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Invasive Non-arthroplasty Treatment Options for Knee Osteoarthritis: Review

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Abstract

Background: Knee osteoarthritis (KOA) is one of the most common joint diseases in the world, such that there exists a variety of treatment methods, ranging from conservative treatments such as physical therapy and weight loss to total replacement of the diseased joint. Invasive non-arthroplasty treatment methods are growing in popularity and this review aims to explore the current literature. Better understanding of these alternatives could allow orthopedic surgeons and primary care providers to offer poor arthroplasty candidates meaningful symptomatic relief.

Material and Methods: A literature review using PubMed, Google Scholar, and SCOPUS was performed to examine the following invasive non-arthroplasty treatment options: Corticosteroid injections (CS), viscosupplementation, platelet-rich plasma injections, stem cell injections, ozone therapy, prolotherapy, radiofrequency nerve ablation (RFA), arthroscopy, and osteotomy. Articles with complete data on the outcomes following these treatment methods were included in the study.

Results: CSs showed strong efficacy in providing short-term pain relief, while viscosupplementation and platelet-rich plasma have shown to be effective in long-term management as well. Aside from the more common injectable treatment options, newer options such as stem cell injection and ozone therapy have shown clinical efficacy while prolotherapy and RFA are still early-stage treatment options. Still, further studies are required to better assess these emerging therapies. Operatively, arthroscopic surgery has shown to be minimally effective while osteotomy demonstrated effective pain and functional improvement.

Conclusion: Multiple therapeutic options exist for invasive management of KOA to a different degree of effectiveness and efficacy. We have analyzed the outcomes of multiple invasive non-arthroplasty treatment options for KOA. This review can better inform patients and surgeons of the pros and cons of different KOA treatment methods. Newer conservative options may have positive clinical implications but will require further investigation. Operative alternatives to arthroplasty can provide symptomatic relief but may increase the associated risk and complexity should the need for arthroplasty ever arises.

Keywords: Total knee arthroplasty, injections, radiofrequency nerve ablation, arthroscopy, osteotomy.

Introduction

Osteoarthritis of the knee is one of the most common joint diseases worldwide. The prevalence of knee osteoarthritis (KOA) is expected to increase in the future with greater life expectancies and obesity rates [1]. While advances in patient selection, pain management, surgical technique, and implant design have helped orthopedic surgeons improve arthroplasty outcomes, a significant percentage of patients remain dissatisfied. Activity modification, weight optimization, and physical therapy are first-line conservative treatments. However, an extensive and growing class of invasive, non-arthroplasty treatments exists for KOA, including injections, radiofrequency nerve ablation (RFA), arthroscopy, and osteotomy [2]. This review examines each of these invasive non-arthroplasty treatment options in detail, along with the relevant outcomes. A better understanding of these treatments could allow orthopedic surgeons and primary care providers to offer meaningful relief of symptoms to patients that are poor candidates for arthroplasty due to age, comorbidities, or body mass index (BMI). Thoughtful consideration and application of these treatments may allow

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some patients to delay arthroplasty and ultimately achieve satisfactory outcomes.

Methods

A literature review using PubMed, Google Scholar, and SCOPUS was performed to examine the following invasive non-arthroplasty treatment options: Corticosteroid injections (CS), viscosupplementation, platelet-rich plasma (PRP) injections, stem cell injections, ozone therapy, prolotherapy, RFA, arthroscopy, and osteotomy. Articles with complete data on the outcomes following these treatment methods were included in the study.

Corticosteroid

Intra-articular corticosteroid (IA CS) injections have been widely used for treating KOA for many years. Various corticosteroids are used for intra-articular injections, such as betamethasone, methylprednisolone, and triamcinolone. The evidence is inconclusive regarding which particular corticosteroid is the most effective [3]. Corticosteroids are thought to be effective for KOA due to their anti-inflammatory properties. Specifically, they reduce the production of inflammatory cytokines, reducing inflammation at the knee joint [4].

From the AAOS 2021 clinical practice guideline, IA CS injections have been downgraded, and there is conflicting evidence about this treatment method for KOA [5]. A clinical study was performed in 2017 that examined WOMAC and VNS scores of patients at baseline, 3 weeks, 6 weeks, 3 months, and 6 months, post IA CS injection for KOA. The study found that patient WOMAC scores improved at a statistically significant level at 3 weeks, 6 weeks, 3 months, and 6 months, as did VNS scores except for at 6 months. Thus, IA CS injections seem to be a viable short-term treatment option for KOA.

Still, various factors such as BMI and the severity of osteoarthritis can influence the efficacy of this treatment method [6]. Najm et al. conducted a systematic review and meta-analysis. They looked at the effectiveness of IA CS injections compared to controls which included intra-articular hyaluronic acid (HA) injections, saline solution/placebo, and intra-articular NSAIDs. The authors found better pain scores in the IA CS group in the short term. However, when comparing the IA GC injections with the controls in the long term (24 weeks), the control injections reduced pain scores to a greater extent than IA GC [7]. While studies have shown that IA CS injections can be effective in the short term, there are still risks associated with the treatment method. According to Wernecke et al., cartilage damage was heavily dependent on the dose of corticosteroids administered, with higher doses corresponding to more significant cartilage damage [8]. In addition, McAlindon analyzed cartilage loss after administering triamcinolone injections every 3 months and found that cartilage thickness decreased by 0.11 mm in patients who had been given triamcinolone injections compared to control saline injections [9]. Overall, IA CS injections appear to be an effective short-term pain relief option for KOA that should not be used repeatedly during short periods of time to avoid cartilage damage.

Viscosupplementation

Viscosupplementation is the injection of intra-articular HA into the knee joint. HA is a glucosamine found in synovial fluid [10]. KOA is often characterized by low levels of HA, which can result in cartilage degeneration since the cartilage is no longer protected by synovial fluid of optimal viscosity [11]. Viscosupplementation is a common treatment method for KOA that is believed to reduce pain by improving the quality of synovial fluid so that it can protect the knee joint. However, the role of HA in disease progression remains inconclusive [12]. Routine use of viscosupplementation is not recommended by the 2021 AAOS clinical practice guideline [5]. He et al. compared the effectiveness of HA injections and CS. They found that IA CS injections were more effective in reducing visual analog score (VAS) than IA HA injections in the short term, with the difference being statistically significant. However, after 6 months, HA was more effective at reducing pain than IA CS, indicating that it was better in the long term [13]. Another study compared the efficacy of HA injections to combined HA and CS injections and found that the combined injection was more effective at reducing WOMAC pain scores than HA injections alone at 2–4, 24–26, and 52 weeks. However, only a small number of trials were examined at 24–26 and 52 weeks [14]. Concoff et al. conducted a systematic review to analyze the effects of repeated IA-HA injections. The efficacy of IA HA injections was compared to the effectiveness of IA saline injections at 3 and 6 months and at different doses (1, 2–4, and 5 injections). At 6 months, the greatest difference in pain was observed when comparing 2–4 IA HA injections to a saline injection. At 6 months, the greatest effect size was once again observed in studies comparing 2–4 IA HA injections to an IA saline injection, although studies with 5 IA HA injections also resulted in a considerable effect size estimate [15]. Thus, while it was the case that repeated IA CS injections resulted in poor outcomes, repeated IA HA injections appear to be more effective than single injections in terms of pain relief.

Tan et al. compared the effectiveness of PRP injections to IA HA injections using WOMAC and VAS scores. In terms of WOMAC total score, pain score and stiffness score, and VAS, those who received PRP had more favorable scores than those treated with IA HA at 3, 6, and 12 months. There was a statistically significant difference in these scores

between the two groups at 3, 6, and 12 months, but not at 1 month. In addition, there was no difference in adverse events between the two groups, indicating that PRP may be a better treatment option than IA HA [16]. A 2019 study aimed to determine if IA HA or IA CS injections before TKA increases the risk of periprosthetic joint infection (PJI). The study found that the risk of PJI was much higher when patients received either an IA HA injection or an IA CS injection 3 months before their TKA. However, when these injections were given >3 months before TKA, there was no significant increase in the risk of PJI. In addition, regarding the risk of PJI based on injection type, there was no significant difference between IA HA and IA CS injections [17]. Overall, viscosupplementation poses minimal risk for adverse events and may uncommonly result in inflammation at the site of injection, infection, and other mild symptoms such as dizziness or numbness [18].

PRP

PRP is a high concentration of one's platelets suspended in plasma. Due to the ability of PRP to release growth factors and its anti-inflammatory and regenerative effects that have been studied, it has become a topic of interest in osteoarthritis. While the exact mechanism of action isn't clear, studies have reported that PRP may restore the production of HA within the joint and reduce cartilage catabolism [19,20]. Although seemingly increasing in popularity, the efficacy of PRP for KOA compared to other treatment methods remains unclear [21, 22, 23]. According to the 2021 AAOS clinical practice guideline, PRP may be effective with pain relief and better function in cases of symptomatic KOA, but its recommendation is still limited [5]. Shen et al. conducted a systematic review of 14 randomized controlled trials in which IA PRP injections were compared to control injections which consisted of saline, HA, ozone, and CS. IA PRP injections were more effective than the control injections at 3, 6, and 12 months with regard to WOMAC scores. Furthermore, PRP injections led to considerable reductions in WOMAC physical function subscores at 3, 6, and 12 months compared to the control. These results were further corroborated with total WOMAC scores as well. There was no increased risk of adverse events for those given PRP injections compared to control injections. Overall, IA PRP injections may be more effective at treating KOA compared to the other control injections [24].

McLarnon and Heron examined the efficacy of IA PRP injections and compared them to the standard IA CS injections for treating KOA. When comparing the two treatment types, it was found that IA PRP injections were much more effective than IA CS injections at relieving symptoms of KOA, including pain and stiffness at 3, 6, and 9 months follow-up. The Knee Injury and Osteoarthritis Outcome Score (KOOS) sports/activities subscale was also examined, and PRP was favored over CS injections at 3 and 6 months. This study also found that triple PRP injections are more effective at reducing pain than single PRP injections. PRP appears to be more effective than CS injections, especially 6–9 months after injection when it was found to be the most effective. However, it is important to remember that these results are seen best in patients with mild-to-moderate KOA [25]. Several studies have examined the efficacy of injections consisting of combined PRP with HA compared to just PRP injections and HA injections alone. The combination of PRP with HA was the most effective at improving pain and function as indicated by improvements in WOMAC and VAS scores at 3, 6, and 12 months [26, 27, 28]. Overall, PRP injections appear to be a promising treatment method for KOA with minimal risks. However, it is important to note that PRP injections are typically not covered by insurance, and the cost of one knee PRP injection administered on the same day is about $714±$144 [29].

Stem cell

Stem cell injections are an emerging therapy for KOA aimed at reducing the progression of KOA and the pain associated with it [30]. Stem cell injections often utilize mesenchymal stem cells (MSCs) which are stem cells from the mesodermal region that have anti-inflammatory effects and differentiation abilities [31,32,33]. In particular, MSCs secrete cytokines, growth factors, and extracellular vesicles that can help in tissue regeneration and promote anti-inflammatory effects [34]. They are able to regenerate tissue, particularly degenerated cartilage, due to their ability to differentiate into chondrocytes. Stem cells used for these injections are often obtained from the same individual's the bone marrow or adipose cells to reduce the risk of rejection from one's own body [30].

Various studies have been conducted on stem cell injections in recent years. Lee et al. performed a double-blinded clinical trial to examine the efficacy of one intra-articular injection of adipose-derived MSCs for patients experiencing KOA at time intervals as long as 6 months. Subjects who received a single stem cell injection improved their WOMAC scores compared to those in the control group at 6 months. In fact, the WOMAC score decreased by a mean of 55% in the stem cell group compared to the control group at 6 months. Moreover, the VAS for knee pain and range of motion improved in the MSC group, while there was no improvement in the control group at 6 months [35].

MRI follow-up studies of stem cells have been performed for chondral injuries in the knee. While the size of the cartilage defect in the PRP group did not decrease

at 6 months, it was found to have increased in the control group, suggesting that the MSC injection may help prevent further chondral injury and degeneration. No major adverse events were found in the MSC group. Limits of this study include abbreviated follow-up and limited sample size [35].

A 2020 review article had similar findings, corroborating that MSCs helped improve pain scores. Specifically, an MSC injection decreased VAS scores at 12 months, decreased WOMAC scores at 6 months, and resulted in no difference in adverse events compared with the control group [36]. Moreover, injection of MSCs along with HA mixed resulted in improved WOMAC and VAS scores compared to those who only received a HA injection [37]. In addition, when comparing CS injections with MSC's and MSCs mixed with PRP, MSCs alone or MSCs combined with PRP resulted in an improved KOOS compared to the CS injection group, which led to a worsening of KOOS score [34]. More long-term studies about stem cell injections need to be conducted to better understand the effects of this treatment method over time. Furthermore, more uniform studies about stem cell therapy need to be conducted since there are various aspects to these studies that are not standardized, including things like the concentration of stem cells used or the source of stem cells, among others. While MSC injections may be a more widespread treatment method in the future, the price of an MSC injection is quite variable with an average price of $2727±$1584 and range of $300–$1200 [38].

Ozone

Ozone therapy is a new treatment method that has not yet been extensively studied compared to traditional injectable treatments such as HA or PRP injections. Ozone therapy consists of ozone gas, a triatomic oxygen gas (O3), and its mechanism of action is still unclear. Still, ozone is thought to have anti-inflammatory, analgesic, and antioxidant effects. It is believed that O3 induces oxidative stress, which then stimulates the antioxidant system and helps protect against tissue damage. Ozone therapy injections allow for a combination of O3 and O2 to be dissolved in the synovial fluid. It produces reactive oxygen species, which then promote the growth of chondrocytes and fibroblasts, reduce the secretion of inflammatory cytokines, and increase the production of antioxidant enzymes. All these processes help work against inflammation that arises from KOA [39]. Ozone is also associated with a very low risk of infection because ozone can prevent bacteria, fungi, and viruses from growing [40].

Lopes De Jesus et al. investigated the effects of intra-articular ozone compared to placebo for the treatment of KOA in a randomized double-blind study. In this study, there was an IA ozone group as well as a placebo group that was given treatment for 8 weeks. The ozone treatment was more effective than the placebo after 8 weeks, as indicated by improvements in VAS and WOMAC scores. There were no major adverse events. However, the effects of ozone injections were only seen over a short period of time, and the efficacy of the injection in the long term cannot be determined [41]. Raeissadat et al. examined the effectiveness of intra-articular HA, PRP, plasma rich in growth factor (PRGF), and ozone injections throughout 2, 6, and 12 months using VAS, WOMAC, and the Lequesne index. At 2 months, the group that received ozone injections demonstrated the most improvement, whereas at 6 months, HA, PRP, and PRGF led to better results. At the 12-month follow-up, the efficacy of ozone treatment waned, and only PRP and PRGF led to improved results. Thus, IA-ozone injections appear to be effective in the short term and much less effective in the long term [42]. Duymus et al. similarly found that 1 month after ozone injection, there were improvements in WOMAC and VAS scores. Still, at 3, 6, and 12 months, the efficacy of IA-ozone injections consistently declined and disappeared at 6 months [43]. Furthermore, in a 2016 randomized controlled trial, patients who received an injection with a both HA and ozone(O2O3) combined demonstrated significantly improved outcomes after 2 months compared to those who just received HA or ozone injections [44]. IA-ozone injections appear to be effective at reducing pain associated with KOA in the short term. Still, more long-term studies are required to measure its effectiveness after prolonged periods of time.

Prolotherapy

Prolotherapy is the injection of an irritant solution, usually, hypertonic dextrose solution, into the ligaments and surrounding joint spaces. While the mechanism of how prolotherapy works is not completely clear, it is believed that when injected near the damaged joint, the hypertonic irritant solution stimulates an inflammatory response by recruiting growth factors and cytokines to the areas. This then promotes the healing of tissue in the area. Prolotherapy is not a common method for treating KOA due to the lack of scientific evidence behind it [45].

In recent evidence, Sert et al. studied the efficacy of dextrose prolotherapy in patients with KOA through a randomized control study. Patients were either treated with dextrose prolotherapy and a saline injection or were left untreated (control) at 0, 3, and 6 weeks. WOMAC, VAS, and health-related quality of life (HRQoL) scores were recorded at 0, 6, and 18-week follow-ups. There was a significant decrease in WOMAC and VAS scores in the group treated with dextrose prolotherapy compared to the saline injection group and the control group at 18 weeks. In

addition, the WOMAC stiffness score, WOMAC physical functioning score, and the physical component score of the HRQoL all improved in the prolotherapy group compared to the control group at 18 weeks [45]. Another randomized controlled trial compared the efficacy of hypertonic dextrose prolotherapy (HDP) with normal saline using WOMAC, VAS, and EuroQol-5D score. WOMAC, VAS, and EuroQol-5D scores all improved among the patients who were administered HDP compared to those given the saline injection at 52 weeks. No adverse events were reported [46]. Rabago et al. studied the long-term effects of HDP in a randomized controlled trial. They found that patients who received prolotherapy improved WOMAC scores at 12 weeks follow-up until 2.5 years follow-up [47]. Thus, prolotherapy improved knee pain, function, and stiffness scores, in the short term and the long term (2.5 years), highlighting its potential as a treatment method for KOA. When comparing HDP to other treatment options such as local anesthetics, HA, ozone, PRP, and radiofrequency, HDP was just as effective as all treatment methods, except for PRP in the short, medium, and long term [48]. Recent studies have shown that HDP may be a more promising treatment option for KOA than it was thought to be in the past.

RFA

RFA is a non-surgical treatment option for KOA that targets the genicular nerves. RFA involves using a probe and transmitting radiofrequency energy through high-frequency ionic vibrations to target tissue. The friction associated with the ionic vibrations leads to the heating and degradation of the target nerve. Thus, RFA helps reduce pain by degrading the target nerve so that the delivery of pain signals is cut off [49]. On the other hand, cooled RFA (CRFA) is a type of RFA that uses a cooled probe, where cooled water is disseminated around the tip of the probe. CRFA is thought to allow larger lesion size and more energy to be transmitted to the target nerve [50]. According to the 2021 AAOS clinical practice guideline, RFA may be effective with pain relief and better function in cases of symptomatic KOA, but its recommendation is still limited and downgraded due to conflicting evidence and bias [5].

A retrospective study conducted by Iannaccone et al. examined the efficacy of genicular RFA in KOA by asking patients to rate their level of pain relief. The average pain relief reported by patients was 67% at the 3 month follow-up, while at 6 months, 95% of the individuals who had reported pain relief at 3 months once again reported sustained pain relief from the procedure. While this study demonstrates that genicular RFA may be a useful treatment option in the short and long term, the sample size was small and the study design can give way to bias [50]. Kocayigit and Beyaz conducted a systematic review to compare the efficacy of cooled versus conventional radiofrequency ablation for treating KOA. They found that WOMAC and VAS score decreased significantly in both the cooled and conventional RFA groups compared to their respective pre-operative scores. However, no major difference in pain reduction was found between the two groups, suggesting that neither method of RFA is superior to the other. The risks associated with both types of RFA were minimal [51]. Moreover, Stake et al., examined prolonged post-operative opioid usage, 90 day complications, and 2-year revision rates, in patients who underwent RFA before primary TKA compared to patients who did not undergo RFA. They found that there was no significant difference in the risk of complications between the two groups, although the RFA group had a lower rate of prolonged post-operative opioid use compared to patients who did not undergo RFA [52]. Similarly, Mishra et al., found that pre-operative genicular nerve RFA did not significantly reduce pain or improve function compared to those who did not receive genicular nerve RFA before TKA [53]. On the other hand, Qudsi-Sinclair et al., performed a randomized clinical trial comparing the efficacy of genicular nerve RFA and corticosteroid block of the genicular nerves among patients with knee pain despite having undergone TKA. They found that post-operative administration of both types of nerve blocks was effective at reducing pain and improving function [54]. Protzman et al., corroborated in their case report that post-operative genicular nerve RFA was able to minimize pain and improve the patient's function [55].

Looking specifically at CRFA, Hunter et al. found that CRFA was able to provide pain reduction at 18 months follow-up and even 24 months follow-up [56]. Chen et al. compared the efficacy of CRFA with a single HA injection at reducing knee pain by analyzing NRS and WOMAC scores at 6 months post-treatment. The average WOMAC score improvement was 48.2% in the CRFA group, while only 22.6% in the HA group. Similarly, the NRS score improvement was also greater for the CRFA group than the HA group, indicating that CRFA may be a superior treatment option to HA injections [57]. Finally, comparing genicular RFA to PRP, Elawamy et al. found that VAS scores were reduced in the group of patients that received RFA compared to the group that received PRP at 6 and 12 months post-treatment [58]. RFA appears to be an efficacious treatment option for reducing pain associated with KOA.

Arthroscopy

While arthroscopy is used to treat many orthopedic injuries and diagnoses, its use in KOA remains controversial. The goal of arthroscopy in KOA is to provide symptom relief through meniscal debridement and chondroplasty as well as removing any loose bodies [59]. The

effectiveness of arthroscopy is highly debated with some arguing that it may only be a viable treatment option for those with mild to moderate KOA [60]. According to 2021 edition of the American Academy of Orthopedic Surgeons Management of Osteoarthritis of the Knee (Non-Arthroplasty), evidence-based clinical practice guideline, patients with a primary diagnosis of KOA are not advised to undergo arthroscopy with lavage and debridement [61].

Arthroscopy may be most effective in patients who have more recently developed pain or symptoms. Those with symptoms lasting over 2 years have a statistically increased likelihood of poor outcomes following arthroscopy [62]. Furthermore, those with more localized pain rather than general diffused pain are more likely to experience positive outcomes following arthroscopy. However, despite some patients being better suited for knee arthroscopy, nearly 15% of patients who undergo arthroscopy of the knee will subsequently undergo arthroplasty about a year after, according to Dearing and Nutton . In addition, 4 years after having an arthroscopy for KOA, nearly 70% of patients see no improvement or have worsened symptoms [63]. From Spahn et al., when patients have four or more of the following characteristics, they are more likely to experience poor outcomes following arthroscopy: KOA lasting longer than 2 years, smoking, obesity, medial tibial osteophytes, medial joint space width on standing radiographs of <5 mm, absence of effusion, absence of synovitis, presence of crystal deposits, deep tibial cartilage defect, and need for subtotal or total meniscectomy [64]. In a systematic review conducted by Brignardello-Petersen et al., patients either underwent arthroscopic surgery for KOA or were subject to conservative management which included exercise therapy or injection, and their pain scores were compared in the short and long term. Patients with an arthroscopy experienced average pain change scores of 5.4 points higher than those who underwent conservative management in the short term. In the long term, this difference was only 3.1 points higher in favor of the arthroscopy group. Thus, the results suggest that no major improvement is seen in patients who undergo arthroscopic surgery for KOA compared to those who conservatively manage their KOA [64]. The indication and utility of arthroscopy in KOA requires further study. Osteotomy can be considered in patients with primarily unicompartmental KOA. There are various types of osteotomies, all with the similar goal of off-loading the arthritic compartment. While the benefits of the alternative procedures may include pain relief and preservation of the native knee joint, the risks of non-union, painful hardware, osteonecrosis, and progression of arthritis must be considered. In addition, osteotomies may increase the eventual risk and complexity of total knee arthroplasty when required [65, 66, 67, 68, 69].

High tibial osteotomy

High tibial osteotomy has been an accepted surgical treatment in medial compartment arthritis [70, 71]. An effective osteotomy below the tibial tubercle can significantly improve the post-operative survival rate as cumulative survival with conversion to arthroplasty [72, 73, 74]. The classical approach of HTO has demonstrated complications including neurovascular injury, under correction, and fracture, but improvements in the technique have prompted an increased attention in recent years [75, 76, 77].

While high tibial osteotomy has often been proposed as an ideal treatment in the early osteoarthritis, inferior results have been reported in higher degrees of osteoarthritis [78, 79, 80, 81]. Schuster et al. demonstrated, in exclusively severe osteoarthritis patients, a cumulative survival of 96.1% (95% CI, 91.8–100%) and improvement in Subjective International Knee Documentation Committee (IKDC) score at the 1–, 3–, 5–, and 10-years follow-ups, suggesting that degree of medical osteoarthritis should not be a limiting factor or contraindication for the procedure [82]. A number of other factors, namely, pre-operative knee function, and pre-operative scores have shown to be associated with significantly inferior survival. Such finding is consistent with the findings of Bonasia et al., who illustrated that an excellent pre-operative knee society score to be a significant predictive factor of high tibial osteotomy outcomes [77]. Furthermore, in a systematic review conducted by Ekhtiari et al., the authors demonstrated an 87.2% return-to-sport rate and 78.6% returned at an equal or great level. About 84.5% of patient returned to work postoperatively, and 65.5% returned at an equal or greater level. While generally with excellent post-operative outcomes, it should be noted that high tibial osteotomy was not shown to be a substitute to total knee arthroplasty, but rather a safe and effective option to delay TKA while allowing patients to return to work and sport at levels similar to their pre-operative levels [72].

Distal femoral osteotomy

While the correction osteotomy is usually applied locally at the site of the deformity, it has been shown that when the valgus deformity exceeds 12° or when the joint surface deviates from the horizontal plane for more than 10°, the deformity should then be corrected at the femoral site; otherwise there exists a risk for lateral tibial subluxation and increased knee instability [82, 83, 84]. As such, a distal femoral osteotomy is usually preferred to correct a valgus knee since the approach is effective in addressing the main joint deformity, the hypoplastic lateral condyle, and it

restores the orientation of the joint line without jeopardizing the medical collateral ligaments stability [72].

Good clinical outcomes and low rate of complications have been reported in distal femoral osteotomy. Buda et al. reported good mid-term outcomes with a conspicuous reduction of pain and acceptable functional improvement [85]. The KOOS and IKDC score showed high survivability, which is consistent with existing literature. However, in line with previous results, the Tegner score outcome was not particularly satisfying, suggesting that post-operative return-to-sport and return-to-work outcomes may leave more to be desired. All in all, it appears that distal femoral osteotomy is an effective procedure for valgus knee in correcting deformity and restoring decent function but may not be optimal for young and active patients.

Discussion

As the prevalence of KOA continues to increase, achieving satisfactory clinical outcomes in the management of the disease becomes more significant. Our review has illustrated a multitude of treatment options in which KOA can be managed with non-arthroplasty treatments. CS remains a mainstay short-term pain relief option while viscosupplementation and PRP have shown to be effective treatments for long-term non-operative management.

While traditional conservative treatments have been effective in managing KOA, newer therapeutic options have emerged with increasing popularity. Stem cell injections and ozone therapy have shown effectiveness and efficacy in the early clinical outcomes, while the current body of literature for prolotherapy and RFA remains inconclusive. Further high-quality studies are required to better assess the role of these newer therapies in KOA.

Despite its popularity in treating other orthopedic injuries, it has been shown that there exhibits no major improvement in patients undergoing arthroscopic surgery for KOA, such that the indication and effectiveness of the procedure in KOA remains controversial. Finally, while osteotomy procedures have been shown to demonstrate effective pain and functional improvements in KOA patients, the eventual risk and complexity of total knee arthroplasty may be increased in a post-osteotomy knee. As such, careful discussion and consideration are essential in advising patients.

Conclusion

Corticosteroid, viscosupplementation, and PRP appear to be effective treatment options of KOA, with viscosupplementation and PRP providing longer-term benefits. Newer treatment options such as stem cell injections, ozone therapy, prolotherapy, and RFA may have positive clinical implications but will require further investigation. Operative alternatives to arthroplasty can provide symptomatic relief but may increase the associated risk and complexity should the need for arthroplasty ever arises.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the Journal. The patient understands that his name and initials will not be published, and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.

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