Bedside Joint, Muscle, and Tendon Injections: Overview

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Essential Concepts

- Joints, tendons, and muscles are common sources of pain for patients.
- Ultrasound has significantly improved the accuracy and ease of performing a joint, tendon, or muscle injection at the bedside.
- A number of different medications exist for injection into these areas including emerging therapies such as platelet-rich plasma, hyaluronic acid, and mesenchymal stem cells.

1 Overview

Chronic pain is a major public health issue. An investigation of 25,916 consecutive patients attending a primary care clinic at 15 centers in 14 countries indicated that 22% of patients suffer from chronic pain [1]. Similar survey studies in the United States (n = 27,035) and in Canada (n = 2012) report a prevalence of chronic pain of

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31% and 29%, respectively, suggesting that chronic pain may be more prevalent in North America [2, 3].

Chronic pain is associated with significant psychosocial distress, and there is a high co-occurrence with mood and psychological disorders (e.g., anxiety and depression) [4, 5]. Further, chronic pain places a financial strain on the patient, healthcare system, and society— pain is one of the top causes for work absenteeism and reduced productivity, and approximately one in five patients with chronic pain will lose their job because of their pain [6, 7]. A United Kingdom study identified that chronic pain resulted in 4.6 million visits to a primary care physician, which cost the system approximately £69 million ($100 million USD) a year [8]. The total direct and indirect costs of chronic pain are staggering and is estimated to be in the billions of dollars each year [9, 10].

A significant portion of patients with chronic pain suffer from musculoskeletal (MSK) pain. MSK pain comprises pain from muscles (myofascial pain), joints, or tendons. MSK pain is estimated to affect up to 47% of the general population [11]. Older age, low socioeconomic status, depression, anxiety, sleep disorders, and manual work are potential risk factors for MSK pain. Management options for MSK pain include a number of strategies such as physical therapy, psychological counselling, oral analgesics, and interventional options [12, 13].

There are a number of interventional therapies targeting pain joints, tendons, and muscles. Performing these injections at the bedside can help reduce waiting times for operating room availability, which can be reserved for procedures requiring sedation, increased monitoring, or fluoroscopy. Bedside procedures, whether performed as an inpatient or within an outpatient pain clinic, can facilitate early interval improvement in pain, faster rehabilitation, and mitigate oral pharmacologic use.

2 Historical Aspects

Traditionally, bedside MSK procedures have been performed using landmark-based approaches. This practice relies heavily on normal anatomy and tactile feedback of the injection needle. Challenges that exist with this approach include access to deeper joints or use in patients with a larger body habitus. Success rates with landmark-based approaches have been variable ranging from 16.7% to 100% [14]. However, since it is not possible to visualize the needle tip with a landmark-based approach, it is not possible to guarantee adequate injection at the desired anatomical location and it can pose unnecessary risks with the potential of puncturing nearby tissues (e.g., blood vessels, viscera, lungs).

Ultrasound technology has significantly improved the accuracy of MSK procedures. Numerous studies have demonstrated improved injection accuracy and decreased injection pain with ultrasound guidance [14]. Accuracy of upper and lower extremity injections using ultrasound has consistently resulted in greater than 90% accuracy. Benefits of ultrasound-guided procedures include needle visualization confirming placement in the joint or targeted tissue, real-time visualization of clear spread of the injectate, and improved safety by avoiding neurovascular structures and inflicting less needle trauma [15].

Acquisition of appropriate ultrasound images is highly user-dependent. A learning curve exists for the safe and accurate use of ultrasound-guided injections [16]. Individuals may have difficulties visualizing two dimensional structures while conceptualizing three-dimensional structures. Other challenges with ultrasound use include the presence of acoustic artifacts, optical illusions, and random noise. Patient characteristics including obesity, edema, air, muscle atrophy, and the need to access deeper anatomical targets pose further difficulties for the operator [17].

Types of Injections

A number of procedural options exist for joint, tendon, and muscle-related pain. Muscle pain, otherwise known as myofascial pain, is characterized by regional pain originating from hyperirritable spots known as myofascial trigger points (MTrPs) [18]. Several studies have suggested that myofascial trigger points accounted for the primary source of pain in up to 85% of patients presenting to a primary care clinic for pain evaluation [19]. Several injections exist for MTrPs, which are believed to mechanically disrupt dysfunctional activity in the motor endplates by both direct need placement and by injection of medications [20]. Dry needling is a common technique where a needle is placed into a trigger point with multiple passes, resulting in a local twitch response from rapid depolarization of the involved muscle fibers [21]. Apart from dry needling, injection of medications (wet needling) including local anesthesia, botulinum type A toxin (BoNT-A), and steroids can be used to alleviate myofascial pain [18]. Unfortunately, there are limited evidence to identify whether dry or wet needling is superior and which type of medication is most helpful.

Further, there are a number of joint and tendon injections that can be done at the bedside using ultrasound guidance. A number of tendon dysfunctions such as trigger fingers, rotator cuff tendinopathies, epicondylitis, biceps tendinopathy, and Achilles tendinopathy could be considered for injection therapy [22]. Furthermore, bedside injection of a number of small and large joints (i.e., zygapophyseal, acromio-clavicular, glenohumeral, hip, and knee joints) can also be performed reliably using ultrasound guidance [23].

Types of Injection Medications

Several different types of medications are commonly used in bedside procedures. Selection of these medications are based on both the etiology of pain and the purpose of the injection. Some injectates are combined (i.e. mixture of local anesthetics and steroids) in hopes of providing an additive or synergistic effect, although evidence for this is lacking. Here we discuss commonly used injection medications along with their potential risks and benefits.

Steroids are among the most commonly used medications for joint, tendon, and muscle injections. Most commonly used steroids are methylprednisolone, triamcinolone, betamethasone, and dexamethasone [24]. Steroids have an anti-inflammatory effect acting directly and indirectly to suppress the activity of pro-inflammatory

cytokines by inhibition of phospholipase A2 activity [25]. Much of the clinical difference that exists between types of steroids is based on water solubility and aggregation characteristics resulting in the classification of *particulate* (poorly soluble) or *non-particulate* (soluble) steroids. Particulate steroids are ester preparations requiring hydrolysis by cellular esterases to produce the active moiety which results in the benefit of clinically longer duration of effect [26]. Non-particulate steroids may be safer in that regard however, they have shorter duration of anti-inflammatory effects. Systemic effects of steroid use are dose-dependent and commonly manifest as transient hypertension, hyperglycemia, post-injection flare, facial flushing and mood alterations [22]. Higher risk complications include septic arthritis, avascular necrosis, and tendon rupture and repeat steroid injections can result in local tissue atrophy and skin de-pigmentation [27].

Local anesthetics act by blocking sodium channels in the nerve membrane, interfering with the propagation of action potentials along the axon. They are often used for both diagnostic and therapeutic purposes, and often in combination with steroids and with a vasoconstrictor (i.e., epinephrine) which can increase the duration of effect and risk of local anesthetic toxicity [26]. Local anesthetics are synthesized as hydrochloride salts to render them water soluble. Intra-articular local anesthetics can improve postoperative pain scores and reduce narcotic consumption [28]. While local anesthetics appear to be safe when used in tendon, joint, and muscle injections, there are concerns for potential side-effects. Intravascular injections of local anesthetics can cause local anesthesia toxicity, resulting in central nervous system dysfunction and cardiorespiratory collapse—case reports have been published reporting local anesthesia toxicity after a single injection [29]. Further, local anesthesia appears to be toxic to both muscles and chondrocytes [30, 31].

3 Recent Developments

Hyaluronic acid is a glycosaminoglycan that is found within synovial fluid and the cartilage matrix [32]. Normal concentrations of hyaluronic acid as part of synovial fluid provides viscous lubrication during joint movements and provides shock-absorbing effects. Synthetic hyaluronic acid has been developed as a potential therapy for joint injections. It is believed to provide an analgesic effect via several mechanisms including anti-inflammatory, anabolic, analgesic, and chondroprotective mechanisms [33]. Specifically, hyaluronic acid can increase chondrocyte proliferation, decrease chondrocyte apoptosis, and retard the overall osteoarthritic process that results in joint space narrowing. Different products for use exist that vary in molecular weight, hyaluronic acid concentration, elasticity, and viscosity. Intra-articular hyaluronic injections are considered safe with transient local reaction of injection site reaction and injection site pain, with systemic reactions being rare [34].

PRP (platelet-rich plasma) is also another novel injection for MSK pathologies that requires separating the patient's blood to collect a solution that is generally four to six times the baseline concentration of platelets [35]. With injection of platelets, it is believed that they become activated and causes the release of these growth

factors leading to an anti-inflammation effect and promotion of healing [36]. Prior studies suggested that 5% was the optimal concentration of platelets required to stimulate chondrocyte proliferation from an intraarticular injection [37]. Preparations of PRP vary considerably and can include leukocyte-rich or leukocyte-poor solutions [38]; leukocyte-rich preparations are preferred for tendon injections while leukocyte-poor preparations are preferred for intraarticular injections. A recent systematic review has evaluated the use of PRP for tendon and ligament pathologies and overall reports positive findings, particularly for lateral epicondylitis and rotator cuff tendinopathy [39]. Several reviews have suggested that PRP may be beneficial for intraarticular injection, particularly in the knee [40, 41].

Mesenchymal stem cells (MSCs) are an emerging therapy used for joint and tendon-related pain. It is believed that since MSCs have pluripotency properties, they can differentiate into different cell lineages, including type II chondrocytes, which can then produce cartilage in deficient joints with osteoarthritis [42]. MSCs can also be derived from bone marrow, adipose tissues, umbilical cord, and from synovium itself, with the greatest yields from adipose tissues [43]. MSCs have been studied in a number of animal models and small human studies and have shown some favorable findings [44]. Apart from stem cell differentiation and release of cartilage, MSCs are believed to possess robust anti-inflammatory properties by antagonizing resident macrophages from secreting pro-inflammatory cytokines [45]. Nonetheless, most studies are small and low-quality and there is a pressing need for more evidence for the use of this therapy.

4 Conclusions and Future Directions

Joint, tendon, and muscle injections are frequently performed procedures to alleviate pain. Bedside procedures can help provide immediate access to these therapies with minimal waiting times to operating room or procedure suites. The wide availability of ultrasound machines has allowed greater availabilities for clinicians to offer bedside procedures; however, there is a learning curve to obtain adequate skills required for ultrasound-guided procedures.

An increasing number of resources are becoming available on different types of joint, tendon, and muscle injections. Further, different injectates are available depending on the type of injection and presumed cause of pain. More evidence is needed on emerging therapies such as hyaluronic acid, platelet-rich plasma, and mesenchymal stem cells to definitively identify the efficacy and safety of these therapies.

References

1. Gureje O, Von Korff M, Simon GE, Gater R. Persistent pain and well-being. JAMA. 2013;280(2):147–52.
2. Johannes CB, Le TK, Zhou X, Johnston JA, Dworkin RH. The prevalence of chronic pain in United States adults: results of an internet-based survey. J Pain. 2010;11(11):1230–9.

3. Moulin D, Clark A, Speechley M, Morley-Forster P. Chronic pain in Canada, prevalence, treatment, impact and the role of opioid analgesia. Pain Res Manag. 2002;7:179–84.
4. Birket-Smith M. Somatization and chronic pain. Acta Anaesthesiol Scand. 2001;11:1114–20.
5. McWilliams LA, Cox BJ, Enns MW. Mood and anxiety disorders associated with chronic pain: an examination in a nationally representative sample. Pain. 2003;106(1):127–33.
6. Allen H, Hubbard D, Sullivan S. The burden of pain on employee health and productivity at a major provider of business services. J Occup Environ Med. 2005;47(7):658–70.
7. Breivik H, Collett B, Ventafridda V, Cohen R, Gallacher D. Survey of chronic pain in Europe: prevalence, impact on daily life, and treatment. Eur J Pain. 2006;10(4):287–333.
8. Belsey J. Primary care workload in the management of chronic pain. A retrospective cohort study using a GP database to identify resource implications for UK primary care. J Med Econ. 2002;5:39–50.
9. Gaskin DJ, Richard P. The economic costs of pain in the United States. J Pain. 2012;13(8):715–24.
10. Coyte PC, Asche CV, Croxford R, Chan B. The economic cost of musculoskeletal disorders in Canada. Arthritis Care Res. 1994;11(5):315–25.
11. Cimmino MA, Ferrone C, Cutolo M. Epidemiology of chronic musculoskeletal pain. Best Pract Res Clin Rheumatol. 2011;25(2):173–83.
12. Bergman S. Management of musculoskeletal pain. Best Pract Res Clin Rheumatol. 2007;21(1):153–66.
13. Babatunde OO, Jordan JL, Van Der Windt DA, Hill JC, Foster NE, Protheroe J. Effective treatment options for musculoskeletal pain in primary care: a systematic overview of current evidence. PLoS One. 2017;12(6):1–30.
14. Daniels EW, Cole D, Jacobs B, Phillips SF. Existing evidence on ultrasound-guided injections in sports medicine. Orthop J Sports Med. 2018;6(2):1–7.
15. Chen CPC, Lew HL, Tsai WC, Hung YT, Hsu CC. Ultrasound-guided injection techniques for the low back and hip joint. Am J Phys Med Rehabil. 2011;90(10):860–7.
16. Deimel GW, Jelsing EJ, Hall MM. Musculoskeletal ultrasound in physical medicine and rehabilitation. Curr Phys Med Rehabil Rep. 2013;1(1):38–47.
17. Henderson M, Dolan J. Challenges, solutions, and advances in ultrasound-guided regional anaesthesia. BJA Educ. 2016;16(11):374–80.
18. Desai MJ, Saini V, Saini S. Myofascial pain syndrome: a treatment review. Pain Ther. 2013;2(1):21–36.
19. Skootsky SA, Jaeger B, Oye RK. Prevalence of myofascial pain in general internal medicine practice. West J Med. 1989;151(2):157–60.
20. Borg-Stein J. Treatment of fibromyalgia, myofascial pain, and related disorders. Phys Med Rehabil Clin. 2006;17(2):491–510.
21. Kalichman L, Vulfsons S. Dry needling in the management of musculoskeletal pain. J Am Board Fam Med. 2010;23(5):640–6.
22. Speed C. Corticosteroid injections in tendon lesions. BMJ. 2002;323:382–6.
23. Narouze S. Atlas of ultrasound-guided procedures in interventional pain management. Springer; 2018.
24. Hwang H, Park J, Lee WK, Lee WH, Leigh JH, Lee JJ, et al. Crystallization of local anesthetics when mixed with corticosteroid solutions. Ann Rehabil Med. 2016;40(1):21–7.
25. McEwen BS, Kalia M. The role of corticosteroids and stress in chronic pain conditions. Metab Clin Exp. 2010;59(Suppl. 1):S9–15.
26. MacMahon PJ, Eustace SJ, Kavanagh EC. Injectable corticosteroid and review for radiologists. Radiology. 2009;252(3):647–61.
27. Sardana V, Burzynski J, Hasan K, Zalzal P. Are non-steroidal anti-inflammatory drug injections an alternative to steroid injections for musculoskeletal pain?: a systematic review. J Orthop. 2018;15(3):812–6.
28. Busch CA, Shore BJ, Bhandari R, Ganapathy S, MacDonald SJ, Bourne RB, et al. Efficacy of periarticular multimodal drug injection in total knee arthroplasty: a randomized trial. J Bone Joint Surg A. 2006;88(5):959–63.

29. Dhir S, Ganapathy S, Lindsay P, Athwal GS. Case report: ropivacaine neurotoxicity at clinical doses in interscalene brachial plexus block. Can J Anesth. 2007;54(11):912–6.
30. Reurink G, Goudswaard GJ, Moen MH, Weir A, Verhaar JAN, Tol JL. Myotoxicity of injections for acute muscle injuries: a systematic review. Sports Med. 2014;44(7):943–56.
31. Dragoo JL, Korotkova T, Kanwar R, Wood B. The effect of local anesthetics administered via pain pump on chondrocyte viability. Am J Sports Med. 2008;36(8):1484–8.
32. Elmorsy S, Funakoshi T, Sasazawa F, Todoh M, Tadano S, Iwasaki N. Chondroprotective effects of high-molecular-weight cross-linked hyaluronic acid in a rabbit knee osteoarthritis model. Osteoarthr Cartil. 2014;22(1):121–7.
33. Altman RD, Manjoo A, Fierlinger A, Niazi F, Nicholls M. The mechanism of action for hyaluronic acid treatment in the osteoarthritic knee: a systematic review. BMC Musculoskelet Disord. 2015;16(1):1–10.
34. Aggarwal A, Sempowski IP. Hyaluronic acid injections for knee osteoarthritis. Systematic review of the literature. Can Fam Physician. 2004;50:249–56.
35. Filardo G, Kon E, Roffi A, Di Matteo B, Merli ML, Marcacci M. Platelet-rich plasma: why intra-articular? A systematic review of preclinical studies and clinical evidence on PRP for joint degeneration. Knee Surg Sports Traumatol Arthrosc. 2015;23(9):2459–74.
36. Anitua E, Andia I, Ardanza B, Nurden P, Nurden AT. Autologous platelets as a source of proteins for healing and tissue regeneration. Thromb Haemost. 2004;91(1):4–15.
37. Spreafico A, Chellini F, Frediani B, Bernardini G, Niccolini S, Serchi T, et al. Biochemical investigation of the effects of human platelet releasates on human articular chondrocytes. J Cell Biochem. 2009;108(5):1153–65.
38. Braun HJ, Kim HJ, Chu CR, Dragoo JL. The effect of platelet-rich plasma formulations and blood products on human synoviocytes: implications for intra-articular injury and therapy. Am J Sports Med. 2014;42(5):1204–10.
39. Kia C, Baldino J, Bell R, Ramji A, Uyeki C, Mazzocca A. Platelet-rich plasma: review of current literature on its use for tendon and ligament pathology. Curr Rev Musculoskelet Med. 2018;11(4):566–72.
40. Laudy ABM, Bakker EWP, Rekers M, Moen MH. Efficacy of platelet-rich plasma injections in osteoarthritis of the knee: a systematic review and meta-analysis. Br J Sports Med. 2015;49(10):657–72.
41. Meheux CJ, McCulloch PC, Lintner DM, Varner KE, Harris JD. Efficacy of intra-articular platelet-rich plasma injections in knee osteoarthritis: a systematic review. Arthroscopy. 2016;32(3):495–505.
42. Marini JC, Forlino A. Replenishing cartilage from endogenous stem cells. N Engl J Med. 2013;366(26):2522–4.
43. Freitag J, Bates D, Boyd R, Shah K, Barnard A, Huguenin L, et al. Mesenchymal stem cell therapy in the treatment of osteoarthritis: reparative pathways, safety and efficacy—a review. BMC Musculoskelet Disord. 2016;17(1):1–13.
44. Jevotovsky DS, Alfonso AR, Einhorn TA, Chiu ES. Osteoarthritis and stem cell therapy in humans: a systematic review. Osteoarthr Cartil. 2018;26(6):711–29.
45. Harrell CR, Markovic BS, Fellabaum C, Arsenijevic A, Volarevic V. Mesenchymal stem cell-based therapy of osteoarthritis: current knowledge and future perspectives. Biomed Pharmacother. 2019;109:2318–26.

Further Reading

Haskins SC, Boretsky K, Boublik J, Bronshteyn Y, Byrne M, Chan V, El-Boghdadly K, Hernandez N, Hogg R, Kalagara H, Kruisselbrink R, Manson W, Nader A, Nejim J, Perlas A, Ramsingh D, Shankar H, Silva M, Souza D, Wilkinson JN, Zimmerman J, Narouze S. American Society of Regional Anesthesia and Pain Medicine expert panel recommendations on point-of-care

ultrasound education and training for regional anesthesiologists and pain physicians, part 1. Reg Anesth Pain Med. 2021;46(12):1031–47. https://doi.org/10.1136/rapm-2021-102560. PMID: 33632778

Rosenquist RW, Souzdalnitski D, Urman R, editors. Chronic pain management for hospitalized patient. 1st ed. New York: Oxford University Press; 2016. 420 p. https://global.oup.com/academic/product/chronic-pain-management-for-the-hospitalized-patient-9780199349302?cc=eu&lang=en&. Assessed 31 Jan 2021.