Medical Research Archives

ESMED
European Society of Medicine

OPEN ACCESS

Published: December 31, 2022

Citation: Ingala Martini L, Velasquez Garcia A, et al., 2022. Non-Operative Treatment Options in Primary Glenohumeral Osteoarthritis: A Comprehensive Review, Medical Research Archives, [online] 10(12). https://doi.org/10.18103/mra.v10i12.3410

DOI
https://doi.org/10.18103/mra.v10i12.3410

ISSN: 2375-1924

REVIEW ARTICLE

Non-Operative Treatment Options in Primary Glenohumeral Osteoarthritis: A Comprehensive Review

Liborio Ingala Martini M.D.[1,2*], **Ausberto Velasquez Garcia M.D.**[3] **Andres Franco Abache M.D.** [4]

[1]Department of Orthopedic Surgery, IVSS Dr Luis Ortega Hospital, Porlamar, Venezuela.
[2] Department of Orthopedic Surgery, Hospital Clinicas del Este.
[3] Department of Orthopedic Surgery, Clinica Universidad de los Andes, Santiago, Chile.
[4] Department of Orthopedic Surgery, Hospital de Especialidades Guayaquil MSP , Guayaquil, Ecuador.

*Corresponding author: liborioingala@gmail.com

ABSTRACT
Primary glenohumeral joint osteoarthritis is a growing pathology with multifactorial aethiology that affects younger and older population. Treatment must be focused on reducing pain, regaining functionality, and slowing the course of the disease. Surgery and non-operative methods are available for treating it and are a frequent source of controversy, the latter being applied to patients with factors that may relatively contraindicate surgery. Practitioners must be acquainted with the therapeutic choices and the current status of the evidence. Given that nonsurgical therapy may be beneficial in relieving symptoms, it should be considered first-line treatment, particularly in low-demand individuals with symptoms that have shown themselves sub acutely. Literature is lacking of high quality evidence on this matter, and up to date, there have not been any high quality studies comparing different options. Optimal treatment of primary glenohumeral osteoarthritis depends on specifically patient´s needs, therefore a combination of all the resources available could represent the best option and result in better outcomes.

Introduction

Glenohumeral (GH) joint is the third most often afflicted major joint, and has been demonstrated, in cadaver and radiographic studies [1,2]. Degenerative alterations in the glenohumeral joint are observed in up to 17% of shoulder pain sufferers, and a third of the patients over sixty years old[3,4], a patient population that has been growing in the last decades. It is a condition that can appear at any time, and practitioners must be acquainted with the therapeutic choices and the current status of the evidence.

The condition of osteoarthritis is complicated and multifactorial. Cartilage, subchondral bone, and synovium conditions plays crucial roles in its etiology[5]. Symptomatic primary glenohumeral joint osteoarthritis is a disorder that causes pain, limited range of motion, and progressive loss of shoulder function. It is distinguished by cartilage loss, adaptive changes to the subchondral bone, and the growth of inferior humeral head osteophytes. Biomechanical changes in the glenohumeral joint develop, joint space narrowing, and subsequent subluxation of the posterior humeral head, followed by progressive posterior glenoid bone may occur[6]. This progressive degeneration results in an abnormal distribution of loads in the GH joint and limits joint movement[7]. Pain and functional disability can have an impact both for physical and psychological well-being, limiting work and recreational activities in younger people and jeopardizing physical autonomy in the elderly [8]. It is usual for osteoarthritis to limit patients range of movement in less than 90 degrees. Some authors hacve reported 20% prevalence of idiopathic glenohumeral joint osteoarthritis in individuals over sixty years of age with shoulder pain[2].

Neer defined primary glenohumeral osteoarthritis (GH-OA) as shoulder movement restriction, loss of joint space, the existence of humeral head osteophytes, and the lack of rotator cuff tear. It is still essential to distinguish GH-OA from rotator cuff arthropathy[9]. When there are no risk factors that potentially contribute to joint dysfunction, primary OA is diagnosed. Chronic dislocations and recurring instability, trauma, surgery, avascular necrosis, inflammatory arthropathy, and severe rotator cuff tears can all lead to secondary OA[10]. Primary GH-OA pain is frequently located posteriorly and deep inside the joint. It is usually accompanied with nighttime discomfort, stiffness, and functional restrictions[11].

Treatment for GH- OA is frequently contentious and involves both nonoperative and surgical options[12]. Reducing pain, recovering function, and limiting disease progression are the main goals for GH-OA treatment, a non-operative management approach should be adopted before considering other[13–15]. Non-invasive techniques should be considered first, especially in individuals with mild-to-moderate OA or when pain and functional impairments are minor despite more advanced radiographic abnormalities. Lifestyle and occupational adjustments are frequently the first steps in this process. Almost all individuals with shoulder OA can benefit from anti-inflammatory medications and physical treatment. Therapy should ideally begin before the onset of atrophy or contracture and should be customized to the patient's unique needs[12,13]. If conservative measures fail, surgical intervention should be considered.

Nonsurgical options are the backbone of treatment for primary glenohumeral osteoarthritis. Given that nonsurgical therapy may be beneficial in alleviating symptoms, it should be considered first-line treatment, particularly in low-demand individuals with symptoms that have shown subacutely[16]. It may also be the preferred treatment for people who are not surgical candidates due to medical conditions.[12]

Intra-articular injectable options

Despite nonsurgical therapy of shoulder OA does not prevent disease progression, it can be useful in minimizing discomfort and improving range of mot ion[17]. For people who do not respond to anti-inflammatory drugs and have persistent pain, intra-articular administration can be performed. The functions of corticosteroids, hyaluronic acid, and autologous blood-derived anti-inflammatory substances, for which there are numerous formulations and methods of preparation, respectively, are of particular importance.[18]

Blaine et al. in a Randomized Control Trial (RCT), assessed 660 individuals with glenohumeral OA and discovered a threefold reduction in pain in the HA group compared to the placebo group, at 26 weeks. [19] Another RCT also studied the efficacy of intra-articular administrated HA compared to a placebo control group in 300 patients with chronic shoulder pain associated with GH-OA. Improvement in the Visual Analogue Scale (VAS) for pain between baseline and 7, 13, 20 and 26 weeks of follow-up favored patients treated with HA. Similar

results were observed using the OMERACT-Osteoarthritis Research Society International (OARSI) that showed a significant difference in favor of the HA treated patients[20] Other prospective case series with significant differences between intervals, dose administration, and follow-ups, show moderate evidence supporting the use of HA in primary GH-OA.[16,21–24] A significant number of systematic reviews and meta-analysis evaluating the efficacy of intra-articular HA treatment in patients with primary GH-OA report similar results with small to moderate treatment effects compared to placebo, although well tolerated and with similar adverse effects to those observed in the hip and knee joint. [25]A significant number of systematic reviews and meta-analysis evaluating the efficacy of intra-articular HA treatment in patients with primary GH-OA report similar results with small to moderate treatment effects compared to placebo, although well tolerated and with similar adverse effects to those observed in the hip and knee joint. [25]

One of the most popular conservative therapy options for symptomatic glenohumeral OA is intra-articular glenohumeral corticosteroid injection, however there is little evidence in the currently available literature on its effectiveness. [25,26] Merolla et al. compared intra-articular methylprednisolone to Hylan G-F 20 and discovered that while both groups significantly reduced pain at one month, only the hyaluronic acid group continued to experience pain alleviation after six months.[27]

According to research conducted by Kimetal, 3-8 years after receiving intra-articular glenohumeral corticosteroid injection for primary glenohumeral OA, 37.3% of shoulders underwent shoulder arthroplasty. About 42% of patients underwent further surgery when the proportion of shoulders that underwent a surgical treatment other than an arthroplasty (4.5%) was taken into account. [28] In a prospective study for assessing the efficacy of a single image-guided corticosteroid injection in the conservative management of GHOA, twenty nine shoulders received an image guided intra-articular corticosteroid injection, resulting in clinically significant improvements in shoulder function up to 4 months post-injection with dwindling effects thereafter, and statistically and clinically significant improvements in their pain (VAS) for up to a year. [29]

There are not many clinical studies that evaluate PRP injections to treat GH osteoarthritis and tend to be case studies. A randomized trial including 70 patients compared the efficacy of ultrasound-guided hyaluronic acid (HA) versus leukocyte-poor platelet-rich plasma (LP-PRP) injection in the treatment of glenohumeral osteoarthritis, and revealed substantial reductions for both groups in pain levels at 1 and 2 months. Hyaluronic acid and a single injection of leukocyte-poor PRP were shown to have comparable effects[30]. PRP treatment has several issues that haven't been fully solved. The majority of PRP clinical research fall short in reporting crucial scientific information that is essential to the result. Leukocyte concentration and preparation methods can vary often.[31,32] Bone marrow derived and adipose derived cell therapies intra-articular injections represent a relatively new option. Although the mechanisms by which these might regulate inflammatory processes are not yet fully understood, they have been proven to be mostly harmless with minimal adverse effects. Centeno et al, in 34 individuals with glenohumeral OA, demonstrated an improvement in pain and function using BMAC (bone marrow aspirate concentrate stem cells)[33].

All around there has been debate in literature regarding different approaches for glenohumeral intra-articular injection, also the lack of image-guided injections in many of these studies is of particular concern, as previous studies have concluded that image-guided corticosteroid injections are more accurate than blind injections, and they may provide longer symptomatic relief in patients with shoulder pathology.[29,34,35]

In specimens of 80 shoulders, Patel et al. compared the accuracy of the blinded procedure with the posterior ultrasound (US) guided approach to the glenohumeral joint. When US guidance was used instead of blind administration, the accuracy rate was much greater (92.5% vs. 72.5%).[36] Rijs, in a prospective trial recommend using the new anterior approach for intra-articular glenohumeral injections instead of ultrasound-guided injections because it will save time and costs associated with ultrasound.[37] However, there is no strong evidence to support the use of intra-articular injections for primary GH-OA. Guidelines have not encouraged or discouraged the use of injectable corticosteroids or pharmaceuticals, which have instead made a "restricted" recommendation about the use of injectable viscosupplementation.[6]

Physical therapy in primary GH-OA

Physical therapy is frequently used in a multidisciplinary context for nonsurgical treatment regimen and there have been no studies that have looked at the effectiveness of physical therapy as a standalone treatment. Intensity or duration of therapy is not stablished. It has been recommended that a cognitive approach combined with supervised physical exercise be used. Patients should be informed about the arthritic process and overall prognosis, rather than focusing on the pathoanatomy of glenohumeral osteoarthritis[38]. Education should also involve activity modification, such as reducing loading and repeated motion over the head and in other provoking situations. After 3 years of follow-up in a study of 129 patients aged 65 years and older, Guo et al. reported improvements in pain and function as part of a multimodal treatment approach[39].

Lifestyle changes may help in the management of glenohumeral osteoarthritis. General recommendations for people with glenohumeral osteoarthritis include good sleep hygiene, quitting smoking, and regular exercise[40]. According to Millet et al, the first care of shoulder discomfort should include a trial of rest, activity adjustment, patient education, physical therapy for mobility, and strengthening exercises, because these modalities are affordable, carry little risk, and may alleviate patient complaints. [11]

The specific exercise prescription for glenohumeral osteoarthritis is not well established in the literature. According to Saltzman et al., research on physical treatment for glenohumeral osteoarthritis is limited and, in some cases, strengthening activities can increase symptoms[14]. The recommended physical therapy modalities include periscapular and shoulder strengthening, stretching, distraction/manual therapy, and range of motion[14]. Enhancing mobility and elasticity is the first objective, and once pain has decreased, strengthening exercises should be started with graded resistance training, depending on tolerance of the deltoid and shoulder girdle and scapular balance, as well as aerobic excercises[38]. Patients with GH-OA should be encouraged to incorporate exercise into their lifestyle. The programs proven to benefit patients last at least 12 weeks[41]. Strengthening the contralateral upper extremity has been shown to increase afflicted limb strength by 9.4% in acute stages where movement may not be tolerated[42].

Regarding the use of physical agents for the treatment of GHOA, these are mostly used for symptomatology control. No superiority between the use of superficial or deep heat, electrotherapy, or phototherapy; therefore, they should be used as an adjuvant as inflammatory process reducers and pain management[26]. The physical therapy intervention and patient care should also take into account the inflammatory process associated with glenohumeral osteoarthritis, and an impairment-based approach should be used to target particular patient deficits[43]. Additionally, considering localized discomfort outside the shoulder may be useful in lowering overall symptoms.

Pharmacological treatment for GH-OA

Multimodal approach should be the cornerstone in conservative treatment of primary glenohumeral osteoarthritis. Managing pain and discomfort represents the main target, therefore, functionality and quality of life can be totally or partially restored. Pharmacological agents can be an important part of the equation, and most of the times, a necessary, and reliable tool. However, there is a lack of literature related to the use of oral agents in specifically primary glenohumeral osteoarthritis, and most of the majority of trials are focused on hip, knee and hand osteoarthritis.

Since the last century, salicylates, acetaminophen, and non-steroidal anti-inflammatory medications have been useful in relieving pain and inflammation in arthritic patients[12]. Nonsteroidal anti-inflammatory medicines (NSAIDs) used orally can alleviate musculoskeletal pain but raise the risk of gastrointestinal, cardiovascular, and renal side effects[44]. The safety of all NSAIDs is a concern, particularly in the elderly, and patients who allegedly decide to opt out for surgical treatment, and those with multisystemic illneses and those at increased risk of cardiovascular and renal side effects. The risk of adverse effects associated with NSAIDs appears to depend on the dosage. Long-term effects have insufficient evidence. A solution to this matter could be the use of COX-2 inhibitors, but have not been shown to be more efficacious[45].
50-67% of patients can expect shoulder pain relief with the use of non-steroidal anti-inflammatory drugs[11]. Improvement has been reported with the use of oral prednisolone has been reported[46]. According to a network meta-analysis (76 randomized controlled trials, 58 451 individuals), NSAIDs relieve osteoarthritis pain somewhat more than placebo after 12 weeks. Higher daily doses of diclofenac (150 mg)

naproxen (1000 mg) ibuprofen (2400 mg) and etoricoxib (60 mg) have more significant benefits (>10 points on a 0-100 scale)[47].

Topical NSAIDs have been reported superior to placebo in the treatment of osteoarthritis, with less side effects than oral versions[48]. Opioids do not give more pain relief than NSAIDs for musculoskeletal pain and might have major side effects such as addiction[44]. Chondroprotective drugs, such as chondroitin and glucosamine sulfate, may play a role in the non-operative care of arthrosis in addition to routine medical management. Despite this fact, there are no peer-reviewed studies on the efficacy of these drugs[12].

Evidence-based approach in primary GH-OA treatment.

From an evidence-based standpoint, physical therapy and educational lifestyle modifications seem to bring the best results, although it has not been demonstrated [11, 38, 40]. When compared to other methods such as intra-articular injections and/or pharmacological therapies, exercise and educational-based lifestyle changes, even prescribed alone, give the presumption to produce better outcomes specially in pain tolerance and patient-perception of limited functionality and also seem to be cost-effective [49]. Literature is lacking of high quality evidence on this matter, and up to date, there have not been any high quality studies comparing these. Optimal treatment of primary GH-OA can be tricky, and depends on specifically patient´s needs, therefore a combination of all the resources available could represent the best option and result in better outcomes.

Conclusions

Primary glenohumeral osteoarthritis is a multifactorial and challenging pathology, that can be hard to diagnose and treat. Even surgical treatment on many occasions cannot be avoided. There are nonsurgical options that can be applied to patients with factors that may relatively contraindicate surgery. We believe that there are effective nonsurgical treatments for the management of this pathology. However, the authors recommend the combination, if possible, of all the measures mentioned for the optimal management of this pathology.

Conflicts of interest

None of the authors have any conflicts of interest or financial ties to disclose.

Acknowledgements

None of the authors have any to declare.

References

1. Cushnaghan J, Dieppe P. Study of 500 patients with limb joint osteoarthritis. I. Analysis by age, sex, and distribution of symptomatic joint sites. *Ann Rheum Dis*. 1991;50(1):8-13. doi:10.1136/ARD.50.1.8
2. Kerr R, Resnick D, Pineda C, Haghighi P. Osteoarthritis of the glenohumeral joint: a radiologic-pathologic study. *AJR Am J Roentgenol*. 1985;144(5):967-972. doi:10.2214/AJR.144.5.967
3. Petersson CJ. Degeneration of the gleno-humeral joint. An anatomical study. *Acta Orthop Scand*. 1983;54(2):277-283. doi:10.3109/17453678308996570
4. Harkness EF, Macfarlane GJ, Silman AJ, Mcbeth J. Is musculoskeletal pain more common now than 40 years ago?: two population-based cross-sectional studies. *Rheumatology*. 2005;44:890-895. doi:10.1093/rheumatology/keh599
5. Glyn-Jones S, Palmer AJR, Agricola R, et al. Osteoarthritis. *Lancet*. 2015;386(9991):376-387. doi:10.1016/S0140-6736(14)60802-3
6. Khazzam M, Gee AO, Pearl M. Management of Glenohumeral Joint Osteoarthritis. *J Am Acad Orthop Surg*. 2020;28(19):781-789. doi:10.5435/JAAOS-D-20-00404
7. Walch G, Badet R, Boulahia A, Khoury A. Morphologic study of the glenoid in primary glenohumeral osteoarthritis. *J Arthroplasty*. 1999;14(6):756-760. doi:10.1016/S0883-5403(99)90232-2
8. Katz P. Function, disability, and psychological well-being. *Adv Psychosom Med*. 2004;25:41-62. doi:10.1159/000079057
9. Neer CS. Replacement arthroplasty for glenohumeral osteoarthritis. *J Bone Joint Surg Am*. 1974;56(1):1-13. doi:10.2106/00004623-197456010-00001
10. Cole BJ, Yanke A, Provencher MT. Nonarthroplasty alternatives for the treatment of glenohumeral arthritis. *J Shoulder Elbow Surg*. 2007;16(5 SUPPL.). doi:10.1016/j.jse.2007.03.011
11. Millett PJ, boykin robert. *Shoulder Osteoarthritis: Diagnosis and Management*.; 2008. www.aafp.org/afp.
12. Boselli KJ, Ahmad CS, Levine WN. Treatment of glenohumeral arthrosis. *American Journal of Sports Medicine*. 2010;38(12):2558-2572. doi:10.1177/0363546510369250
13. Chillemi C, Franceschini V. Shoulder Osteoarthritis. *Arthritis*. 2013;2013:1-7. doi:10.1155/2013/370231
14. Saltzman BM, Leroux TS, Verma NN, Romeo AA. Glenohumeral Osteoarthritis in the Young Patient. *J Am Acad Orthop Surg*. 2018;26(17):E361-E370. doi:10.5435/JAAOS-D-16-00657
15. Ansok CB, Muh SJ. Optimal management of glenohumeral osteoarthritis. *Orthop Res Rev*. 2018;10:9-18. doi:10.2147/ORR.S134732
16. Silverstein E, Leger R, Shea KP. The use of intra-articular hylan G-F 20 in the treatment of symptomatic osteoarthritis of the shoulder: a preliminary study. *Am J Sports Med*. 2007;35(6):979-985. doi:10.1177/0363546507300256
17. van der Meijden OA, Gaskill TR, Millett PJ. Glenohumeral Joint Preservation: A Review of Management Options for Young, Active Patients with Osteoarthritis. *Orthopedics*. 2012;2012. doi:10.1155/2012/160923
18. Denard PJ, Wirth MA, Orfaly RM. Management of glenohumeral arthritis in the young adult. *J Bone Joint Surg Am*. 2011;93(9):885-892. doi:10.2106/JBJS.J.00960
19. Blaine T, Moskowitz R, Udell J, et al. Treatment of persistent shoulder pain with sodium hyaluronate: a randomized, controlled trial. A multicenter study. *J Bone Joint Surg Am*. 2008;90(5):970-979. doi:10.2106/JBJS.F.01116
20. Kwon YW, Eisenberg G, Zuckerman JD. Sodium hyaluronate for the treatment of chronic shoulder pain associated with glenohumeral osteoarthritis: a multicenter, randomized, double-blind, placebo-controlled trial. *J Shoulder Elbow Surg*. 2013;22(5):584-594. doi:10.1016/J.JSE.2012.10.040
21. Leardini G, Perbellini A, Franceschini M, Mattara L. Intra-articular injections of hyaluronic acid in the treatment of painful shoulder. *Clin Ther*. 1988;10(5):521-526. Accessed November 5, 2022. https://pubmed.ncbi.nlm.nih.gov/2856594/
22. Noël E, Hardy P, Hagena FW, et al. Efficacy and safety of Hylan G-F 20 in shoulder osteoarthritis with an intact rotator cuff.

Open-label prospective multicenter study. *Joint Bone Spine*. 2009;76(6):670-673. doi:10.1016/J.JBSPIN.2009.10.008

23. Valiveti M, Reginato AJ, Falasca GF. Viscosupplementation for degenerative joint disease of shoulder and ankle. *J Clin Rheumatol*. 2006;12(3):162-163. doi:10.1097/01.RHU.0000222057.02268.59
24. Brander VA, Gomberawalla A, Chambers M, Bowen M, Nuber G. Efficacy and safety of hylan G-F 20 for symptomatic glenohumeral osteoarthritis: a prospective, pilot study. *PM R*. 2010;2(4):259-267. doi:10.1016/J.PMRJ.2010.02.010
25. Colen S, Geervliet P, Haverkamp D, van den Bekerom MPJ. Intra-articular infiltration therapy for patients with glenohumeral osteoarthritis: A systematic review of the literature. *Int J Shoulder Surg*. 2014;8(4):114-121. doi:10.4103/0973-6042.145252
26. Izquierdo R, Voloshin I, Edwards S, et al. Treatment of glenohumeral osteoarthritis. *J Am Acad Orthop Surg*. 2010;18(6):375-382. doi:10.5435/00124635-201006000-00010
27. Merolla G, Sperling JW, Paladini P, Porcellini G. Efficacy of Hylan G-F 20 versus 6-methylprednisolone acetate in painful shoulder osteoarthritis: a retrospective controlled trial. *Musculoskelet Surg*. 2011;95(3):215-224. doi:10.1007/S12306-011-0138-3
28. Kim HM, Muhammad M, Heil SD, Smith MJ. Clinical Fate of Glenohumeral Osteoarthritis Following Intraarticular Corticosteroid Injection: An Analysis in 311 Shoulders. *J Shoulder Elb Arthroplast*. 2022;6:247154922210754. doi:10.1177/24715492221075446
29. Metzger CM, Farooq H, Merrell GA, et al. Efficacy of a single, image-guided corticosteroid injection for glenohumeral arthritis. *J Shoulder Elbow Surg*. 2021;30(5):1128-1134. doi:10.1016/j.jse.2020.08.008
30. Kirschner JS, Cheng J, Creighton A, et al. Efficacy of Ultrasound-Guided Glenohumeral Joint Injections of Leukocyte-Poor Platelet-Rich Plasma Versus Hyaluronic Acid in the Treatment of Glenohumeral Osteoarthritis: A Randomized, Double-Blind Controlled Trial. *Clin J Sport Med*. 2022;32(6). doi:10.1097/JSM.0000000000001029
31. Chahla J, Cinque ME, Piuzzi NS, et al. A Call for Standardization in Platelet-Rich Plasma Preparation Protocols and Composition Reporting: A Systematic Review of the Clinical Orthopaedic Literature. *J Bone Joint Surg Am*. 2017;99(20):1769-1779. doi:10.2106/JBJS.16.01374
32. Murray IR, Geeslin AG, Goudie EB, Petrigliano FA, LaPrade RF. Minimum Information for Studies Evaluating Biologics in Orthopaedics (MIBO): Platelet-Rich Plasma and Mesenchymal Stem Cells. *J Bone Joint Surg Am*. 2017;99(10):809-819. doi:10.2106/JBJS.16.00793
33. Centeno CJ, Al-Sayegh H, Bashir J, Goodyear SH, D Freeman M. A prospective multi-site registry study of a specific protocol of autologous bone marrow concentrate for the treatment of shoulder rotator cuff tears and osteoarthritis. *J Pain Res*. 2015;8:269-276. doi:10.2147/JPR.S80872
34. Aly AR, Rajasekaran S, Ashworth N. Ultrasound-guided shoulder girdle injections are more accurate and more effective than landmark-guided injections: a systematic review and meta-analysis. *Br J Sports Med*. 2015;49(16):1042-1049. doi:10.1136/BJSPORTS-2014-093573
35. Soh E, Li W, Ong KO, Chen W, Bautista D. Image-guided versus blind corticosteroid injections in adults with shoulder pain: A systematic review. *BMC Musculoskelet Disord*. 2011;12. doi:10.1186/1471-2474-12-137
36. Patel DN, Nayyar S, Hasan S, Khatib O, Sidash S, Jazrawi LM. Comparison of ultrasound-guided versus blind glenohumeral injections: a cadaveric study. *J Shoulder Elbow Surg*. 2012;21(12):1664-1668. doi:10.1016/J.JSE.2011.11.026
37. Rijs Z, de Groot PCJ, Zwitser EW, Visser CPJ. Is the Anterior Injection Approach Without Ultrasound Guidance Superior to the Posterior Approach for Adhesive Capsulitis of the Shoulder? A Sequential, Prospective Trial. *Clin Orthop Relat Res*. 2021;479(11):2483-2489. doi:10.1097/CORR.0000000000001803
38. Macías-Hernández SI, Morones-Alba JD, Miranda-Duarte A, et al. Glenohumeral osteoarthritis: overview, therapy, and rehabilitation. *Disabil Rehabil*. 2017;39(16):1674-1682. doi:10.1080/09638288.2016.1207206

39. Guo JJ, Wu K, Guan H, et al. Three-Year Follow-up of Conservative Treatments of Shoulder Osteoarthritis in Older Patients. *Orthopedics*. 2016;39(4):e634-e641. doi:10.3928/01477447-20160606-02
40. Onishi K, Utturkar A, Chang E, Panush R, Hata J, Perret-Karimi D. Osteoarthritis: A Critical Review. *Crit Rev Phys Rehabil Med*. 2012;24(3-4):251-264. doi:10.1615/CRITREVPHYSREHABILMED.2013007630
41. Menge TJ, Boykin RE, Byram IR, Bushnell BD. A comprehensive approach to glenohumeral arthritis. *South Med J*. 2014;107(9):567-573. doi:10.14423/SMJ.0000000000000166
42. Manca A, Dragone D, Dvir Z, Deriu F. Cross-education of muscular strength following unilateral resistance training: a meta-analysis. *Eur J Appl Physiol*. 2017;117(11):2335-2354. doi:10.1007/S00421-017-3720-Z
43. Crowell MS, Tragord BS. Orthopaedic manual physical therapy for shoulder pain and impaired movement in a patient with glenohumeral joint osteoarthritis: a case report. *J Orthop Sports Phys Ther*. 2015;45(6):453-461. doi:10.2519/JOSPT.2015.5887
44. MacHado GC, Abdel-Shaheed C, Underwood M, Day RO. Non-steroidal anti-inflammatory drugs (NSAIDs) for musculoskeletal pain. *BMJ*. 2021;372. doi:10.1136/BMJ.N104
45. Gordo AC, Walker C, Armada B, Zhou D. Efficacy of celecoxib versus ibuprofen for the treatment of patients with osteoarthritis of the knee: A randomized double-blind, non-inferiority trial. *J Int Med Res*. 2017;45(1):59-74. doi:10.1177/0300060516673707
46. Wenham CYJ, Hensor EMA, Grainger AJ, et al. A randomized, double-blind, placebo-controlled trial of low-dose oral prednisolone for treating painful hand osteoarthritis. *Rheumatology (Oxford)*. 2012;51(12):2286-2294. doi:10.1093/RHEUMATOLOGY/KES219
47. da Costa BR, Reichenbach S, Keller N, et al. Effectiveness of non-steroidal anti-inflammatory drugs for the treatment of pain in knee and hip osteoarthritis: a network meta-analysis. *Lancet*. 2017;390(10090):e21-e33. doi:10.1016/S0140-6736(17)31744-0
48. Zeng C, Wei J, Persson MSM, et al. Relative efficacy and safety of topical non-steroidal anti-inflammatory drugs for osteoarthritis: a systematic review and network meta-analysis of randomised controlled trials and observational studies. *Br J Sports Med*. 2018;52(10):642-650. doi:10.1136/BJSPORTS-2017-098043
49. Malik, A. T., Bishop, J. Y., Neviaser, A., Jain, N., & Khan, S. N. What are the costs of glenohumeral osteoarthritis in the year prior to a total shoulder arthroplasty (TSA)? *Physician and Sportsmedicine*. 2020; 48(1), 86–97. https://doi.org/10.1080/00913847.2019.1632159