: a randomized controlled study. *J Rheumatol*. 2005;32(9):1691–1698.
- Bhattacharjee DP, Biswas C, Haldar P, et al. Efficacy of intraarticular dexamethasone for postoperative analgesia after arthroscopic knee surgery. *J Anaesthesiol Clin Pharmacol*. 2014;30(3):387–390.
- Jones A, Doherty M. Intra-articular corticosteroids are effective in osteoarthritis but there are no clinical predictors of response. *Ann Rheum Dis*. 1996;55:829–832.
- Paavola M, Kannus P, Järvinen T, et al. Treatment of tendon disorders. Is there a role for corticosteroid injection? *Foot Ankle Clin*. 2002;7:501–513.
- Marks M, Gunther S. Efficacy of cortisone injection in treatment of trigger fingers and thumbs. *J Hand Surg*. 1989;14A:722–727.
- Alvarez CM, Litchfield R, Jackowski D, et al. A prospective, double-blind, randomized clinical trial comparing subacromial injection of betamethasone and xylocaine to xylocaine alone in chronic rotator cuff tendinosis. *Am J Sports Med*. 2005;33:255–262.
- Blair B, Rokito AS, Cuomo F, et al. Efficacy of injections of corticosteroids for subacromial impingement syndrome. *J Bone Joint Surg Am*. 1996;78:1685–1689.
- Buchbinder R, Green S, Youd JM. Corticosteroid injections for shoulder pain. *Cochrane Database Syst Rev*. 2003;1:CD004016.
- Cole BJ, Schumacher Jr HR. Injectable corticosteroids in modern practice. *J Am Acad Orthop Surg*. 2005;13:37–46.
- Ford LT, DeBender J. Tendon rupture after local steroid injection. *South Med J*. 1979;72:827–830.
- Rostron PK, Calver RF. Subcutaneous atrophy following methylprednisolone injection in Osgood-Schlatter epiphysitis. *J Bone Joint Surg Am*. 1979;61:627–628.
- Kleinman M, Gross AE. Achilles tendon rupture following steroid injection. Report of three cases. *J Bone Joint Surg Am*. 1983;65:1345–1347.
- Melmed EP. Spontaneous bilateral rupture of the calcaneal tendon during steroid therapy. *J Bone Joint Surg Br*. 1965;47:104–105.
- Nelson AE, Allen KD, Golightly YM, et al. A systematic review of recommendations and guidelines for the management of osteoarthritis: the Chronic Osteoarthritis Management Initiative of the U.S. Bone and Joint Initiative. *Semin Arthritis Rheum*. 2014;43(6):701–712.
- Dehghan A, Pishgooei N, Salami MA, et al. Comparison between NSAID and intra-articular corticosteroid injection in frozen shoulder of diabetic patients; a randomized clinical trial. *Exp Clin Endocrinol Diabetes*. 2013 Feb;121(2):75–79.
- Convery PN, Milligan KR, Quinn P, et al. Low-dose intra-articular ketorolac for pain relief following arthroscopy of the knee joint. *Anaesthesia*. 1998;53(11):1125–1129.
- Gupta A, Axelsson K, Allvin R. Postoperative pain following knee arthroscopy: the effects of intra-articular ketorolac and/or morphine. *Reg Anesth Pain Med*. 1999 May-Jun;24(3):225–230.
- Reuben SS, Connelly NR. Postoperative analgesia for outpatient arthroscopic knee surgery with intraarticular bupivacaine and ketorolac. *Anesth Analg*. 1995 Jun;80(6):1154–1157.
- Reuben SS, Steinberg RB, Kreitzer JM. Intravenous regional anesthesia using lidocaine and ketorolac. *Anesth Analg*. 1995 Jul;81(1):110–113.
- McGinn T, Wyer PC, Newman TB, et al. Evidence-Based Medicine Teaching Tips Working Group. Tips for learners of evidence-based medicine: 3 measures of observer variability (kappa statistic). *CMAJ*. 2004;171(11):1369–1373.
- Landis JR, Koch GG. An application of hierarchical kappa-type statistics in the assessment of majority agreement among multiple observers. *Biometrics*. 1977 Jun;33(2):363–374.
- Min KS, Pierre PS, Ryan PM, et al. A double-blind randomized controlled trial comparing the effects of subacromial injection with corticosteroid versus NSAID in patients with shoulder impingement syndrome. *J Shoulder Elbow Surg*. 2013;22:595–601.
- Shakeel H, Ahmad S. Steroid injection versus NSAID injection for trigger finger: a comparative study of early outcomes. *J Hand Surg*. 2012;37A:1319–1323.
- Bellamy JL, Goff BJ, Sayeed SA. Economic Impact of Ketorolac vs Corticosteroid Intra-Articular Knee Injections for Osteoarthritis: A Randomized, Double-Blind, Prospective Study. *J Arthroplasty*. 2016 Sep;31(9 Suppl):293–297. <https://doi.org/10.1016/j.arth.2016.05.015>.
- Aldrete JA. Epidural injections of indomethacin for postlaminectomy syndrome: a preliminary report. *Anesth Analg*. 2003 Feb;96(2):463–468.
- Dessery Y, Belzile ÉL, Turmel S, et al. Modulation of physical activity to optimize pain sensation following an intra-articular corticosteroid injection in patients with knee osteoarthritis. *Sci World J*. 2014;2014:209165.
- Murphy D, Failla J, Konich M. Steroid versus placebo injection for trigger finger. *J Hand Surg*. 1995;20A:628–631.
- Rhoades C, Gelberman R, Manjarrés J. Stenosing tenosynovitis of the fingers and thumb. Results of a prospective trial of steroid injection and splinting. *Clin Orthop Relat Res*. 1984;190:236–238.
- Clark D, Ricker J, MacCollum M. The efficacy of local steroid injection in the treatment of stenosing tenovaginitis. *Plast Reconstr Surg*. 1973;51:179–180.
- Dogan N, Erdem AF, Gundogdu C, et al. The effects of ketorolac and morphine on articular cartilage and synovium in the rabbit knee joint. *Can J Physiol Pharmacol*. 2004;82:502–505.
- Jean YH, Wen ZH, Chang YC, et al. Intraarticular injection of the cyclooxygenase-2 inhibitor parecoxib attenuates osteoarthritis progression in anterior cruciate ligament-transected knee in rats: role of excitatory amino acids. *Osteoarthritis Cartilage*. 2007;15:638–645.
- Itzkowitch D, Ginsberg F, Leon M, et al. Periarticular injection of tenoxicam for painful shoulders: a double-blind, placebo controlled trial. *Clin Rheumatol*. 1996;15:604–609.
- Ozyuvaci H, Bilgic B, Ozyuvaci E, et al. Intraarticular injection of tenoxicam in rats: assessment of the local effects on the articular cartilage and synovium. *J Int Med Res*. 2004;32:312–316 26:224–228.
- Thoma A, Farrokhhyar F, McKnight L, Bhandari M. Practical tips for surgical research: how to optimize patient recruitment. *Can J Surg*. 2010;53(3):205–210.
- Dean BJ, Lostis E, Oakley T, et al. The risks and benefits of glucocorticoid treatment for tendinopathy: a systematic review of the effects of local glucocorticoid on tendon. *Semin Arthritis Rheum*. 2014 Feb;43(4):570–576.
- Iannotti JP, Zlatkin MB, Esterhai JL, et al. Magnetic resonance imaging of the shoulder. *J Bone Joint Surg Am*. 1991;73:17–29.
- Singon RD, Hoang T, Dan S, et al. MR evaluation of rotator cuff pathology using T2-weighted fast spin-echo technique with and without fat suppression. *AJR Am J Roentgenol*. 1996;166:1061–1065.
- Conaghan PG. A turbulent decade for NSAIDs: update on current concepts of classification, epidemiology, comparative efficacy, and toxicity. *Rheumatol Int*. 2012;32(6):1491–1502.
- Haroutiunian S, Drennan DA, Lipman AG. Topical NSAID therapy for musculoskeletal pain. *Pain Med*. 2010;11:535–549.
- Rhon DI, Boyles RB, Cleland JA. One-year outcome of subacromial corticosteroid injection compared with manual physical therapy for the management of the unilateral shoulder impingement syndrome: a pragmatic randomized trial. *Ann Intern Med*. 2014;161(3):161–169.