A Review of Current Pain Management Options for Chronic Lumbar Facet Joint-Related Pain

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Abstract

Low back pain is the highest contributor to disability in the global population, with estimates of over 600 million affected individuals worldwide. Pain originating from the facet joints of the lumbar spine vertebrae are prevalent in this population, with up to 45% of cases being attributed to facetogenic origin. Chronic lumbar facet joint-related pain is a key focus area for current research, as there have been varied results from the different treatment options currently available, with no consensus on the best standard of care. This review examines recent research into treatment options available at present, their effectiveness in managing lumbar facet joint-related pain, as well as provides a comparative analysis between treatment options described here. Key aspects of current methods and study designs were analysed and discussed in relation to future directions in research, particularly regarding diagnostic criteria, standardised methods and outcomes for comparability, and the need for high quality, randomised controlled data to accurately assess efficacy.

Keywords: *facet joint pain, facetogenic pain, low back pain, radiofrequency ablation, facet joint injection, endoscopic surgery, regenerative therapy.*

Introduction

Low back pain is ranked as the highest contributor to disability burden worldwide and has an estimated prevalence between 6-12% within the global population, depending on country (GBD 2021 Low Back Pain Collaborators, 2023). Estimates from 2020 suggest 619 million people reported having low back pain globally, with a significant increase of 60.4% from 1990 estimates, with prevalence highest in central and eastern Europe, and Australasia (GBD 2021 Low Back Pain Collaborators, 2023). The total number of cases is predicted to increase by a further 36.4% by 2050 and hence poses a significant public health and policy focus on management to address the growing associated cost and burden of disease (GBD 2021 Low Back Pain Collaborators, 2023). Back pain as a general concept is multifactorial in nature, with various pathological causes identified, including degenerative or mechanical, infective, oncological, systemic or metabolic, and traumatic (Mosabbir, 2022; Yoo & Kim, 2024). Low back pain is commonly categorised by its duration (acute under 6 weeks, subacute from 6-12 weeks, and chronic if longer than 12 weeks) and source (Urits et al., 2019). Sources of pain generation are either axial (predominantly from the vertebral column and sacrum), radicular (nerve root related pain radiating down the extremity in a dermatomal distribution), and referred (radiating to a remote region in a non-dermatomal distribution), which tend to indicate different instigating structures (Urits et al., 2019). Issue arises however from the difficulty in attributing a specific pathological or structural cause to the experienced back pain, resulting in the classification of non-specific back pain, which occurs in up to 90% of cases (Han et al., 2023). Potential sources for non-specific back pain have been suggested, including intervertebral discs, sacroiliac joints, and vertebral facet joints, as innervated structures that can generate painful signals (Han et al., 2023).

Facet joint or facetogenic pain, is pain arising from the vertebral facet joint, a highly innervated synovial joint between the inferior and superior articulating facets of adjacent vertebrae in the vertebral column (W. Li et al., 2021; T. Wu et al., 2016; Yoo & Kim, 2024). Facet joint-related pain was initially described in the early 20th century (Ghormley, 1933; Goldthwait, 1911) and is suggested to be responsible for up to 45% of low back pain presentations, with prevalence increasing with age (Kanth et al., 2021; Kawu et al., 2011; Lakemeier et al., 2013; T. Wu et al., 2016). The bilateral facet joints, posteriorly, and intervertebral disc, anteriorly, between each vertebral level comprise the triarticular weight-bearing complex, a stabilising structure of the spine, which is most prone to degenerative changes (W. Li et al., 2021; Yoo & Kim, 2024). Sub-failure injury, the most commonly spinal injury mechanism, is a result of trauma below the threshold to produce major injury but, with summation, causes inflammation and degenerative changes in the spine (Mosabbir, 2022). Many facet joint pathologies can result in pain (facet joint cysts, hypertrophy, septic arthritis, ankylosing spondylitis, traumatic dislocation etc.) however, the most common cause is osteoarthritic changes, frequently affecting the lower lumbar levels (L4/5, L3/4 and L5/S1 in order of highest frequency) (Yoo & Kim, 2024).

The facet joint complex of subchondral bone, articular cartilage, synovial membranes and a fibrous capsule, is highly innervated with nerve endings from the medial branch of the posterior ramus of the spinal cord (W. Li et al., 2021; Mosabbir, 2022). Degenerative damage to the synovial facet joint prompts an inflammatory response and release of cytokines and mediators (Igarashi et al., 2004). Nociceptive afferent fibres, mainly C- and Aδ-fibres, respond to mechanical and chemical stimuli in degenerative change, transmitting pain signals to the dorsal horn of the spinal cord to synapse with projection neurons in ascending pathways to the brain and somatosensory areas (D'Mello & Dickenson, 2008). Such pain is also modulated by descending signals from the central nervous system (CNS) which can become maladaptive (Mosabbir, 2022). Acute pain (<6 weeks duration) is the response to tissue damage, however with persistent injury and continuous nociceptive input, alterations to the pain pathways and CNS modulation can result in increased peripheral and central sensitisation to stimuli, altered central processing of incoming pain signals, and incorporation of emotion and memory into response, resulting in a severe chronic pain experience (D'Mello & Dickenson, 2008; W. Li et al., 2021; Mosabbir, 2022). These combined aspects of chronic low back pain from a bio-psycho-social model becomes of high importance in addressing the variety of components related to the individual's pain experience (Mosabbir, 2022).

Diagnosis of facetogenic pain is complicated as clinical and radiological features are not pathognomonic or reliably accurate in isolating the facet joint as the cause of pain (Itz et al., 2016; Maas et al., 2017). Clinically, patients experience unilateral or bilateral back pain, radiating towards the flanks, hips and posterolateral thighs, whilst not extending below the knees (Itz et al., 2016). It is described as worsened with extension and rotation movements, but not with flexion of the spine (Itz et al., 2016). Clinical and radiological diagnostic criteria have been suggested, however there has been conflicting evidence for their reliability (Han et al., 2023; Maas et al., 2017). The reference standard for identifying facet joint-related pain involves a diagnostic anaesthetic block of the medial branch of the dorsal ramus supplying the suspected facet joint (Maas et al., 2017). As there is a high false positive rate for this procedure, it is recommended that repeated testing with dual branch blocks (using two different anaesthetic agents over two spatially separated tests) is more specific for accurate diagnosis (Itz et al., 2016).

Management of facet joint-related pain, as with most types of chronic low back pain, is advised to progress from least to most complex treatment options, considering invasiveness, risk, cost, and availability (Mekhail et al., 2023). This includes conservative, interventional (such as injections or percutaneous procedures), and surgical treatments (Mekhail et al., 2023). With development of advanced imaging techniques and therapeutic options, the potential treatments for managing facetogenic pain has broadened, and approaches to implement these treatments are not unified at present (Itz et al., 2016; van Tilburg et al., 2016). As the prevalence of low back and facetogenic pain continues to increase, the need for effective management becomes paramount. Current research has shown mixed results regarding outcomes for management of chronic lumbar facet joint-related pain, and this review of the literature aims to examine the outcomes for the various strategies commonly utilised at the present state, highlighting the support for various treatment and areas for further investigation.

Method

Objectives

To review the current literature on management strategies for chronic degenerative lumbar facet joint-related pain.

Literature search strategy

Multiple databases were utilised for a comprehensive review of the current literature on facet joint pain and management. This included PubMed and MEDLINE, EMBASE and the Cochrane databases. The search was limited to articles published between 1st January 2000 and 1st January 2024, and by those published in English. Search strategies utilised Boolean operators to refine results and produce relevant studies. The keywords and phrases used for the searches (as well as variations for completeness) included combinations of "facet joint pain", "low back pain", "lumbar", "chronic", "zygapophyseal", "injection", "surgery", "radiofrequency ablation", "regenerative", and "stem cell" (see Appendix A). Records also identified through other sources and extended reading, such as key papers and through bibliography review of articles, were also included in the literature review.

Inclusion and exclusion criteria

The criteria for inclusion of articles for this review consisted of human studies, adult population (aged 18 and over) with a focus on chronic lumbar/low back pain of spinal facet joint origin. Articles needed to examine management options (conservative, interventional, or surgical) and outcomes using a validated pain and/or functional outcome measure, such as the Visual Analogue Scale (Wewers & Lowe, 1990), Oswestry Disability Index for lower back pain (Fairbank et al., 1980), Roland-Morris Disability Questionnaire (Stevens et al., 2016), or other equivalent measures. Primary evidence and review articles with meta-analyses were included for this literature review. For efficacy studies, interventions needed to be compared to controls or other forms of intervention. Exclusion criteria removed case reports and reviews not presenting original data, narrative reviews, those focusing on non-facetogenic and non-arthritic pain and other causes of lower back pain (radiculopathy, spinal canal stenosis, neural foraminal stenosis, facet joint cyst, adjacent segment disease following spinal surgery etc.), studies with collated data whereby that specific to facet joint interventions were not able to be distinguished from other causes of lower back pain, and those not published in English.

Data extraction, analysis and quality review

Articles selected after meeting inclusion criteria were reviewed and relevant data extracted, including author(s), year of publication, study design, sample size, patient demographics, diagnostic criteria, treatment methods and key findings. These were grouped into subcategories by similar features (diagnosis, pathophysiology, treatment) for analysis and synthesis of findings. Studies were reviewed on their quality and content, which informed their bearing in the subsequent information synthesis.

Synthesis of findings

The findings from the literature review are presented through a narrative synthesis, due to the heterogeneity of study designs and outcomes, as well as inclusion of higher analysis research such as meta-analyses. Key themes emerged from review of the literature, namely pathophysiology, diagnosis and investigations, treatment modalities including conservative practices, interventional procedures, surgical operations and regenerative treatments. Quantitative data from the literature has been summarised when appropriate to descriptive statistics to highlight the key outcomes for the various treatments within the review.

RESULTS

The results of the literature review are summarised below, synthesised in a narrative format. Randomised controlled trials identified through this review are summarised with key features and outcomes in Table 1 (see Appendix B). Five intervention areas were identified: conservative management, facet joint injections, radiofrequency ablation, surgical interventions, and regenerative therapies. Each area has been discussed as an overview of the treatment and review of recent research and outcomes of the treatment alone and compared to other intervention areas.

Conservative management

Conservative medical management is the least invasive technique for addressing chronic low back pain, with the least risk and cost of treatment (Mekhail et al., 2023). Management includes incorporation of non-pharmacological strategies, such as exercises and physical rehabilitation, and pharmacological treatment with analgesia, non-steroidal anti-inflammatory drugs (NSAIDs) and, in select patients, opioid medications (Qaseem et al., 2017). Psychological therapies have also been suggested to address the cognitive components of pain (Okudan et al., 2024).

Recent research has investigated Lumbar Stabilisation Exercises (LSE) as a physical therapy to improve neuromuscular control of the lumbar spine through strengthening the spinal support muscles (multifidus, transversus abdominis, diaphragm and pelvic floor) to reduce painful movement (Cetin et al., 2019; Wahyuddin et al., 2020). Wahyuddin et al. (2020) investigated LSE compared to Muscle Energy Technique, a manipulation technique aiming to restore motion and eliminate muscle spasms, through invoking neurological and biomechanical responses. This small sample randomised trial did not show significant difference in range of motion, pain or disability outcomes following a single session (Wahyuddin et al., 2020). Cetin et al. (2019) compared LSE to a control group following radiofrequency denervation for lumbar facet joint syndrome in a randomised study and showed significantly greater improvement in pain levels and functionality following LSE over 6 weeks.

Further Comparisons

Sae-Jung and Jirarattanaphochai (2016) found oral Diclofenac (a NSAID) to be less effective for controlling pain and improving function compared to methylprednisolone intra-articular facet injections alone or in combination. Z. Z. Li et al., (2014) also found a significant improvement in pain following endoscopic rhizotomy of the dorsal ramus medial branch when compared to conservative management of NSAIDs, physical therapy and cognitive behavioural therapy. These are discussed further below (see below sections: Therapeutic Injections, Surgical Techniques).

There were limited investigations into conservative management specifically for lumbar facet-related pain, with only those investigating physical and pharmacological therapies meeting the criteria of this review. However, conservative management remains the recommended first line therapy for managing facet joint related pain (Qaseem et al., 2017) and may have benefits in conjunction with other treatment options.

Therapeutic injections

Therapeutic injections, with either corticosteroids or anaesthetics, are a mainstay of intervention for facetogenic pain (Anshul et al., 2023). Utilisation of imaging-guidance allows accurate targeting of structures, usually the intra-articular space or the medial branch of the dorsal nerve root, with fluoroscopy being the most studied modality (Anshul et al., 2023). Whilst performed percutaneously, there are risks due to the invasive nature of the procedures depending on the target location, with medial branch blocks being the safest due to lack of vulnerable structures in the target region, and intra-articular injections having recorded complications of infection (iatrogenic septic arthritis, epidural abscess, spondylodiscitis, paraspinal abscess) and potential neural structure injury (Bogduk et al., 2008).

Corticosteroid injection is proposed as an anti-inflammatory agent with immunosuppressive effects, to reduce transcription and activity of inflammatory mediators, such as phospholipase A2 and prostaglandin E2, acting on and sensitising pain receptors in the synovial joint (Kanth et al., 2021; Patel et al., 2022; Vekaria et al., 2016). Intra-articular administration has been theorised to target the inflammatory response within the synovial facet joint, associated with osteoarthritic degeneration, and reduce joint and capsule swelling and the associated innervated pain (Igarashi et al., 2004; Itz et al., 2016; Kim et al., 2015). Medial branch blocks are proposed to provide benefit through the suppression of ectopic discharges from the medial branches of the dorsal root to reduce pain transmission (Cohen et al., 2018).

Studies have had mixed results for the efficacy of injection therapies on both facetogenic pain and associated disability. Several studies investigated the efficacy of facet joint corticosteroid injection compared to anaesthetic injection control groups, with no significant difference between pain levels or disability between groups (Manchikanti et al., 2001; Manchikanti et al., 2008, 2010). One prospective randomised study compared intra-articular corticosteroid injection to saline control, however was unable to reach the primary timeframe for outcome evaluation due to high volume drop out due to receiving radiofrequency ablation (RFA) for unresolved pain (Kennedy et al., 2018). It was noted that the dropout rate and timing was similar across groups which the authors suggested may represent comparative treatment outcomes (Kennedy et al., 2018). Further to this, a meta-analysis of three randomised controlled trials showed similar effectiveness for normal saline and active substance (corticosteroid, anaesthetic) intra-articular injections (Suputtitada, et al., 2023).

Intra-articular injections vs medial branch blocks

Two groups have investigated the outcomes from different locations of facet joint injection; intra-articular or medial branch block. Anshul et al. (2023) performed a randomised controlled trial of intra-articular and dorsal ramus medial branch corticosteroid injections (bupivacaine and triamcinolone), which showed both targets providing significant improvement in pain and disability at 6 months, but no difference between treatments. Cohen et al. (2015) initially performed a retrospective case-controlled review of injection targets and predictive value for subsequent RFA success and concluded that outcomes were better following two separate medial branch blocks rather than intra-articular injections or only a single diagnostic block. However, in their more recent randomised controlled trial comparing intra-articular and medial branch corticosteroid injections with a saline placebo, Cohen et al. (2018) found a significant difference in duration of pain relief compared to placebo, but no significant difference between injection locations. Further to this, subsequent RFA rates across all injections were comparable (intra-articular, medial branch block, and saline placebo), however there was a noted trend of more prominent positive outcomes for those who received active injections (Cohen et al., 2018). The results of this prospective study and the study by Anshul et al. (2023) do support a comparative effect of intra-articular injection and medial branch blocks for pain and disability outcomes, however do not appear to reduce the likelihood of subsequent RFA or need for further therapy.

Imaging modality

For intra-articular facet joint injections, there has been a recent shift in imaging modality for accurate procedural guidance, with investigation into ultrasound-guidance due to the lack of radiation, real-time monitoring, higher availability, and lower cost (Galiano et al., 2007). Randomised controlled trials have shown comparative outcomes in both computer tomography (CT)/fluoroscopy and ultrasound-guided facet joint injections, across injection success rates, pain and functional outcomes (Galiano et al., 2007; Touboul et al., 2022; Yun et al., 2012). A meta-analysis supported ultrasound as non-inferior to CT/fluoroscopy for these procedures and noted no significant difference in mean procedure duration (T. Wu et al., 2016). The only unsuccessful ultrasound-guided procedures reported were due to high body mass index (BMI) and inaccuracy in joint space identification due to depth restrictions (T. Wu et al., 2016). Overall, there is growing support for ultrasound use in facet joint procedures due to its comparable accuracy and the benefit of reduced ionizing radiation exposure.

Compared to conservative management

When comparing facet joint injections to conservative medical management, corticosteroid injections have been shown to be superior to physiotherapy regimens and oral NSAIDs (Diclofenac) alone, with better pain and disability outcomes at the end of treatment (Kawu et al., 2011; Sae-Jung & Jirarattanaphochai, 2016). It was also shown that the combination of intra-articular corticosteroids and systemic anti-inflammatory medication provided greater benefit at 12 weeks than either therapy alone (Sae-Jung & Jirarattanaphochai, 2016). Whilst there appears to be a benefit to intra-articular injections, the evidence for corticosteroid injection is not substantial for superiority to active or non-active control injections, and the outcomes are likely to be more beneficial in conjunction with conservative management strategies.

Further comparisons

Investigations comparing intra-articular corticosteroid injections (methylprednisolone, betamethasone, dexamethasone) against RFA techniques, have supported short-term improvement with facet joint injections, but a longer duration of sustained effect from RFA

(Civelek et al., 2012; Duger et al., 2012; Kanth et al., 2021; Wardhana et al., 2022). However, in some longer-term studies, no significant difference in outcomes were found between treatments (Do et al., 2017; Lakemeier et al., 2013; Manchikanti et al., 2022; Yasar et al., 2018). One study did note that facet-joint injection treatment did have sustained efficacy at 12-month follow-up, which was longer than other reported outcomes (Yasar et al., 2018). Corticosteroid injections have also been compared to regenerative therapies, particularly platelet-rich plasma (PRP) injections, with short-term studies showing no significant clinical difference, however did identify improvement in radiological classification of disease severity (Kotb et al., 2022). Longer follow-up studies have shown support for greater sustained efficacy of PRP (Singh et al., 2023; J. Wu et al., 2017). These are discussed further in this review (see below sections: Radiofrequency Ablation, Regenerative Therapies).

Radiofrequency ablation (RFA)

Radiofrequency techniques administer an electrical field, via a circuit involving an insulated electrode, body tissue, and a dispersive ground plate, to generate ionic motion and frictional heat within the adjacent tissue (Lee et al., 2017). In RFA used for facet joint-mediated pain, the generated heat denatures the medial branch of the dorsal ramus as it runs through the fibro-osseous canal to supply the zygapophyseal joint, generating a neurotomy and disconnection of pain signal transmission (Hashim et al., 2020). Whilst proposed to provide longer-lasting relief due to direct disruption of the nerve fibres, the effects of RFA are not permanent, and recurrence of pain is observed after some time, attributed to nerve recovery over weeks-to-months, facilitated by the intact ganglia and nerve sheath (Manchikanti et al., 2022). RFA is performed under imaging-guidance to ensure correct location, and is programmed to generate a specific temperature for a set duration to achieve adequate ablation (Maas et al., 2015). This is a commonly performed procedure for facet joint-mediated pain following failed conservative and injection therapies, as it is a more invasive procedure with greater potential risk, mainly with nerve structure and rootlet damage from incorrect electrode placement, resulting in sensory and motor deficits (Bogduk et al., 2008). Generally performed under local anaesthetic and light sedation, there is increased risk when using general anaesthetic due to absence of active patient feedback (Bogduk et al., 2008). Overall, with correct positioning and application, RFA has minimal permanent complications and is well tolerated (Maas et al., 2015).

Two randomised, controlled studies have compared continuous RFA to sham control in patients with positive diagnostic medial branch blocks over 3-month periods (Leclaire et al., 2001; van Tilburg et al., 2016). Neither study found significant differences in pain or functional outcomes at 3 months, despite RFA showing significant improvement in pain at 1-month post-procedure (Leclaire et al., 2001; van Tilburg et al., 2016). A meta-analysis including trails earlier than the selection for this review, reviewed RFA compared to sham or epidural block controls for facetogenic pain, and concluded that there was support for conventional RFA producing a significant reduction in pain up to 12 months (Lee et al., 2017). Whilst this did not meet the threshold clinically important difference in pain level, the authors noted that exclusion of earlier data, which was suggested as less reliable and accurate, did result in exceeding this minimum level of improvement for clinical relevance (Lee et al., 2017). The only Cochrane review relating to facet joint pain management supports RFA over placebo at 1 and 6 months, with moderate evidence for pain relief, however found only low evidence for functional improvement (Maas et al., 2015). These studies may indicate a longer-term benefit from RFA.

Different RFA techniques

Variation on conventional or continuous thermal RFA have been suggested as alternative techniques for treatment (Shih et al., 2020). Conventional RFA applies constant high frequency electrical current, generating constant temperature to crease neuro-destructive lesions, whereas pulsed RFA aims to produce non-neurolytic lesions, avoiding neural damage, through lower energy and temperature cycles (Lu et al., 2012; Shih et al., 2020). Pulsed RFA utilises a brief stimulation followed by a long resting phase and is suggested to be selective to smaller principal sensory nociceptor C-fibres targeting pain signalling (Do et al., 2017). Cooled RFA, a third technique, utilises internally cooled radiofrequency probes to achieve a cooler tip but larger lesional size in the surrounding tissue, potentially increasing the chance of complete denervation of the adjacent nerve (Shih et al., 2020). The larger area of affect is also proposed to provide a technical advantage, reducing reliance on specific orientation of positioning due to a spherical effect field (McCormick et al., 2023).

Lu et al. (2012) compared efficacy of conventional RFA (protocol: 80^{O}C, 90 seconds) against pulsed RFA (protocol: 2x20ms cycles, maximum 42^{O}C, over 180s) in a small, randomised trial and showed that conventional RFA had significantly better pain relief, but comparable functional improvement to pulsed RFA. A meta-analysis of randomised controlled trials found significant improvement from baseline in all three of conventional, pulsed, and cooled RFA at 12 months, with no statistically significant difference in efficacy between techniques, but did note cooled radiofrequency showed greater improvement at 6 months compared to the others, supporting an increased benefit in the shot-term (Shih et al., 2020). One study examined monopolar vs bipolar RFA techniques, proposing a greater surface area of coagulation with bipolar application, however, did not find any added benefit when comparing treatments (Hashim et al., 2020).

Compared to facet joint injection techniques

Given the denaturing effect of RFA on the dorsal ramus medial branch, it is expected that there is longer-standing benefit of treatment for facet joint-mediated pain than facet joint injection methods, however comparative studies have shown mixed results (Civelek et al., 2012).

Kanth et al. (2021) and Lakemeier et al. (2013) both performed randomised controlled trials, comparing efficacy of conventional RFA (protocol: 80^{O}C, 90 seconds) with intra-articular corticosteroid injections (betamethasone) for diagnostic block-confirmed facet joint syndrome. Kanth et al. (2021) found significant improvement with RFA compared to facet joint injection at 6 months across pain and disability measures. They also noted that corticosteroid injections had an approximate duration of relief of 3 months, with pain scores similar to pre-intervention levels by the 6-month follow-up (Kanth et al., 2021). Conversely, Lakemeier et al. (2013) found no significant difference between treatments, with similar overall improvement at 6 months in both groups compared to baseline. (Civelek et al., 2012) compared efficacy of conventional RFA (protocol: 80^{O}C, 120 seconds) to medial branch blocks over a 12-month period and found RFA significantly improved pain levels compared to the injection group, despite initially providing less relief, however there was no significant difference in quality-of-life assessment at 12 months. A recent large cohort retrospective case-control review of conventional RFA against facet joint nerve blocks identified significant improvement in pain scores up to 12 months, with no difference between treatment types and similar average overall cost (Manchikanti et al., 2022).

Pulsed RFA has been compared to intra-articular injections with comparable long-term outcomes. Yasar et al. (2018) compared maximum 42^{O}C pulsed RFA over 120 second against methylprednisolone intra-articular injections over 12 months and found similar endpoint outcomes, despite an earlier significant greater reduction in pain scores following RFA. Functional improvement was shown at 12 months compared to baseline, with no significant difference between groups (Yasar et al., 2018). Another study compared pulsed RFA (protocol: maximum 40^{O}C, over 6 mins) against intra-articular injection monotherapy (methylprednisolone) and combined RFA-injection treatment over 12 months (Duger et al., 2012). Pulsed RFA and combination therapy had significant improvement compared to injection monotherapy at 12 months, with combination therapy showing greater pain and satisfaction improvement in the early follow-up period, but no long-term difference between pulsed RFA and combination groups (Duger et al., 2012). Do et al. (2017) conducted a randomised controlled trial on a different pulsed RFA technique, applying the electrodes directly into the intra-articular space rather than the medial branch pathway, at a maximum 42^{O}C over 360 seconds, and compared outcomes against dexamethasone intra-articular injection therapy. Whilst there was initially a significant difference in pain relief favouring the intra-articular injection group at 1 month, pain levels were comparable at 6 months (Do et al., 2017).

One recent study has investigated cooled RFA (protocol: 60^{O}C, 165 seconds) compared to intra-articular facet joint injections (triamcinolone) in a small randomised trial, which initially showed higher treatment success in the cooled RFA group up to 6 months, but no significant difference in pain levels or functional improvement between groups at 12 months (McCormick et al., 2023).

Two meta-analyses comparing RFA to lumbar facet injection and placebo treatments did suggest a benefit with RFA, however noted the quality of studies to be low grade and cautioned interpretation of the results (Poetscher et al., 2014; Wardhana et al., 2022). Wardhana et al. (2022) concluded that RFA provided better pain relief up to 12 months, but improved functional scores only up to 6 months post-procedure. Poetscher et al. (2014) found RFA to be more effective for pain control and functional improvement compared to placebo and suggested a possible benefit for pain management compared to steroid injection, however acknowledged the evidence to be limited. In a review by Maas et al. (2015), only low and very low evidence studies were found to support improvement benefit with RFA compared to steroid injections over 12 months. There is not substantial support for the superiority of RFA compared to injection therapy, with only a handful of small, randomised studies providing positive benefits of long-term outcomes, despite the RFA technique used. A large variance in parameters and comparison injections explored in these studies makes evaluation difficult, however, as highlighted, the evidence thus far is not of high quality.

Further comparisons

When comparing RFA to more invasive and developing treatment options, there have been studies performed into relative efficacies of endoscopic neurotomy and regenerative therapies. Studies examining endoscopic neurotomy did find significant improvement compared to percutaneous RFA at 12 months follow-up, in both pain control and function (Song et al., 2019; Woiciechowsky, 2022; Xue et al., 2020). One study compared percutaneous RFA with platelet-rich plasm (PRP) intra-articular injection alone and in combination, and found RFA to be superior in pain management and functional improvement compared to PRP injection alone, but inferior to combined RFA/PRP treatment at 4 months follow-up (Paswan & Rath, 2023). These are examined further in this review (see below sections: Surgical Techniques, Regenerative Therapies)

Surgical techniques

Surgical options for managing facet joint-mediated pain in patients are the most invasive group of therapeutic techniques, and usually the last to be considered in the management process (Mekhail et al., 2023). These aim to address underlying pathologies and modulate the chronic pain pathway, utilising direct visualisation of involved components for increased accuracy and more substantial intervention (Mekhail et al., 2023). There are two main applications of surgical intervention for facet joint-related pain; surgically-assisted neurotomy of the medial branch of the dorsal ramus, to more accurately and definitively disrupt the facet joint pain signal afferent transmission pathway (Z. Z. Li et al., 2014), and addressing microinstability in the vertebral column causing facet joint-related pain (Manfrè et al., 2020). Vertebral microinstability is described as early degenerative biomechanical dysfunction, involving the intervertebral discs, vertebral endplates, facet joints, and multifidus muscle, resulting in low back pain with minimal/mild degenerative changes radiologically (Manfrè et al., 2020).

Of note, fusion surgery is mainly reserved as the last option for degenerative spinal conditions, and indicated with spinal cord or spinal nerve compromise and radicular/myopathic symptoms (Musso et al., 2022). Two systematic reviews identified did not support fusion for chronic low back pain due to poor long-term outcomes (Hegmann et al., 2021; Musso et al., 2022). A meta-analysis of the data concluded there was no demonstratable long-term benefit, with higher potential for subsequent adjacent segment disease (iatrogenic degeneration of adjacent spinal segment structures), and likely inferiority to rehabilitation programs alone (Hegmann et al., 2021). Whilst some studies have investigated the efficacy of less invasive fusion techniques (see below), spinal fusion for chronic low back pain alone is not currently a recommended treatment option.

Endoscopic neurotomy

Endoscopic neurotomy utilises minimally invasive endoscopic surgery dorsally to directly visualise, expose and disrupt the medial branch of the dorsal ramus to achieve pain control in individuals with facet joint-mediated pain (Song et al., 2019). The procedure involves fluoroscopic guidance to identify the correct level transverse process, then a dilatation process over a guidewire to insert the endoscopic equipment and approach the target region (Xue et al., 2020). The medial branch of the dorsal ramus is identified beneath the mamillo-accessory ligament, dissected, coagulated and severed under direct vision to perform the neurotomy, disconnecting afferent pain signal transmission from the affected facet joint (Woiciechowsky, 2022; Xue et al., 2020). The procedure has been documented as performed under local anaesthetic (Xue et al., 2020), procedural sedation (Z. Z. Li et al., 2014), and general anaesthetic (Woiciechowsky, 2022).

Z. Z. Li et al. (2014) have shown efficacy of endoscopic dorsal ramus rhizotomy compared to conservative management (NSAIDs, physical therapy, and cognitive behavioural therapy) for dual medial branch block-diagnosed chronic facetogenic pain. In their randomised controlled trial with 12 months follow-up, endoscopic treatment was shown to maintain pain relief consistently to 12 months (no significant difference in pain measures compared to post-medial branch block assessment), contrasting the conservatively managed group whose pain scores were comparable to pre-diagnostic medial branch block levels (Z. Z. Li et al., 2014). Significant difference was shown at 12-month follow-up supporting endoscopic rhizotomy as more effective than conservative management (Z. Z. Li et al., 2014). The authors also noted that new variant anatomy of the dorsal medial branch was identified during their procedures, which would not have been considered in a percutaneous RFA procedure, highlighting a benefit of direct visualisation under endoscopy for accuracy and effectiveness of intervention (Z. Z. Li et al., 2014). Although there is higher potential for complications with surgical endoscopy compared to other techniques described here, none were recorded in this study (Z. Z. Li et al., 2014).

Compared to radiofrequency ablation

Three randomised controlled trials have investigated endoscopic neurotomy compared to RFA in medial branch block-diagnosed lumbar facet joint pain, supporting a potential increased efficacy with endoscopic treatment (Song et al., 2019; Woiciechowsky, 2022; Xue et al., 2020). All studies followed the same standard endoscopic technique to dissect, coagulate, and sever the medial branch of the dorsal ramus, and had similar radiofrequency protocols; 80^{O}C for 90 seconds (Song et al., 2019; Woiciechowsky, 2022), or a 2-stage process of 80^{O}C for 60 seconds, then 90^{O}C for 80 seconds (Xue et al., 2020). Song et al. (2019) found that, over 2 years follow-up, endoscopic neurotomy had significant pain reduction and treatment success compared to RFA, with RFA effectiveness reducing 1 year post-procedure, whilst endoscopic neurotomy effectiveness decreased only towards 2 years post-procedure and maintained significant improvement compared to pre-procedure measures. Woiciechowsky (2022) showed significant effectiveness in both RFA and endoscopic neurotomy groups compared to pre-intervention pain measures, however only up to 6 months following RFA compared to 12 months following endoscopic neurotomy. Functional and quality of life outcomes were significantly improved at 12 months similarly across groups, however there was a significant improvement in all pain and functional assessments at 12 months favouring endoscopic denervation as more effective treatment (Woiciechowsky, 2022). The study by Xue et al. (2020) concluded that endoscopic neurotomy achieved better pain control than RFA at 12 months post-procedure, although both showed significant improvement compared to pre-procedure assessment. No significant complications were shown in the studies reviewed, with Xue et al. (2020) noting a lesser incidence of minor complications in the endoscopic group (lack of skin sensation, analgesia).

These studies provide support for the superiority of endoscopic neurotomy when compared to radiofrequency ablation, with sustained duration of pain management and functional improvement. The authors had suggested this may be due to the ability to accommodate altered anatomy and severe deformities, which would reduce percutaneous RFA accuracy, as well as physically severing the nerve to reduce regenerative ability (Song et al., 2019; Woiciechowsky, 2022). Nevertheless, endoscopic neurotomy does not appear to be permanent, with slow increase in pain scores across long-term follow-up indicating nerve regeneration may still be occurring (Song et al., 2019). However, the duration of regeneration appears to be much longer than in RFA procedures, with pain increase only being identified in the 2-year follow-up study (Song et al., 2019). Endoscopic neurotomy has potential as a longer efficacy treatment for chronic facet joint-mediated back pain, however cost, risk, treatment duration, and technical ability of treating practitioners needs to be considered, and current recommendations suggest this as a complimentary procedure for difficult percutaneous candidates and therapy-refractory cases (Woiciechowsky, 2022).

Other surgical techniques

One study examined the feasibility of endoscopic facet debridement for treatment of facet joint-related pain, with the procedure removing capsular tissue and denuding the facet joint surface to reduce pain-generating afferent signals (Haufe & Mork, 2010). This retrospective review identified over half of the subjects receiving surgical treatment reporting 75-100% improvement in pain and functional outcomes over at least 3 years follow-up, and the authors highlighted potential for this technique with further comparative research (Haufe & Mork, 2010).

One group has been investigating facet joint screw fixation to address concerns of microinstability generating facet joint-related pain, with an initial short-term, small cohort, and subsequent large prospective feasibility study (Manfré, 2014; Manfrè et al., 2020). Patients with dual diagnostic medial branch block-confirmed facet joint-related pain underwent surgical fixation of afflicted facet joints by CT-guided trans-facet pedicle screw insertion, through the inferior articular process of the above level into the superior articular process of the below level (Manfré, 2014; Manfrè et al., 2020). Whilst these were uncontrolled feasibility studies, initial results showed resolution of low back pain in 6 of the 8 patients at 2 months, and the subsequent study showed significant reduction in pain and disability at 2 years post-operatively, with no mobility reduction, hardware issues or other complications (Manfré, 2014; Manfrè et al., 2020). These studies highlight potential feasibility and indication for further investigation, with the proposed benefit of facet joint fixation to prevent further microinstability movement generated pain, however it is noted that there are anatomical morphology considerations for the procedure which may limit its use in all patients (Manfrè et al., 2020).

Finally, one study investigated a minimally invasive facet arthrodesis to restore degenerative articulating components potentially contributing to facet joint-related pain generation (Meisel et al., 2014). At 1 year post-operatively there was found to be significant decrease in pain and disability compared to pre-treatment, which provided support for the feasibility of this technique, however there were noted to be higher complication rates of 22% involving the prosthesis and procedural components which need to be considered in further research (Meisel et al., 2014).

Regenerative techniques

Regenerative techniques for chronic facet joint-related pain aim to stimulate innate cellular functions to address degenerative changes by reducing pain generating components and promoting tissue repair and growth (Patel et al., 2022). Options such as platelet-rich plasma, stem cell therapy and prolotherapy or sclerotherapy have been investigated in other synovial joints and are potential options for treatment in facet joint pain (Patel et al., 2022; Yildirim, 2021). As this is a developing field, there are limited studies addressing regenerative techniques for facet joint-related pain, however investigation into platelet-rich plasma has been more prominent in current research.

Platelet-rich plasma (PRP) is an autologous derived substance from the patient's venous blood following 2-stage centrifugation (stage 1 separating platelets and leukocytes from erythrocytes, and stage 2 removing platelet poor plasma) to produce a highly concentrated platelet suspension in plasma (3-9x normal blood levels) (Patel et al., 2022; J. Wu et al., 2017). PRP has been shown to degranulate on exposure to collagen in damaged tissues and release growth factors, angiogenesis factors, and cytokines which stimulate cell proliferation, migration, matrix synthesis, chondrogenesis and improved cartilage healing (Kanth et al., 2021; Kolber et al., 2018; Paswan & Rath, 2023; Patel et al., 2022). The mediators released by PRP are anti-nociceptive and anti-inflammatory, suppressing inflammatory mediators and further gene expression to halt perpetuation of the inflammatory cascade (J. Wu et al., 2017).

Compared to facet joint injection techniques

Intra-articular injection of platelet-rich plasma (PRP) has been compared to intra-articular corticosteroid injections in randomised controlled trials for facet joint-related pain. Kotb et al. (2022) and J. Wu et al. (2017) compared outcomes of PRP and betamethasone intra-articular injections over 3- and 6-month periods, respectively. Kotb et al. (2022) found both groups had significant improvement in pain and disability at 3 months compared to pre-treatment, however no inter-group differences, although MRI radiological features of synovitis severity grading were significantly decreased following PRP treatment compared to the corticosteroid treatment, suggesting potential for further pathological recovery. J. Wu et al. (2017) found that, whilst the corticosteroid group had a peak in subjective satisfaction and objective success rate at 1 month, the PRP group showed continued improvement at 6 months post-procedure, supporting a longer efficacy duration.

Singh et al. (2023) compared PRP and corticosteroid intra-articular injections with a saline control in patients with medial branch block-diagnosed, single level facet joint pain undergoing continuous RFA (protocol: 80^{O}C, 90 seconds). They found overall improvement in pain and functionality compared to pre-intervention in all groups at 6 months, however, as with the previous studies, the saline and steroid groups had a peak improvement at 1 months before lessening, whilst the PRP group had continued and significant improvement comparatively at 3 and 6 months, suggesting superiority of PRP with longer efficacy duration (Singh et al., 2023). There was no significant difference between corticosteroid and saline group results throughout the follow-up period, noting that all treatment was in conjunction with conventional RFA (Singh et al., 2023).

From the reviewed studies, there appears to be support for PRP as a potential improvement on conventional corticosteroids for intra-articular injections, due to a greater sustained improvement in pain relief and disability reduction.

Compared to radiofrequency ablation

One randomised controlled trial compared PRP intra-articular injections with conventional RFA monotherapy (protocol: 80^{O}C, 90 seconds) as well as combined PRP/RFA treatment with 4 months follow-up (Paswan & Rath, 2023). All three treatment groups showed improvement in pain control, functionality, and analgesic reduction at 4 months, however the combined PRP/RFA group was significantly better than the RFA monotherapy group, which in turn was significantly better than the PRP monotherapy group at 4 months follow-up (Paswan & Rath, 2023). The authors concluded that, acknowledging their study limitations (small sample size, short follow-up, lack of true control), the combination RFA/PRP treatment regime suggested better longer-term outcomes than either monotherapy (Paswan & Rath, 2023). Although not a primary outcome, PRP monotherapy was not shown to be superior to RFA monotherapy for pain control or functional improvement over this study duration (Paswan & Rath, 2023).

Prolotherapy

Prolotherapy or sclerotherapy involves irritating targeted tissue to stimulate regenerative healing in the damaged area, potentially accelerating healing in chronically damaged tissues (Yildirim, 2021). One study retrospectively reviewed intra-articular injection of 25% dextrose solution as prolotherapy against conventional methylprednisolone facet joint injection for management of low back pain, finding prolotherapy to have significantly better pain relief scores at 3 months, however worse disability outcomes compared to corticosteroid injections (Yildirim, 2021). This study was limited by its retrospective nature as well as identified higher pre-intervention pain scores in the corticosteroid group compared to the prolotherapy group (Yildirim, 2021), so the results are not without influence and further investigation into this treatment is warranted to understand the comparative efficacy.

Discussion

This review has examined the current literature around management options for chronic degenerative lumbar facet joint-related pain. Interventions including conservative management strategies, percutaneous interventional treatment, and invasive surgical options, have been explored with varying outcomes and evidence.

The current literature identifies conservative options of analgesia/NSAIDs, physical therapy, and holistic chronic pain treatment, with main support for benefit in conjunction with the more invasive treatment options.

Therapeutic corticosteroid and anaesthetic injections to the facet joint have conflicting support for increased efficacy compared to saline placebo injection, however, appear to have more benefit than conservative management alone, with no difference shown between intra-articular and medical branch targets. Ultrasound guidance of procedures has been shown as comparable to CT/fluoroscopy, with the added benefit of non-exposure to ionising radiation.

Radiofrequency ablation (RFA) of the medial branch of the dorsal ramus has been considered more definitive treatment than injection techniques, however the literature does not provide strong support for this. Meta-analysis has shown superiority of RFA over placebo for pain and functionality at 6 months. Different variants of RFA have not been shown to be significantly different in long-term follow-up.

Surgical techniques are limited and usually reserved for unstable or neural-compromising conditions. Endoscopic neurotomy has increasing evidence for significantly improved long-term outcomes compared to percutaneous RFA, and whilst not permanent, could provide an extended management option. Other surgical techniques are less researched however may show future promise.

Recent study into regenerative therapies has shown varied results. Platelet-rich plasma intra-articular injections have mixed outcomes compared to corticosteroid injections but there is some support for longer duration of efficacy. Whilst still unclear of its comparative effect, early studies did not suggest superiority to RFA. Limited research has been performed for other regenerative therapies.

This review has highlighted a large variance in outcomes for many frequently utilised procedures in clinical management of facet joint pain. All techniques have shown significant differences compared to pre-intervention measures; however, the reliability of duration and improvement overall is dubious. It would be suggested, from this review, to work through current available management options from least to most invasive, as without clear comparative superiority of treatments, overall risk should be minimised.

Some features of the reviewed literature have been identified as potentially implicating the variance in outcomes and lack of clear consensus findings.

Diagnostic medial branch blocks have been suggested as the reference standard for identifying facetogenic pain (Maas et al., 2017), however in many studies this is not included as a selection criteria, which questions how representative the included population group is. Only 12 of 31 randomised controlled trials reviewed had inclusion criteria of diagnostic medial branch blocks, with only 8 performing the standard dual diagnostic blocks (see Table 1, Appendix B). Without a consistent sample population for the targeted pathology, interpretation of the results become unclear and difficult to compare due to potential inclusion of heterogenous pathologies. There are difficulties with implementing this in study design, especially when investigating medial branch block treatment efficacy, as the inclusion condition is also the treatment examined. However, accepting a standardised inclusion criteria will produce a clearer consistent study population, facilitating more robust analysis of results, and the generalisation of outcomes to similar patient populations.

Furthermore, the complexity of chronic pain and the modulating factors from a bio-psycho-social model of pain introduces confounding factors into the patient population. This is difficult to control, and larger sample sizes will provide a more representative cohort of the general population. These confounders are not always addressed in the current literature, and the effect of this on study results should not be discounted.

Non-consensus on treatment standards also introduces variability into study design and difficulty with comparative analysis of results. We have highlighted a variety of options for almost all interventions (see Table 1, Appendix B), particularly various conservative management regimens, corticosteroids used for injections, and RFA techniques and protocols for temperature and duration. Difficulty arises in accurately comparing results of these subtle, but potentially significantly impacting differences within the same treatment modality. Whilst research into each technique is still occurring to optimise protocols, the variety does pose comparative issues through introducing additional factors, and more focused intra-treatment research is needed to consolidate this for future research.

As identified in all meta-analyses reviewed, there is a paucity of research, and specifically high-quality studies, for facet joint-related pain management. Aside from the difficulties mentioned previously, large scale randomised controlled trials are lacking, with most of the current literature involving either small subject groups, or retrospective data. This review highlights again the need for quality prospective research into management strategies to provide more informative support for treatment options.

This literature review has limitations in the lack of formal systematic structure and meta-analysis of data. Whilst it provides an overview of the state of current literature, the narrative approach does not allow for clear comparison, which is also reflective of the heterogeneity of the studies reviewed. The breadth of treatments included for review also limits the depth of this analysis, however it does provide an overview for current clinical options and developing fields.

This study has identified future directions for research, mainly in the need for clarity around the specific patient population through standardised selection and diagnostic methods, investigation into treatment options to optimise protocols and selected agents for further comparison of different treatment modalities, and the need for high quality, prospective, randomised controlled studies. Further research with these in mind will provide a basis for clearer outcomes, comparison, and meta-analysis which will benefit the understanding of management options for clinical practice.

Conclusion

Chronic degenerative lumbar facet joint-mediated pain is a significant cause of disability and quality of life impairment in the global population, and with an increasing burden on international health systems, effective management is becoming a key area of priority. Various options are suggested, including conservative, percutaneous interventional, and surgical techniques, with support compared to non-intervention, however there is no strong evidence of their comparative superiority. It would be suggested to trial current available options working from least to most invasive, to minimise risk exposure in the absence of clear treatment superiority. Further high-quality research is needed to clarify the efficacy of these treatments and form a foundation for application in clinical practice.

References

Anshul, Malhotra, N., Kumar, A., Jyotsna, Rohilla, K., & Sinha, N. (2023). Comparative evaluation of intraarticular facet joint injection versus medial branch block in patients with low back pain: A randomised controlled study. *Cureus, 15*(11), e49232. doi:10.7759/cureus.49232

Bogduk, N., Dreyfuss, P., Baker, R., Yin, W., Landers, M., Hammer, M., & Aprill, C. (2008). Complications of spinal diagnostic and treatment procedures. *Pain Medicine, 9*, S11-S34. doi:10.1111/j.1526-4637.2008.00437.x

Cetin, H., Kose, N., Turkmen, C., Dulger, E., Bilgin, S., & Sahin, A. (2019). Do stabilization exercises increase the effects of lumbar facet radiofrequency denervation? *Turkish Neurosurgery, 29*(4), 576-583. doi:10.5137/1019-5149.Jtn.24946-18.2

Civelek, E., Cansever, T., Kabatas, S., Kircelli, A., Yilmaz, C., Musluman, M., Ofluoglu, D., & Caner, H. (2012). Comparison of effectiveness of facet joint injection and radiofrequency denervation in chronic low back pain. *Turkish Neurosurgery, 22*(2), 200-206. doi:10.5137/1019-5149.Jtn.5207-11.1

Cohen, S. P., Doshi, T. L., Constantinescu, O. C., Zhao, Z., Kurihara, C., Larkin, T. M., Griffith, S. R., Jacobs, M. B., Kroski, W. J., Dawson, T. C., Fowler, I. M., White, R. L., Verdun, A. J., Jamison, D. E., Anderson-White, M., Shank, S. E., & Pasquina, P. F. (2018). Effectiveness of lumbar facet joint blocks and predictive value before radiofrequency denervation: The facet treatment study (FACTS), a randomized, controlled clinical trial. *Anesthesiology, 129*(3), 517-535. doi:10.1097/aln.0000000000002274

Cohen, S. P., Moon, J. Y., Brummett, C. M., White, R. L., & Larkin, T. M. (2015). Medial branch blocks or intra-articular injections as a prognostic tool before lumbar facet radiofrequency denervation: A multicenter, case-control study. *Regional Anesthesia and Pain Medicine, 40*(4), 376-383. doi:10.1097/aap.0000000000000229

Collaborators., G. L. B. P. (2023). Global, regional, and national burden of low back pain, 1990-2020, its attributable risk factors, and projections to 2050: a systematic analysis of the global burden of disease study 2021. *The Lancet Rheumatology, 5*(6), e316-e329. doi:10.1016/S2665-9913(23)00098-X

D'Mello, R., & Dickenson, A. H. (2008). Spinal cord mechanisms of pain. *British Journal of Anaesthesia, 101*(1), 8-16. doi:10.1093/bja/aen088

Do, K. H., Ahn, S. H., Cho, Y. W., & Chang, M. C. (2017). Comparison of intra-articular lumbar facet joint pulsed radiofrequency and intra-articular lumbar facet joint corticosteroid injection for management of lumbar facet joint pain: A randomized controlled trial. *Medicine (Baltimore), 96*(13), e6524. doi:10.1097/md.0000000000006524

Duger, C., Kol, I. O., Kaygusuz, K., Gursoy, S., & Mimaroglu, C. (2012). Effects of facet joint nerve block addition to radiofrequency in the treatment of low back pain. *HealthMED, 6*(6), 2052-2056.

Fairbank, J. C., Couper, J., Davies, J. B., & O'Brien, J. P. (1980). The Oswestry low back pain disability questionnaire. *Physiotherapy, 66*(8), 271-273.

Galiano, K., Obwegeser, A. A., Walch, C., Schatzer, R., Ploner, F., & Gruber, H. (2007). Ultrasound-guided versus computed tomography-controlled facet joint injections in the lumbar spine: A prospective randomized clinical trial. *Regional Anesthesia and Pain Medicine, 32*(4), 317-322. doi:10.1016/j.rapm.2007.03.010

Ghormley, R. K. (1933). Low back pain: with special reference to the articular facets, with presentation of an operative procedure. *Journal of the American Medical Association, 101*, 1773-1777.

Goldthwait, J. E. (1911). The lumbo-sacral articulation; an explanation of many cases of "lumbago," "sciatica" and paraplegia. *The Boston Medical and Surgical Journal, 164*(11), 365-372. doi:doi:10.1056/NEJM191103161641101

Han, C. S., Hancock, M. J., Sharma, S., Sharma, S., Harris, I. A., Cohen, S. P., Magnussen, J., Maher, C. G., & Traeger, A. C. (2023). Low back pain of disc, sacroiliac joint, or facet joint origin: A diagnostic accuracy systematic review. *EClinicalMedicine, 59*, 101960. doi:10.1016/j.eclinm.2023.101960

Hashim, M. M., Abdelkhalek, W. M., Shaaban, A. M., & Alkhudairi, D. A. (2020). Radiofrequency ablation for the treatment of chronic lumbar facet arthropathy: A randomized control trial. *Journal of Pain Management, 13*(1), 49-56.

Haufe, S. M., & Mork, A. R. (2010). Endoscopic facet debridement for the treatment of facet arthritic pain--a novel new technique. *International Journal of Medical Sciences, 7*(3), 120-123. doi:10.7150/ijms.7.120

Hegmann, K. T., Travis, R., Andersson, G. B. J., Belcourt, R. M., Carragee, E. J., Eskay-Auerbach, M., Galper, J., Goertz, M., Haldeman, S., Hooper, P. D., Lessenger, J. E., Mayer, T., Mueller, K. L., Murphy, D. R., Tellin, W. G., Thiese, M. S., Weiss, M. S., & Harris, J. S. (2021). Invasive treatments for low back disorders. *Journal of Occupational and Environmental Medicine, 63*(4), e215-e241. doi:10.1097/jom.0000000000001983

Igarashi, A., Kikuchi, S., Konno, S., & Olmarker, K. (2004). Inflammatory cytokines released from the facet joint tissue in degenerative lumbar spinal disorders. *Spine, 29*(19), 2091-2095.

doi:10.1097/01.brs.0000141265.55411.30

Itz, C. J., Willems, P. C., Zeilstra, D. J., & Huygen, F. J. (2016). Dutch multidisciplinary guideline for invasive treatment of pain syndromes of the lumbosacral spine. *Pain Practice, 16*(1), 90-110. doi:10.1111/papr.12318

Kanth, M. V., Vangapandu, A., & Rajendra Prasad, M. (2021). To study the comparison of intraarticular lumbar facet joint steroid injections and lumbar facet joint radiofrequency denervation in treatment of low back pain. *Journal of Cardiovascular Disease Research, 15*(8), 1829-1849. doi:10.48047/jcdr.2024.15.08.200

Kawu, A. A., Olawepo, A., & Salami, A. O. (2011). Facet joints infiltration: a viable alternative treatment to physiotherapy in patients with low back pain due to facet joint arthropathy. *Nigerian Journal of Clinical Practice, 14*(2), 219-222. doi:10.4103/1119-3077.84021

Kennedy, D. J., Huynh, L., Wong, J., Mattie, R., Levin, J., Smuck, M., & Schneider, B. J. (2018). Corticosteroid injections into lumbar facet joints: A prospective, randomized, double-blind placebo-controlled trial. *American Journal of Physical Medicine and Rehabilitation, 97*(10), 741-746. doi:10.1097/phm.0000000000000960

Kim, J. S., Ali, M. H., Wydra, F., Li, X., Hamilton, J. L., An, H. S., Cs-Szabo, G., Andrews, S., Moric, M., Xiao, G., Wang, J. H., Chen, D., Cavanaugh, J. M., & Im, H. J. (2015). Characterization of degenerative human facet joints and facet joint capsular tissues. *Osteoarthritis Cartilage, 23*(12), 2242-2251. doi:10.1016/j.joca.2015.06.009

Kolber, M. J., Purita, J., Paulus, C., Carreno, J. A., & Hanney, W. J. (2018). Platelet-rich plasma: Basic science and biological effects. *Strength & Conditioning Journal, 40*(5), 77-94. doi:10.1519/ssc.0000000000000402

Kotb, S. Y., Sherif, N. M., Saleh, H. A., Ahmed, S. F., Sakr, H. M., & Taeimah, M. O. (2022). The role of intra-articular injection of autologous platelet-rich plasma versus corticosteroids in the treatment of synovitis in lumbar facet joint disease. *Saudi Medical Journal, 43*(11), 1200-1208. doi:10.15537/smj.2022.43.11.20220449

Lakemeier, S., Lind, M., Schultz, W., Fuchs-Winkelmann, S., Timmesfeld, N., Foelsch, C., & Peterlein, C. D. (2013). A comparison of intraarticular lumbar facet joint steroid injections and lumbar facet joint radiofrequency denervation in the treatment of low back pain: A randomized, controlled, double-blind trial. *Anesthesia and Analgesia, 117*(1), 228-235. doi:10.1213/ANE.0b013e3182910c4d

Leclaire, R., Fortin, L., Lambert, R., Bergeron, Y. M., & Rossignol, M. (2001). Radiofrequency facet joint denervation in the treatment of low back pain: A placebo-controlled clinical trial to assess efficacy. *Spine, 26*(13), 1411-1416; discussion 1417.

doi:10.1097/00007632-200107010-00003

Lee, C. H., Chung, C. K., & Kim, C. H. (2017). The efficacy of conventional radiofrequency denervation in patients with chronic low back pain originating from the facet joints: A meta-analysis of randomized controlled trials. *The Spine Journal, 17*(11), 1770-1780. doi:10.1016/j.spinee.2017.05.006

Li, W., Gong, Y., Liu, J., Guo, Y., Tang, H., Qin, S., Zhao, Y., Wang, S., Xu, Z., & Chen, B. (2021). Peripheral and central pathological mechanisms of chronic low back pain: A narrative review. *Journal of Pain Research, 14*, 1483-1494. doi:10.2147/jpr.S306280

Li, Z. Z., Hou, S. X., Shang, W. L., Song, K. R., & Wu, W. W. (2014). Evaluation of endoscopic dorsal ramus rhizotomy in managing facetogenic chronic low back pain. *Clinical Neurology and Neurosurgery, 126*, 11-17. doi:10.1016/j.clineuro.2014.08.014

Lu, K., Liliang, P. C., Liang, C. L., Wang, K. W., Tsai, Y. D., & Chen, H. J. (2012). Efficacy of conventional and pulsed radiofrequency for treating chronic lumbar facet joint pain. *Formosan Journal of Surgery, 45*(4), 107-112. doi:10.1016/j.fjs.2012.06.001

Maas, E. T., Juch, J. N., Ostelo, R. W., Groeneweg, J. G., Kallewaard, J. W., Koes, B. W., Verhagen, A. P., Huygen, F. J., & van Tulder, M. W. (2017). Systematic review of patient history and physical examination to diagnose chronic low back pain originating from the facet joints. *European Journal of Pain, 21*(3), 403-414. doi:10.1002/ejp.963

Maas, E. T., Ostelo, R. W., Niemisto, L., Jousimaa, J., Hurri, H., Malmivaara, A., & van Tulder, M. W. (2015). Radiofrequency denervation for chronic low back pain. *The Cochrane Database of Systematic Reviews, 2015*(10), Cd008572. doi:10.1002/14651858.CD008572.pub2

Manchikanti, L., Kosanovic, R., Pampati, V., Sanapati, M. R., Soin, A., Knezevic, N. N., Wargo, B. W., & Hirsch, J. A. (2022). Equivalent outcomes of lumbar therapeutic facet joint nerve blocks and radiofrequency neurotomy: comparative evaluation of clinical outcomes and cost utility. *Pain Physician, 25*(2), 179-192.

Manchikanti, L., Pampati, V., Bakhit, C. E., Rivera, J. J., Beyer, C. D., Damron, K. S., & Barnhill, R. C. (2001). Effectiveness of lumbar facet joint nerve blocks in chronic low back pain: A randomized clinical trial. *Pain Physician, 4*(1), 101-117.

Manchikanti, L., Singh, V., Falco, F. J., Cash, K. A., & Pampati, V. (2008). Lumbar facet joint nerve blocks in managing chronic facet joint pain: One-year follow-up of a randomized, double-blind controlled trial: Clinical Trial NCT00355914. *Pain Physician, 11*(2), 121-132.

Manchikanti, L., Singh, V., Falco, F. J., Cash, K. A., & Pampati, V. (2010). Evaluation of lumbar facet joint nerve blocks in managing chronic low back pain: A randomized, double-blind, controlled trial with a 2-year follow-up. *International*

Journal of Medical Sciences, 7(3), 124-135. doi:10.7150/ijms.7.124

Manfré, L. (2014). CT-guided transfacet pedicle screw fixation in facet joint syndrome: A novel approach. *Interventional Neuroradiology, 20*(5), 614-620. doi:10.15274/inr-2014-10031

Manfré, L., De Vivo, A. E., Al Qatami, H., Ventura, F., Zobel, B., Midiri, M., Chandra, R. V., Carter, N. S., & Hirsch, J. (2020). Percutaneous CT-guided lumbar trans-facet pedicle screw fixation in lumbar microinstability syndrome: Feasibility of a novel approach. *Neuroradiology, 62*(9), 1133-1140. doi:10.1007/s00234-020-02438-4

McCormick, Z. L., Conger, A., Kendall, R., Wagner, G., Henrie, A. M., Littell, M., Sperry, B. P., Petersen, R., Cooper, A. N., Teramoto, M., & Burnham, T. R. (2023). A pragmatic randomized prospective trial of cooled radiofrequency ablation of the medial branch nerves versus facet joint injection of corticosteroid for the treatment of lumbar facet syndrome: 12 month outcomes. *Pain Medicine, 24*(12), 1318-1331. doi:10.1093/pm/pnad107

Meisel, H. J., Seller, K., Th, A. L., Ttner-Janz, K. B., Stosberg, P., Moser, A., Miller, L. E., Block, J. E., & Pimenta, L. (2014). Minimally invasive facet restoration implant for chronic lumbar zygapophysial pain: 1-year outcomes. *Annals of Surgical Innovation and Research, 8*, 7. doi:10.1186/s13022-014-0007-5

Mekhail, N., Eldabe, S., Templeton, E., Costandi, S., & Rosenquist, R. (2023). Pain management interventions for the treatment of chronic low back pain: A systematic review and meta-analysis. *The Clinical Journal of Pain, 39*(7), 349-364. doi:10.1097/ajp.0000000000001116

Mosabbir, A. (2022). Mechanisms behind the development of chronic low back pain and its neurodegenerative features. *Life, 13*(1). doi:10.3390/life13010084

Musso, S., Buscemi, F., Bonossi, L., Silven, M. P., Torregrossa, F., Iacopino, D. G., & Grasso, G. (2022). Lumbar facet joint stabilization for symptomatic spinal degenerative disease: A systematic review of the literature. *Journal of Craniovertebral Junction and Spine, 13*(4), 401-409. doi:10.4103/jcvjs.jcvjs_112_22

Okudan, B., Çelik, D., & Koban, O. (2024). The effectiveness of telerehabilitation-based exercise combined with pain neuroscience education for patients with facet joint arthrosis: A randomized controlled study. *European Journal of Pain, 28*(3), 382-395. doi:10.1002/ejp.2187

Paswan, A. K., & Rath, A. (2023). Critical evaluations of intra-articular platelet rich plasma alone or combination with medial branch radiofrequency neurotomy in patients with lumbar facet joint arthropathy: A prospective outcome study. *Journal of Musculoskeletal Research, 26*(04), 2350006. doi:10.1142/s0218957723500069

Patel, A., Koushik, S., Schwartz, R., Gritsenko, K., Farah, F., Urits, I., Varrassi, G., Viswanath, O., & Shaparin, N. (2022). Platelet-rich plasma in the treatment of facet mediated low back pain: A comprehensive review. *Orthopaedic Reviews, 14*(4), 37076. doi:10.52965/001c.37076

Poetscher, A. W., Gentil, A. F., Lenza, M., & Ferretti, M. (2014). Radiofrequency denervation for facet joint low back pain: A systematic review. *Spine, 39*(14), E842-849. doi:10.1097/brs.0000000000000337

Qaseem, A., Wilt, T. J., McLean, R. M., Forciea, M. A., Denberg, T. D., Barry, M. J., Boyd, C., Chow, R. D., Fitterman, N., Harris, R. P., Humphrey, L. L., & Vijan, S. (2017). Noninvasive treatments for acute, subacute, and chronic low back pain: A clinical practice guideline from the American college of physicians. *Annals of Internal Medicine, 166*(7), 514-530. doi:10.7326/m16-2367

Sae-Jung, S., & Jirarattanaphochai, K. (2016). Outcomes of lumbar facet syndrome treated with oral diclofenac or methylprednisolone facet injection: A randomized trial. *International Orthopaedics, 40*(6), 1091-1098. doi:10.1007/s00264-016-3154-y

Shih, C. L., Shen, P. C., Lu, C. C., Liu, Z. M., Tien, Y. C., Huang, P. J., & Chou, S. H. (2020). A comparison of efficacy among different radiofrequency ablation techniques for the treatment of lumbar facet joint and sacroiliac joint pain: A systematic review and meta-analysis. *Clinical Neurology and Neurosurgery, 195*. doi:10.1016/j.clineuro.2020.105854

Singh, C., Yadav, S., Loha, S., Prakash, S., & Paswan, A. K. (2023). Comparison of intra-articular lumbar facet joint injection of platelet-rich plasma and steroid in the treatment of chronic low back pain: A prospective study. *Journal of Orthopaedics, Trauma and Rehabilitation, 30*(2), 180-187. doi:10.1177/22104917231161836

Song, K., Li, Z., Shuang, F., Yin, X., Cao, Z., Zhao, H., Qin, J., & Li, Z. (2019). Comparison of the effectiveness of radiofrequency neurotomy and endoscopic neurotomy of lumbar medial branch for facetogenic chronic low back pain: A randomized controlled trial. *World Neurosurgery, 126*, e109-e115. doi:10.1016/j.wneu.2019.01.251

Stevens, M. L., Lin, C. C., & Maher, C. G. (2016). The Roland Morris Disability Questionnaire. *Journal of Physiotherapy, 62*(2), 116. doi:10.1016/j.jphys.2015.10.003

Suputtitada, A., Nopsopon, T., Rittiphairoj, T., & Pongpirul, K. (2023). Intra-articular facet joint injection of normal saline for chronic low back pain: A systematic review and meta-analysis. *Medicina, 59*(6). doi:10.3390/medicina59061038

Touboul, E., Salomon-Goëb, S., Boistelle, M., Sobhy Danial, J., Deprez, V., & Goëb, V. (2022). Lumbar zygapophyseal joints injections under ultrasound guidance an alternative to fluoroscopy guidance in the management of low back pain. *Scientific Reports, 12*(1), 3615. doi:10.1038/s41598-022-07695-2

Urits, I., Burshtein, A., Sharma, M., Testa, L., Gold, P. A., Orhurhu, V., Viswanath, O., Jones, M. R., Sidransky, M. A., Spektor, B., & Kaye, A. D. (2019). Low back pain, a comprehensive review: Pathophysiology, diagnosis, and treatment. *Current Pain and Headache Reports, 23*(3), 23. doi:10.1007/s11916-019-0757-1

van Tilburg, C. W., Stronks, D. L., Groeneweg, J. G., & Huygen, F. J. (2016). Randomised sham-controlled double-blind multicentre clinical trial to ascertain the effect of percutaneous radiofrequency treatment for lumbar facet joint pain. *The Bone and Joint Journal, 98-b*(11), 1526-1533. doi:10.1302/0301-620x.98b11.Bjj-2016-0379.R2

Vekaria, R., Bhatt, R., Ellard, D. R., Henschke, N., Underwood, M., & Sandhu, H. (2016). Intra-articular facet joint injections for low back pain: A systematic review. *European Spine Journal, 25*(4), 1266-1281. doi:10.1007/s00586-016-4455-y

Wahyuddin, W., Vongsirinavarat, M., Mekhora, K., Bovonsunthonchai, S., & Adisaipoapun, R. (2020). Immediate effects of muscle energy technique and stabilization exercise in patients with chronic low back pain with suspected facet joint origin: A pilot study. *Hong Kong Physiotherapy Journal, 40*(2), 109-119. doi:10.1142/S1013702520500109

Wardhana, A., Ikawaty, R., & Sudono, H. (2022). Comparison of radiofrequency and corticosteroid injection for treatment of lumbar facet joint pain: A meta-analysis. *Asian Journal of Anesthesiology, 60*(2). doi:10.6859/aja.202206_60(2).0003

Wewers, M. E., & Lowe, N. K. (1990). A critical review of visual analogue scales in the measurement of clinical phenomena. *Research in Nursing and Health, 13*(4), 227-236. doi:10.1002/nur.4770130405

Woiciechowsky, C. (2022). Comparison of endoscopic facet joint denervation to the percutaneous technique regarding efficacy in patients with low back pain: A randomized controlled trial. *Spine, 47*(17), 1187-1193. doi:10.1097/brs.0000000000004392

Wu, J., Zhou, J., Liu, C., Zhang, J., Xiong, W., Lv, Y., Liu, R., Wang, R., Du, Z., Zhang, G., & Liu, Q. (2017). A prospective study comparing platelet-rich plasma and local anesthetic (LA)/corticosteroid in intra-articular injection for the treatment of lumbar facet joint syndrome. *Pain Practice, 17*(7), 914-924. doi:10.1111/papr.12544

Wu, T., Zhao, W. H., Dong, Y., Song, H. X., & Li, J. H. (2016). Effectiveness of ultrasound-guided versus fluoroscopy or computed tomography scanning guidance in lumbar facet joint injections in adults with facet joint syndrome: A meta-analysis of controlled trials. *Archives of Physical Medicine and Rehabilitation, 97*(9), 1558-1563. doi:10.1016/j.apmr.2015.11.013

Xue, Y., Ding, T., Wang, D., Zhao, J., Yang, H., Gu, X., Feng, D., Zhang, Y., Liu, H., Tang, F., Wang, W., Lu, M., & Wu, C. (2020). Endoscopic rhizotomy for chronic lumbar zygapophysial joint pain. *Journal of Orthopaedic Surgery and Reseasrch, 15*(1), 4. doi:10.1186/s13018-019-1533-y

Yasar, D., Korgun, O., & Emine, D. (2018). Radiofrequency and methylprednisolone in treatment of lower back pain caused by facet joint syndrome: Comparison of the outcomes. *Asian Journal of Neurosurgery, 13*(2), 283-287. doi:10.4103/1793-5482.228569

Yildirim, T. (2021). Comparison of the effectiveness of prolotherapy and facet joint injection in the treatment of chronic low back pain: A retrospective study. *Turkiye Klinikleri Journal of Medical Sciences, 41*(1), 1-6. doi:10.5336/medsci.2020-80271

Yoo, Y. M., & Kim, K. H. (2024). Facet joint disorders: from diagnosis to treatment. *Korean Journal of Pain, 37*(1), 3-12. doi:10.3344/kjp.23228

Yun, D. H., Kim, H. S., Yoo, S. D., Kim, D. H., Chon, J. M., Choi, S. H., Hwang, D. G., & Jung, P. K. (2012). Efficacy of ultrasonography-guided injections in patients with facet syndrome of the low lumbar spine. *Annals of Rehabilitation Medicine, 36*(1), 66-71. doi:10.5535/arm.2012.36.1.66

Appendix A – Search Strategies

PubMed

Limiters: Date Range 01/01/2000-01/01/2024, Language English

((low back) OR (lumbar)) AND ((pain) OR (LBP) OR (CLBP)) AND ((facet) OR (facetogenic) OR (zygapophyseal)) AND ((conservative management) OR (physiotherapy))

((low back) OR (lumbar)) AND ((pain) OR (LBP) OR (CLBP)) AND ((facet) OR (facetogenic) OR (zygapophyseal)) AND (injection)

((low back) OR (lumbar)) AND ((pain) OR (LBP) OR (CLBP)) AND ((facet) OR (facetogenic) OR (zygapophyseal)) AND ((radiofrequency ablation) OR (RF ablation) OR (ablation)))

((low back) OR (lumbar)) AND ((pain) OR (LBP) OR (CLBP)) AND ((facet) OR (facetogenic) OR (zygapophyseal)) AND (surgery) AND ((randomised control trial) OR (RCT))

((low back) OR (lumbar)) AND ((pain) OR (LBP) OR (CLBP)) AND ((facet) OR (facetogenic) OR (zygapophyseal)) AND (fusion)

((low back) OR (lumbar)) AND ((pain) OR (LBP) OR (CLBP)) AND ((facet) OR (facetogenic) OR (zygapophyseal)) AND (endoscopic)

((low back) OR (lumbar)) AND ((pain) OR (LBP) OR (CLBP)) AND ((facet) OR (facetogenic) OR (zygapophyseal)) AND ((minimally invasive) OR (MIS))

((low back) OR (lumbar)) AND ((pain) OR (LBP) OR (CLBP)) AND ((facet) OR (facetogenic) OR (zygapophyseal)) AND ((arthroplasty) OR (TFA))

((low back) OR (lumbar)) AND ((pain) OR (LBP) OR (CLBP)) AND ((facet) OR (facetogenic) OR (zygapophyseal)) AND ((stem cell) OR (regenerative) OR (prolotherapy) OR (plasma) OR (platelet))

EMBASE

(low AND back OR lumbar) AND (pain OR lbp OR clbp) AND (facet OR facetogenic OR zygapophyseal) AND (conservative AND management OR physiotherapy) AND [english]/lim AND [2000-2023]/py

(low AND back OR lumbar) AND (pain OR lbp OR clbp) AND (facet OR facetogenic OR zygapophyseal) AND injection AND [english]/lim AND [2000-2023]/py

(low AND back OR lumbar) AND (pain OR lbp OR clbp) AND (facet OR facetogenic OR zygapophyseal) AND (radiofrequency AND ablation OR (rf AND ablation) OR ablation) AND [english]/lim AND [2000-2023]/py

(low AND back OR lumbar) AND (pain OR lbp OR clbp) AND (facet OR facetogenic OR zygapophyseal) AND surgery AND (randomised AND control AND trial OR rct) AND [english]/lim AND [2000-2023]/py

(low AND back OR lumbar) AND (pain OR lbp OR clbp) AND (facet OR facetogenic OR zygapophyseal) AND fusion AND [english]/lim AND [2000-2023]/py

(low AND back OR lumbar) AND (pain OR lbp OR clbp) AND (facet OR facetogenic OR zygapophyseal) AND endoscopic AND [english]/lim AND [2000-2023]/py

(low AND back OR lumbar) AND (pain OR lbp OR clbp) AND (facet OR facetogenic OR zygapophyseal) AND (minimally AND invasive OR mis) AND [english]/lim AND [2000-2023]/py

(low AND back OR lumbar) AND (pain OR lbp OR clbp) AND (facet OR facetogenic OR zygapophyseal) AND (arthroplasty OR tfa) AND [english]/lim AND [2000-2023]/py

(low AND back OR lumbar) AND (pain OR lbp OR clbp) AND (facet OR facetogenic OR zygapophyseal) AND (stem AND cell OR regenerative OR prolotherapy OR platelet OR plasma) AND [english]/lim AND [2000-2023]/py

MEDLINE

Limiters: Date Range 01/01/2000-01/01/2024, Language English

((low back) OR (lumbar)) AND ((pain) OR (LBP) OR (CLBP)) AND ((facet) OR (facetogenic) OR (zygapophyseal)) AND ((conservative management) OR (physiotherapy))

((low back) OR (lumbar)) AND ((pain) OR (LBP) OR (CLBP)) AND ((facet) OR (facetogenic) OR (zygapophyseal)) AND (injection)

((low back) OR (lumbar)) AND ((pain) OR (LBP) OR (CLBP)) AND ((facet) OR (facetogenic) OR (zygapophyseal)) AND ((radiofrequency ablation) OR (RF ablation) OR (ablation)))

((low back) OR (lumbar)) AND ((pain) OR (LBP) OR (CLBP)) AND ((facet) OR (facetogenic) OR (zygapophyseal)) AND (surgery) AND ((randomised control trial) OR (RCT))

((low back) OR (lumbar)) AND ((pain) OR (LBP) OR (CLBP)) AND ((facet) OR (facetogenic) OR (zygapophyseal)) AND (fusion)

((low back) OR (lumbar)) AND ((pain) OR (LBP) OR (CLBP)) AND ((facet) OR (facetogenic) OR (zygapophyseal)) AND (endoscopic)

((low back) OR (lumbar)) AND ((pain) OR (LBP) OR (CLBP)) AND ((facet) OR (facetogenic) OR (zygapophyseal)) AND ((minimally invasive) OR (MIS))

((low back) OR (lumbar)) AND ((pain) OR (LBP) OR (CLBP)) AND ((facet) OR (facetogenic) OR (zygapophyseal)) AND ((arthroplasty) OR (TFA))

((low back) OR (lumbar)) AND ((pain) OR (LBP) OR (CLBP)) AND ((facet) OR (facetogenic) OR (zygapophyseal)) AND ((stem cell) OR (regenerative) OR (prolotherapy) OR (platelet) OR (plasma))

Search Result Refinement

Conservative Management – 921 articles identified from search strategies, 19 articles post-title review and removal of duplicates, 3 key articles identified (post-abstract review)

Injection Techniques – 1883 articles identified from search strategies, 139 articles post-title review and removal of duplicates, 22 key articles identified (post-abstract review)

Radiofrequency Ablation – 801 articles identified from search strategies, 76 articles post-title review and removal of duplicates, 11 key articles identified (post-abstract review)

Surgical Techniques (combining all techniques) – 3702 articles identified from search strategies, 65 articles post-title review and removal of duplicates, 12 key articles identified (post-abstract review)

Regenerative Techniques – 921 articles identified from search strategies, 19 articles post-title review and removal of duplicates, 3 key articles identified (post-abstract review)

Appendix B

Table 1.

Summary of randomised controlled trials (RCTs) for management of chronic lumbar facet joint-related pain

Author(s)	Year	Management Type	Treatment	Comparison/Control	Specific Interventional Protocols	Diagnostic Selection	Follow-Up Period	Outcome Measures	Conclusion
Cetin et al.	2019	Conservative Management	Lumbar Stabilisation Exercises (LSE) Program (n=20)	Control (Biomechanics information) (n=19)		Unclear	6 weeks	VAS, ODI, Physical performance measures	LSE significantly better across all measures
Wahyuddin et al.	2020	Conservative Management	Muscle Energy Technique (MET) (n=11)	Lumbar Stabilisation Exercises (LSE) (n=10)		Clinical	2 days	VAS, ODI, Range of motion	No significant difference across groups at 2 days
Anshul et al.	2023	Facet Joint Injections	IA Injection (Corticosteroid) (n=34)	MBB Injection (Corticosteroid) (n=34)	Triamcinolone and Bupivacaine	Clinical, Radiological	6 months	RMQ, ODI, 4-Point pain scale	No significant difference across groups at 6 months
Cohen et al.	2018	Facet Joint Injections	IA Injection (Corticosteroid) (n=91)	MBB Injection (Corticosteroid) (n=91), Placebo (Saline) (n=47)	Depomethylprednisolone and Bupivacaine	Clinical	6 months	10-Point Pain Scale, ODI, Progression to RFA	Significant difference compared to placebo, no difference between groups in outcomes or progression to RFA
		RFA	RFA post-failed IA Injection (n=45)	RFA post-failed Medial Branch Block (n=48), RFA Control (Saline Injection) (n=42)	Conventional RFA (90C for 135s)	Diagnostic Block (unspecified)	6 months	10-Point Pain Scale	No significant differences across groups
Kennedy et al.	2018	Facet Joint Injections	IA Injection (n=12)	Placebo (Saline) (n=12)	Triamcinolone	Dual Diagnostic MBB (Bupivacaine, Lidocaine)	6 weeks	10-Point Pain Rating Scale, ODI	N/A - Did not reach primary endpoint
Manchikanti et al.	2001	Facet Joint Injections	IA Injection (Corticosteroid, Sarapin, Anaesthetic) (n=41)	IA Injection (Sarapin, Anaesthetic) (n=32)	Methylprednisolone	Dual Diagnostic Block (unspecified) (Lidocaine, Bupivacaine)	30 months	10-Point Pain Scale, Physical and Mental Health Assessment	No significant difference across groups
Manchikanti et al.	2010[A]	Facet Joint Injections	IA Injection (Corticosteroid, Sarapin, Anaesthetic) (n=60)	IA Injection (Sarapin, Anaesthetic) (n=60)	Betamethasone, Bupivacaine	Dual Diagnostic MBB (Lidocaine, Bupivacaine)	24 months	NRS, ODI, Employment, Opioid Intake	No significant difference across groups
Galiano et al.	2007	Facet Joint Injections	US-Guided IA Injection (Corticosteroid) (n=20)	CT-Guided IA Injection (Corticosteroid) (n=20)	Betamethasone, Bupivacaine, Lidocaine	Clinical	6 weeks	Duration, Radiation Dose, VAS	Equivalent outcomes, reduced time and radiation dose in US group
Yun et al.	2012	Facet Joint Injections	US-Guided IA Injection (Corticosteroid) (n=25)	Fluoroscopy-Guided IA Injection (Corticosteroid) (n=32)	Triamcinolone, Lidocaine	Clinical	3 months	VAS, PhyGA, PaGA, modified ODI, Duration	Equivalent outcomes, procedure time reduced in fluoroscopy group
Kawu et al.	2011	Facet Joint Injections	IA Injection (Corticosteroid) (n=10)	McKenzie Regimen Physiotherapy (n=8)	Methylprednisolone, Bupivacaine	Clinical, Radiological	6 months	ODI, VAS, Patient Satisfaction Score	IA Injection significant improvement compared to Physiotherapy alone
Sae-Jung & Jirarattanap-hochai	2016	Facet Joint Injections	IA Injection (Corticosteroid) and Oral Diclofenac (n=34)	IA Injection (Corticosteroid) alone (n=32), Oral Diclofenac alone (n=33)	Methylprednisolone, Bupivacaine	Clinical	12 weeks	ODI, VAS	Combination group significantly better than either alone, IA injection alone significantly better than Oral Diclofenac alone
Civelek et al.	2012	Facet Joint Injections, RFA	RFA (N=50)	MBB Injection (n=50)	Conventional RFA (80C for 120s), Methylprednisolone, Bupivacaine	Clinical, Radiological	12 months	VNS, NASS Patient Satisfaction Score, EQ-5D	RFA significant improvement compared to MBB Injection
Do et al.	2017	Facet Joint Injections, RFA	RFA Intra-Articular (n=30)	IA Injection (n=30)	Pulsed RFA (5ms pulse, <42C over 360s), Dexamethasone, Bupivacaine	Diagnostic IA Block	6 months	NRS	No significant difference across groups

Author(s)	Year	Management Type	Treatment	Comparison/Control	Specific Interventional Protocols	Diagnostic Selection	Follow-Up Period	Outcome Measures	Conclusion
Duger et al.	2012	Facet Joint Injections, RFA	RFA and IA Injection (Corticosteroid) (n=40)	RFA (n=40), IA Injection (Corticosteroid) (n=40)	Pulsed RFA (40C for 360s), Methylprednisolone, Bupivacaine	Clinical	12 months	VAS	Combination group and Radiofrequency group significant improvement compared to IA injection, no long-term difference between combined and RFA
Kanth et al.	2021	Facet Joint Injections, RFA	RFA (n=30)	IA Injection (Corticosteroid) and RFA Sham (n=30)	Conventional RFA (80C for 90s), Betamethasone, Bupivacaine	Diagnostic IA Block	6 months	VAS, DN4, RMQ, NHP	Significantly improved VAS, RMQ and DN4 in RFA group compared to IA injection
Lakemeier et al.	2013	Facet Joint Injections, RFA	RFA (n=26)	IA Injection (Corticosteroid) and RFA Sham (n=28)	Conventional RFA (80C for 90s), Betamethasone, Bupivacaine	Diagnostic IA Block	6 months	RMQ, VAS, ODI	No significant difference across groups at 6 months
Yasar et al.	2018	Facet Joint Injections, RFA	RFA (n=50)	IA Injection (Corticosteroid) (n=50)	Pulsed RFA (42C for 120s), Methylprednisolone, Bupivacaine	Diagnostic Block (unspecified)	12 months	VAS, ODI	No significant difference across groups at 12 months, RFA significantly better VAS compared to IA Injection up to 6 months
McCormick et al.	2023	Facet Joint Injections, RFA	RFA (n=20)	IA Injection (Corticosteroid) (n=12)	Cooled RFA (60C for 165s), Triamcinolone, Lidocaine	Dual Diagnostic MBB (Bupivacaine, Lidocaine)	12 months	NPS, QDI, Global Impression of Change	No significant difference across groups at 12 months, RFA significant improvement compared to IA Injection up to 6 months
Leclaire et al.	2001	RFA	RFA (n=36)	Placebo (Sham) (n=34)	Conventional RFA (80C for 90s)	Diagnostic IA Block	12 weeks	ODI, RMQ, VAS	No significant difference across groups at 12 weeks, RMQ significantly improved in RFA group at 4 weeks
Van Tilburg et al.	2016	RFA	RFA (n=30)	Placebo (Sham) (n=30)	Conventional RFA (80C for 60s)	Diagnostic MBB	3 months	NRS-11, GPE	No significant difference across groups at 3 months, RFA significant improvement in NRS-11 compared to Placebo at 1 month
Hashim et al.	2020	RFA	Monopolar RFA (n=25)	Bipolar RFA (n=25)	Conventional RFA (80C for 90s)	Diagnostic Block (unspecified)	6 months	VAS, Patient Satisfaction Score	No significant difference across groups
Lu et al.	2012	RFA	Pulsed RFA (n=18)	Conventional RFA (n=16)	Conventional RFA (80C for 90s), Pulsed RFA (2 cycles of 20ms, <42C over 180s)	Dual Diagnostic MBB	6 months	VAS, revised ODI	VAS significantly better in conventional RFA group, no significant difference between groups for functional improvement
Li et al.	2014	Surgery	Endoscopic Rhizotomy (n=45)	Conservative Management (n=13)		Dual Diagnostic MBB (Lidocaine, Bupivacaine)	12 months	VAS, MacNab Score	Operative intervention significantly better than Conservative management at 12 months
Song et al.	2019	Surgery, RFA	Endoscopic Rhizotomy (n=20)	RFA (n=20)	Conventional RFA (80C for 90s)	Dual Diagnostic MBB (Lidocaine, Bupivacaine)	24 months	VAS, ODI	Operative intervention significantly better than RFA group at 24 months
Wojciechow-sky	2022	Surgery, RFA	Endoscopic Rhizotomy (n=20)	RFA (n=20)	Conventional RFA (80C for 90s)	Diagnostic MBB	12 months	VAS, ODI, RMQ, SF-36	Operative intervention significantly better than RFA group at 12 months
Xue	2020	Surgery, RFA	Endoscopic Rhizotomy (n=30)	RFA (n=30)	Conventional RFA (80C for 60s then 90C for 80s)	Dual Diagnostic MBB (Lidocaine, Bupivacaine)	12 months	VAS, MacNab Score	Operative intervention significantly better than RFA group at 12 months
Kotb et al.	2022	Regenerative Therapy, Facet Joint injection	IA PRP Injection (n=15)	IA Injection (Corticosteroid) (n=15)	Autologous PRP, Betamethasone, Lidocaine	Clinical, Radiological	3 months	VAS, ODI, MRI Synovitis Grading	No significant difference across groups at 3 months, PRP group had significant improvement in Synovitis Grading
Wu et al.	2017	Regenerative Therapy, Facet Joint injection	IA PRP Injection (n=21)	IA Injection (Corticosteroid) (n=20)	Autologous PRP, Betamethasone, Lidocaine	Diagnostic MBB (Lidocaine)	6 months	VAS, RMQ, ODI, MacNab Score, Patient Satisfaction Score	No significant difference across groups for VAS, RMQ, ODI at 6 months, significantly improved subjective satisfaction in PRP group
Singh et al.	2023	Regenerative Therapy, Facet Joint injection	IA PRP Injection and RFA (n=15)	IA Injection (Corticosteroid) and RFA (n=15), Placebo (Saline Injection) and RFA (n=19)	Autologous PRP, Triamcinolone, Bupivacaine, Conventional RFA (80C for 90s)	Diagnostic MBB (Lidocaine)	6 months	VAS, ODI, Patient Satisfaction Score, Analgesia Use	PRP group significantly better VAS, ODI and Analgesic use at 6 months compared to Corticosteroid and Placebo groups, no significant difference between Corticosteroid and Placebo groups
Paswan & Rath	2023	Regenerative Therapy, RFA	IA PRP Injection and RFA (n=27)	IA PRP Injection (n=25), RFA (n=26)	Autologous PRP, Conventional RFA (80C for 90s)	Dual Diagnostic MBB (Lidocaine)	4 months	VAS, ODI, Patient Satisfaction Score, Analgesia Use	Combined group significantly better than RFA group and PRP group at 4 months for VAS and ODI, comparable patient satisfaction in Combined and RFA groups

[A] Study includes preliminary data found in Manchikanti et al. (2008)

Abbreviations: DN4 = Douleur Neuropathique en 4 Questionnaire, EQ-5D = Euro-Qol in 5 Dimensions, GPE = Global Perceived Effect Scale, IA = Intra-Articular, MBB = Medial Branch Block, NASS = North American Spine Society, NHP = Nottingham Health Profile, NPS = Numeric Pain Rating Scale, ODI = the Oswestry Disability Index, PaGA = Patient's Global Assessment, PBQ = Pain Belief Questionnaire, PhyGA = Physicians Global Assessment, PRP = Platelet-Rich Plasma, RFA = Radiofrequency Ablation, RMQ = Roland-Morris Questionnaire, SF-36 = Short Form Health Survey, US = Ultrasound, VAS = Visual Analogue Scale, VNS = Visual Numeric Pain Scale