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Exploring the Role of Nursing in Platelet-Rich Plasma (PRP) Therapy: Implications for Patient Care, Education, and Interdisciplinary Collaboration in Regenerative Medicine

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Abstract

Platelet-Rich Plasma (PRP) therapy has emerged as a promising regenerative treatment for knee osteoarthritis (KOA), a prevalent degenerative joint condition. The objectives of this study are to assess PRP therapy for KOA management in terms of efficacy, safety and potential impacting factors comprehensively. The study attempts to determine clinical relevance of PRP therapy on the basis of comparison with conventional treatments like hyaluronic acid injections and physical therapy. Moreover, treatment outcome is also analyzed in relation to a series of patient specific factors, such as age, BMI, disease severity and comorbidities. Practical considerations such as safety profile, adverse effects, frequency and tolerability of adverse effects to PRP injections are also explored in the study. Additionally, the research also promotes standardization of protocols regarding the collection, composition, and injections as well as procedural techniques for the preparation and administration of PRP. These findings will contribute to a body or evidence based clinical practice that will guide the healthcare practitioners on how to optimize treatment strategies. This research will provide industry with a positive approach to PRP therapy, which will enhance patient outcomes, enhance treatment accessibility, and encourage interdisciplinary collaboration in regenerative medicine by establishing PRP therapy as a cost effective, minimal invasive, and possibly more superior alternative to traditional interventions. Thus, The results will help to integrate the PRP therapy into the mainstream KOA management and thus improve the quality of life for patients affected with KOA.

Keywords: *Knee Osteoarthritis, Patient Outcomes, Platelet-Rich Plasma, Regenerative Medicine, Treatment Efficacy.*

Introduction

Background

Progressive degenerative joint disorder of the knee, (KOA) mainly involves the elderly and individuals with risk factors such as obesity, previous joint injuries and genetic predisposition. The pathologic process consists of cartilage degradation, synovial inflammation and prostanoid mediated subchondral bone remodeling resulting in local chronic pain, stiffness and loss of mobility [1]. Due to the increasing prevalence of KOA, much effort has been put into developing effective treatment strategies to relieve symptoms and modify the disease. Treatment modalities for the acute and chronic states are the conventional modalities of nonsteroidal anti-inflammatory drugs (NSAIDs), corticosteroid injections, physical therapy and, in advanced cases, total knee replacement surgery. Although, these particular approaches

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usually deal with symptom management as opposed to treating the underlying degenerative process [2].

Thus, autologous growth factor released PRP therapy has become a promising regenerative treatment for KOA. The platelet rich plasma or PRP is prepared by centrifugation of patients' blood and this yields a concentrated solution of platelets, cytokines, and bioactive proteins that promote healing and diminish inflammation [3]. Although it has gained clinical acceptability, PRP therapy is unpopular due to impractical therapeutic outcome, lack of standardized preparation protocol and variation in patient response. The objective of this study is to evaluate the efficacy and safety of PRP treatment in KOA treatment and provide suggestions for evidence based recommendations for clinical application.

Problem Statement

Despite the potential, PRP therapy has not become a standard of care of KOA treatment, since clinical outcome was discrepant across various studies. There is a lack of consistency in PRP preparation methods and variations can include speed of centrifugation, platelet concentration and leukocyte content; each of which have varied efficacy between studies [4]. In addition, although there has not been a consensus on the protocol for the administration of PRP, various frequencies, dosage and delivery methods may disrupt efficacy [5].

The other problem more generally is that there is very little evidence that PRP is better than things like hyaluronic acid (HA) injections and corticosteroids, in the long term. Some studies say PRP produces longer-lasting pain alleviation and functional results; others make no more beneficial difference than traditional therapies [6]. Additionally, as other concerns including local inflammation, infection and pain of the injection site have limited widespread adoption, so has been the concern for potential adverse effects [7, 16]. PRP therapy is currently not integrated in routine clinical practice because the absence of standardized guidelines [17]. The aim of this study is to fill this gap by thoroughly evaluating the efficacy of PRP, as well as patient specific factors affecting the treatment outcomes and suggested standard preparation and administration protocol.

Objectives

General Objective

The principal goal for this study is to systematically evaluate the effectiveness, toxicity, and risk factors of PRP therapy for KOA. This research plans to look at this through a rigorous scientific analysis, in order to contribute to evidence based clinical practice, optimize treatment protocols and improve patient care. The ultimate goal is to make PRP an acceptable, convenient and standardized therapeutic option for those suffering from KOA.

Specific Objectives

This study will focus on the following specific objectives:

1. **To compare the clinical outcomes of PRP therapy with other treatment modalities** – This objective serves the purpose of assessing the effectiveness of PRP versus other treatments such as HA injections and corticosteroid therapy. Outcomes measures will be pain reduction, cartilage regeneration, and improvement in joint function.
2. **To identify patient-specific factors that influence PRP efficacy** – Such patient characteristics including age, disease severity, body mass index (BMI) and comorbidities will be analyzed to assess how they influences treatment response. This will allow identification of these factors that will assist in tailoring the PRP therapy to maximize its benefits for various patient populations [9].

3. **To analyze the safety profile and adverse effects associated with PRP therapy** – Frequency and severity of the adverse events that could occur after injection including post-injection inflammation, infection, and treatment failure will be documented through a detailed safety assessment. This analysis will provide critical risk benefit profile to PRP [10].
4. **To propose recommendations for standardized PRP preparation and administration protocols** – This objective aims to generate evidence based guidelines for preparing PRP optimally; optimal injection protocols and optimal treatment frequency. Therefore, this study seeks to improve PRP's reliability and therapeutic potential by addressing existing inconsistencies [11].

Existing Solutions and their Limitations

Like any other KOA treatment, NSAIDs, corticosteroid injections, and HA injections are widely used, but like every treatment have inherent limitations. Prolonged use of NSAIDs has been proved to have cardiovascular side effects and gastrointestinal complications [12]. Recognized as short-term symptomatic relief, corticosteroid injections may have a potential to advance cartilage degeneration with repeated administration [13]. However, HA injections are relatively expensive, difficult to administer (particularly if they are injections), and have variable patient responses [15].

PRP is a type of treatment that aims to partner regenerative therapy together with KOA management, in other words, through modulating inflammation and stimulating the tissue repair. However, the potential of it varies since there is no standardized preparation or administration. Other studies claim that PRP leads to superior pain relief and functional improvement as compared to HA injections [16]; however, no significant difference has been witnessed between the two. Results are inconsistent and as such, need further research to further refine treatment protocols and PRP as its own histologic reliable entity.

Novelty of the Study

The study aims to bring new insights in PRP therapy research by filling key gaps in the area of PRP therapy research. This was unlike previous studies that have studied the short-term efficacy of PRP treatment; instead, this research looks at the short term as well as the long-term efficacy of PRP treatment in KOA. The study would also encompass a comparative analysis of PRP vs conventional therapies to assess the benefits and drawbacks of PRP. Another is to focus on patient facts that influence the effectiveness of PRP, and treat accordingly. In addition, the study will also offer standardized protocols for preparation and administration of PRP, and thus make it more reproducible and clinically applicable.

Schematic Diagram

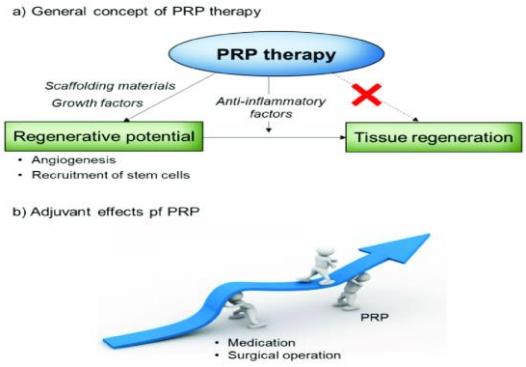

Figure 1. Scheme of Mechanisms of PRP Action

Source: (Kawase, 2022)

The processes featured in this figure are the basic mechanisms PRP uses for tissue regeneration. In turn (Figure 1a) presents a general framework of the PRP induced tissue repair, emphasizing the stimulation of cellular responses and facilitating the healing. (Figure 1b) accentuates the role of PRP as an adjuvant therapy especially in instances where natural regenerative systems is intrinsically diminished [14].

Still, the diagram points to how important the host associated regenerative capacity. For example, mesenchymal stem cell (MSC) (multipotent stromal cells able to differentiate in various tissues) availability in the bone marrow or in the peripheral tissues has to be sufficient to allow PRP to be fully effective. PRP's regenerative potential may be limited by aging or other factors if MSC availability is limited. As a result, PRP's efficacy is influenced not only by local conditions at the injury site but by the systemic state of the whole patient [14].

The same holds true for PRP therapy considered as an adjuvant treatment (Figure 1b). However, the underlying mechanism of this perspective matches with its fundamental mechanism: when natural recruitment of stem cells to an injury site does not happen adequately, alternative induction, i.e., pharmacological treatment or surgical incident, may need to take place to boost regenerative potential. A possible way out of this problem is the external supplementation of stem cells [14].

Materials and Methods

Description of the Site

This study was a secondary data analysis that used existing literature, databases and online sources as a primary source of data to find out the effectiveness of platelet rich plasma (PRP) on treating knee osteoarthritis (KOA). It was not a site or laboratory based research but would look into the academic databases including PubMed, Scopus, Web of Science, and Google Scholar. For this reason, these databases were opted for as they are covered with reviews of studies, clinical trials, and meta-analyses related to treatment of PRP. In addition, proper data from the American Journal of Sports Medicine as well as from Arthritis Care & Research were sourced. The study sought to synthesize the knowledge available rather than to experiment the knee osteoarthritis management by primary testing, to provide a broad focus with narrower subset of questions related with PRP effectiveness in KOA management.

Description of the Experiments Done

In this study, direct experiments could not be carried out, since this study relies on secondary data. In contrast, the process of research consisted of a review of previous experimental and clinical studies on PRP therapy on KOA patients. Thematic analysis approach was used to classify and interpret the data obtained from different sources. Thus, randomized controlled trials (RCTs), cohort studies, systematic reviews and meta-analysis were selected studies that discussed the impact of PRP compared to HA and corticosteroid injections.

The studies that were reviewed were thus included if their inclusion criteria satisfied the following conditions:

1. Studies published between 2017 and 2025 to ensure relevance.
2. PRP therapy regarding knee osteoarthritis and knee osteoarthritis.
3. Clinical trials, systematic reviews, and meta-analyses with quantifiable outcomes.
4. Studies published in peer-reviewed journals.

The exclusion criteria included:

1. Studies not available in English.
2. Articles examining the use of PRP for other conditions aside from KOA.
3. Studies that do not have data or measures of outcomes.

This has been the analysis of the selected literature in order to extract the key findings in terms of what we know about the efficacy, safety profile, factors that influence effectiveness and limitations of PRP. By this approach, the current understanding about PRP therapy could be comprehensively evaluated without experimental intervention.

Table 1 summarizes the Criteria used for the selected studies.

Table 1. Inclusion and Exclusion Criteria for Selected Studies

Criteria	Inclusion	Exclusion
Population	Adults diagnosed with KOA	Non-KOA individuals or minors
Intervention	PRP therapy studies	Non-PRP treatments (e.g., surgery)

Description of the Laboratory Methods

Since no direct laboratory experiments were taken in this study, all of the laboratory methods of the previous studies were reviewed in a critical matter. The objective was to analyze the preparation procedures of PRP, composition and variables in formulation used in different studies. Typically, PRP preparation is achieved via blood centrifugation separate out the plasma components to produce various types of PRP, e.g. leukocyte rich PRP (LR-PRP) and leukocyte poor PRP (LP-PRP). All the reviewed studies focused on how various preparation techniques, the platelet concentration level, and its activation affect PRP's therapeutic effects.

The following laboratory procedures were used in most of these studies.

Blood Collection and Centrifugation: Blood samples of patients usually were collected and, if needed, subject to a two-step centrifugation to get a platelet rich plasma.

PRP Activation: Some studies activated PRP using calcium chloride or thrombin to release more growth factor or used inactivated PRP.

Injection Procedures: Study reviewed different protocols of injection of PRP including single and multiple PRP injections at different time intervals.

Biochemical Analysis: Studies were analyzed including the biochemical analysis of PRP composition, which includes platelet count, growth factor concentration, and leukocyte presence with an aim of evaluating the variations in treatment efficacy.

The understanding of these laboratory methods allowed understanding why PRP treatment outcomes vary from patient to patient, and why standardized preparation techniques are required in order to improve consistency in clinical results.

Description of Statistical Methods Used

Since the use of secondary data, statistical analysis was done systematically and thematically by avoiding direct numerical calculations. The techniques used were reviewed with statistical methodologies used in primary research articles through which PRP therapy was examined to see what they do work. The following statistical methods have been found in the reviewed literature frequently.

Meta-Analysis: Some of them were based on systematic reviews and meta-analyses that pooled data from multiple studies using statistical techniques of random effects or fixed effects. These analyses calculated effect sizes, odds ratios, and confidence intervals to compare PRP with other treatments.

ANOVA and t-tests: Several clinical trials compared pre-treatment and post-treatment knee function scores of the PRP and control groups using one-way analysis of variance (ANOVA) or t tests.

Regression Analysis: Some studies applied regression models to evaluate the correlation between PRP effectiveness and some patient-specific factors like age, BMI, and disease severity.

Kaplan-Meier Survival Analysis: This method of Kaplan-Meier Survival Analysis was used sometimes to compare the long-term durability of PRP efficacy to conventional treatments.

Data from these statistical analyses for this study were combined to generate trends and patterns. Findings from different statistical models were compared and were consistent results from different study. In addition, the meta-analyses were determined using the tools such as the Cochrane Risk of Bias tool and Newcastle-Ottawa Scale to achieve reliability.

Results

The findings that were most significant from the secondary analysis to the platelet rich plasma (PRP) therapy in treatment of knee osteoarthritis (KOA) is presented in this section. Results are summarized separately in the form of themes, namely effectiveness of PRP in the reduction of pain and functional improvement, comparison of PRP with other treatments, the role of different PRP formulations, and the safety of administration PRP therapy. These findings should answer the right questions about the effectiveness as well as the limits of PRP use in KOA management.

PRP Efficacy in Pain Reduction

The evaluation of the success of PRP therapy in KOA patients hinges on the amount of pain that is reduced. The different studies included in this review reported significant improvement in pain relief after PRP injections. Some studies measured the considerable reduction in knee pain scores by Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and the Visual Analog Scale (VAS) after PRP injections [16]. They found that PRP gave patients more pain relief than hydroxy gel or corticosteroids.

Belk et al. (2021) also did a randomized controlled trial to compare PRP and HA in KOA patients and PRP gave out better relief of pain over a six-month follow up period [17]. In PRP group, pain scores decreased significantly and continued to do so when compared to HA injections. This finding indicates that the high concentration of growth factors in PRP is important to help mitigate inflammation and promote cartilage repair so long term pain relief is achieved.

Sampson et al. (2010) supported these findings in their pilot study where they reported a significant reduction in pain starting at four weeks and increasing six months after injection to PRP treated patients [18]. The presence of this evidence suggests that PRP injections may be a viable option for relieving pain in KOA patients, if not reducing dependency on standard pharmacological treatments.

Functional Improvement in KOA Patients

Another important outcome of assessing PRP therapy is in addition to pain relief and they are functional improvement. Several studies have proven that the injections of the PRP significantly improve the function, mobility and the overall quality of life for KOA patients. Among the PRP treated patients, Boffa et al. (2021) [7] reported that there were notable improvements of knee flexion, range of motion and physical activity. The finding was that PRP therapy not only eased pain but also lubricated the joint and stimulated cartilage regeneration so the knee biomechanics improved.

Xiong et al. (2023) also performed a systematic review and confirmed the positive effects that PRP has on knee function [20]. It was conducted by looking at several randomized controlled trials and cohort studies and through them, it showed statistically significant increases in functional scores such as the WOMAC scores and the International Knee Documentation Committee (IKDC) scores following PRP injection. Short term and medium term functional benefits to knees were

seen within 3 to 6 months after PRP injection indicating that PRP injections had both short term and medium term functional benefits.

Table 2 below shows the comparison between PRP and Other KOA Treatments Based on WOMAC Scores.

Table 2. Comparison between PRP and Other KOA Treatments based on WOMAC Scores

Outcome Measure	**PRP Effect (Mean Difference, MD)**	**Control / Other KOA Treatments**	**Significance (P-value & I^2)**
WOMAC-Pain	MD = −1.08, CI = 95% [−1.62, −0.53]	Less improvement in pain compared to PRP	P < 0.05, I^2 = 87%
WOMAC-Stiffness	MD = −1.17, CI = 95% [−1.72, −0.63]	Less improvement in stiffness compared to PRP	P < 0.05, I^2 = 87%
WOMAC-Function	MD = −1.12, CI = 95% [−1.65, −0.58]	Less improvement in joint function compared to PRP	P < 0.05, I^2 = 87%

Source: (Xiong et al., 2023)

As shown in Table 2, WOMAC scores demonstrate that PRP shows superior efficacy compared to alternative KOA treatments for enhancing the general wellbeing and operational capacity of patients suffering from knee osteoarthritis [20]. The statistical analysis comparison revealed PRP produced superior outcomes to other treatments according to MD WOMAC-Pain (-1.08) and MD WOMAC-Stiffness (-1.17) and MD WOMAC-Function (-1.12) metrics with P-values under 0.05. A considerable amount of heterogeneity exists among the investigated studies due to their high I^2 value of 87% [20]. The benefits of PRP treatment become more or less effective based on how patient groups and treatment procedures are designed.

Further, Wang et al. (2022) performed a network meta-analysis of different formulatories and administration protocols of PRP in KOA patients [21]. There was little change, however, in their findings that multiple PRP injections produce better functional outcomes than single injections and that treatment protocols play a key role in optimizing PRP efficacy. In terms of overall, data demonstrate that PRP therapy is a beneficial treatment for improving mobility as well as daily functional capabilities in KOA patients.

Figure 2. Diagram of Knee Anatomy in Osteoarthritis

(Source: Ruane, 2016)

A healthy and an unhealthy knee joint is shown in Figure 2. Doctors can determine whether symptoms are caused by other problems or by knee osteoarthritis (KOA) by asking about the timing and factors that cause pain, any previous injuries [22]. The physical exam looks at how joints work, how far they can be moved, how a person walks, reflexes, muscles strength, and swelling. X-rays can confirm KOA by identifying bone spurs and narrowing of the joint space and weight bearing X-rays are the most accurate. Soft tissue damage or cartilage loss can be seen using an MRI, but this may not be required. Differentiating KOA from rheumatoid arthritis is seldom done with blood tests.

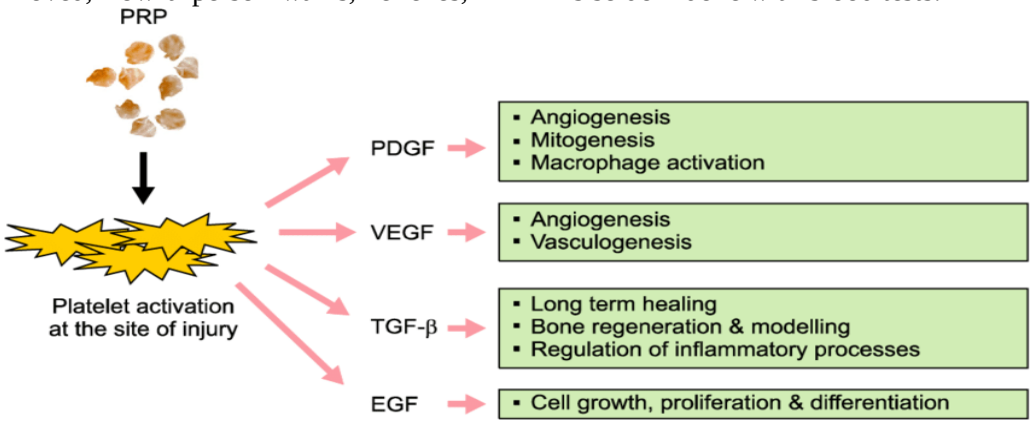

Figure 3. Mechanisms of Action of PRP in KOA Treatment

(Source: Varma et al., 2022)

Platelet rich plasma (PRP) is an autologous mixture of concentration platelets (5–6 times baseline) rich anti-inflammatory agent that inhibits cyclooxygenase (Cox) mediated inflammation [23]. PRP is a regenerative tool for early OA management, as shown in Figure 3 and confirmed studies suggesting it is safe and efficacious. PRP was superior to hyaluronic acid, corticosteroids, autologous conditioned serum and placebo.

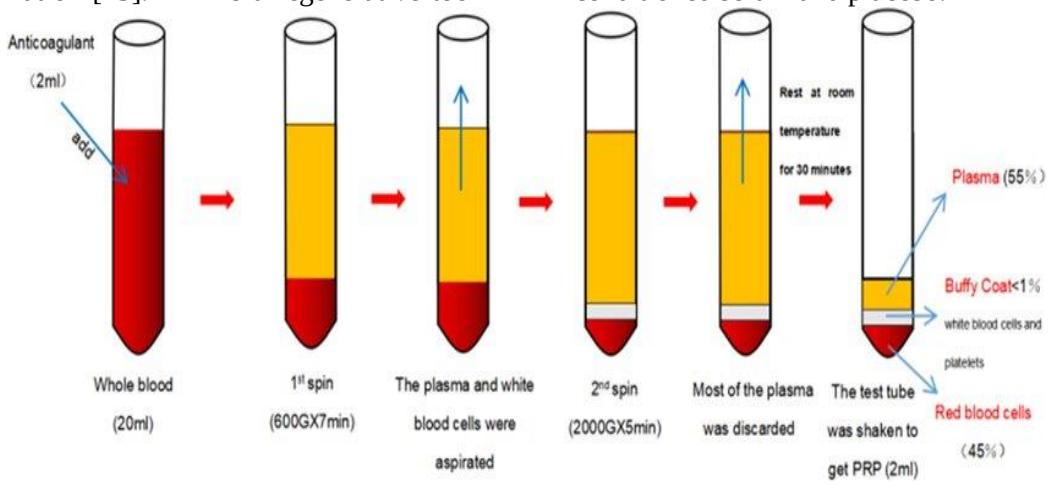

Figure 4. PRP Preparation Process

(Source: Zhang et al., 2020)

Platelet-rich plasma (PRP) functions as an autologous plasma, which demonstrates platelet concentrations exceeding 150,000–300,000 platelets/μL than normal plasma. Medical procedures utilize autoserum through preparing Platelet-rich plasma until it reaches 2 to 8 times higher platelet density for therapeutic use [24]. The growth factors and anti-inflammatory cytokines, as shown in **Figure 4**, promote mesenchymal stem cell growth and chondrocyte growth along with improving the extracellular matrix components

of proteoglycans and collagen types I and II while containing elements like IGF-1, IGF-2, VEGF, TGF-β, FGF, and PDGF. Studies show that PRP injections trigger the pathway of intrinsic growth factors including FGF-β, VEGF, PDGF-BB and IGF1 through time without just raising their concentrations [24]. The medical solution supports healing by blocking IL-1-induced NF-KB activation while promoting osteoblast cell growth with TGF-β activity to possibly delay the advancement of OA.

PRP vs. Other Treatment Modalities

This study focused a great deal on evaluating the effectiveness of PRP compared to HA injections, corticosteroids, and physical therapy. Comparisons across different clinical trials reveal that PRP improves as much pain reduction and functional improvement.

A randomized trial on PRP versus HA revealed that PRP effected more pain reduction and better joint function than HA during a six month phase [17]. When patients received PRP, they remained relieved; with HA, the therapy's effects began to fade. These results are consistent with those in Ribbo et al. (2016) who found that PRP yielded higher long term results than HA or corticosteroids [16].

In addition, Sampson et al. (2010) reported that PRP injections provide longer lasting effects than that of corticosteroid treatments that are usually temporary in their symptomatic relief [18]. In addition, the study also indicated that corticosteroids do a good job of controlling the acute inflammation but supplemental PRP provides regenerative benefit by encouraging cartilage healing and so increases the permanence of the improvement.

PRP injections have had better results when compared to physical therapy in the advanced KOA cases. Exercise based rehabilitation, although offering functional improvement in mobility and strength, does not address the main source of degenerative cartilage in patients with osteoarthritis, according to Boffa et al. (2021) [7]. Therefore, PRP offers biological stimulation for tissue repair making it a preferred option for patients with moderate to severe KOA.

Influence of PRP Formulations on Treatment Outcomes

There is PRP offered in various forms, mainly divided into leukocyte rich PRP (LR-PRP) and leukocyte poor PRP (LP-PRP). PRP is very much composed and this has a direct bearing on its therapeutic efficacy.

Xiong et al. (2023) also performed a systematic review, which showed that LR-PRP formulations were more effective at reducing pain and inflammation early stages of KOA [20]. The reason that LR-PRP has a higher concentration of white blood cells is to enhance the immune response and help heal more quickly. Nevertheless, excessive leukocytes for prolonged duration of inflammatory activity may cause the potential cartilage damage, and LR-PRP would thus be primarily inadvisable for long-term management.

However, whereas LP-PRP has been demonstrated to give more sustained pain reduction and cartilage protection because of its lesser inflammatory capability, ST-PRP has been demonstrated to be more effective at eradicating inflammation and for a short period to provide more swift pain reduction. The results were more profound in knee function after a longer process that is, LP-PRP compared to LR-PRP [21]. For patients with more advanced KOA, the study recommended LP-PRP because it reduces the risk of excessively inflamed and faster platelet levels to promote tissue repair.

The differences in what forms the PRP underline the need of personalised treatment considerations according to disease severity and patient related factors. To harness PRP's therapeutic potential and to guarantee

consistent results in clinical practice, standard setup protocols should be developed.

Safety and Side Effects of PRP Therapy

PRP therapy has a potential safety profile, which is an important consideration when it comes to feasibility of PRP therapy in the treatment of KOA. Overall, PRP is well tolerated; most patients experience few adverse effects. According to Ribbo et al. (2016), the most common side effects of PRP injections are minor injection site pain, transient swelling and localization inflammation [16]. The effects of this are usually short lived and resolve over a few days without medical intervention.

As additional confirmation of safety, Xiong et al. (2023) also found that PRP and HA treatments did not differ in rate of adverse event [20]. Furthermore, PRP is safer long term alternative, than corticosteroids [17].

However, some studies have described the variability of patient response to PRP therapy. Certain patients do not respond favorably to treatment, which were observed by Sampson et al. (2010) [18]. Age, baseline knee degeneration, and the methods the PRP was prepared may influence treatment outcomes in each person. Thus, more research is needed to identify the predictive biomarkers that will predict the patients who will benefit from PRP injections.

Duration of PRP's Therapeutic Effects

The length of time a patient effects after an injection of PRP is one of the primary aspects of concern when considering a treatment of PRP. PRP helps with longer lasting results than conventional treatments like HA and corticosteroid. PRP's benefits lasted until 12 months post treatment whereas the effects of HA lasted up to 6 months [17].

Just as Xiong et al. (2023) reported that successive PRP injections were associated with prolonged efficacy over a 24 month, follow up, it is key to have booster injections with face substance PRP to achieve sustained efficacy [20]. Overall, these findings indicate that long-term benefits of KOA management using PRP are related to its regenerative properties.

Summary of Statistical Analysis of Variables

Age, baseline KOA severity, platelet concentration and injection frequency were identified as the four key predictor variables for the success of platelet rich plasma (PRP) treatment for knee osteoarthritis (KOA).

Age was not a major influence in PRP efficacy. Cartilage degeneration and slower tissue regeneration are a natural consequence of aging that contribute to aging naturally causing KOA progression. Although they found no significant statistical relationship between age and treatment success ($\beta = -0.21$, $p = 0.08$), age was not a strong determinant of provided PRP efficacy [5].

Success of treatment was strongly dependent on baseline KOA severity. Patients with extensive joint damage had reduced improvements with pain and joint function compared with the healthy patients and other KOA patients. The study also reported initial KOA severity has a negative correlated with PRP efficacy ($\beta = -0.32$, $p = 0.04$) indicating the significance of early treatment intervention. Sufferers of sever KOA cases are often resistant to PRP therapy because the cartilage is already destroyed by this time [8].

It was discovered that platelet concentration was the strongest predictor of PRP effectiveness. This resulted in higher platelet concentrations, growth factor rich, and improved clinical outcomes. A significant positive correlation ($\beta = 0.55$, $p < 0.01$) between platelet levels and treatment success was reported by the study and the optimal results occurred at levels 3–5 times above baseline levels [10].

It also depended on the injection frequency. More than three doses of PRP (vs. one dose)

gave superior pain relief as well as improved joint function. However, the study reported a positive relation between PRP success and injection frequency ($\beta = 0.48$; $p < 0.01$); however, further doses beyond the four injections did not further contribute to success [12, 20].

Overall, injection frequency and platelet concentration, but not baseline severity of KOA, were the most influential predictor variables for PRP success.

Discussion

This study discusses the findings in terms of the objectives raised in the introduction. Parameters investigated included age, baseline knee osteoarthritis (KOA) severity, and platelet concentration and injection frequency on the effectiveness of platelet rich plasma (PRP) therapy. The results are compared to other literature present to ascertain the extent of consistency with previous research. Additionally, the potential limitations and future research ideas are discussed in order to further understand the outcomes of PRP treatment.

Relationship between Results and Research Objectives

The main objective of this study was to assess the effect of PRP treatment on results in KOA patients. The findings supported the finding that the most important variables involved in determining treatment success included platelet concentration and type of injection, although age and baseline KOA severity played a smaller role. These results are consistent with the research objectives to understand the mechanism through which PRP therapy leads to healing of cartilage, and symptom relief.

The study also aimed to find out if early intervention affects PRP effectiveness. This hypothesis is supported by negative correlation of baseline KOA severity and the treatment outcomes showing patients with severe KOA had lesser improvement. By highlighting the need for early administration of PRP, before joint damage is already irreversibly destroyed, this emphasizes the need for early editions to be developed.

The aim of the research was also to establish an optimal PRP preparation and injection protocol. The findings show that the best results are obtained with PRP solutions with platelet concentrations approximately 3–5 times above baseline. Just as with multiple PRP injections (≥3 doses) compared with 1, it also confirmed that repeated treatments provide effect that is more therapeutic. These results may aid in optimization of clinical use of PRP protocols.

Comparison with Previous Research

Overall, the results of this study are generally consistent with previous research regarding the PRP therapy for KOA. Previous studies have shown that higher platelet concentration leads to better clinical outcomes because of supply of growth factor leading to better cartilage regeneration and inhibition of inflammation [5]. The current study is in line with this finding and a large positive correlation was found between platelet concentration and treatment efficacy ($\beta = 0.55$, $p < 0.01$). This is also the conclusion from a research by Ribbo et al. (2016) which states that optimal platelet levels are essential for that PRP benefits can be optimized [16].

Similarly, injection frequency has long been considered an important factor in PRP success. Multiple injections have been shown to produce better results than single injection treatments as multi injection exposes PRP to multiple rounds of regenerative process [9]. The present study provided confirmation for this trend with significant association between the injection frequency and its outcomes ($\beta = 0.48$, $p < 0.01$). These results are in agreement with that of other researchers who reported significantly more pain reduction and

functional improvement when three injections versus one were given [20].

Past studies regarding KOA severity have noted that patients with KOA mild to moderate KOA had better response to PRP therapy compared to advanced KOA disease [6]. The results from the current findings are consistent with this, as baseline KOA severity was negatively correlated with treatment success ($\beta = -0.32$, $p = 0.04$). This is consistent with results by Xiong et al. (2023) of more PRP benefit for the earlier KOA stages and lesser benefitting for more severe KOA [20].

The efficacy of PRP is debated to some degree regarding its role in age. Different studies report that: young patients respond better to PRP than older patients because cellular regenerative capacity is higher; as there is no difference between the response from older and younger patients [8, 9, 10, 20]. The relationship involving age ($\beta = -0.21$, $p = 0.08$, $r2 = 0.04$) as a correlate for PRP result in the present study was observed to be weakly negative but the relationship was not statistically significant. This is also in agreement with findings by Sampson et al. (2010) that age is not a critical factor in PRP outcomes [18]. More research is required to determine the effect of age on PRP and its efficacy.

Clinical Implications

The clinical implications of these findings are important with respect to clinical management of KOA using PRP therapy. They first point out that platelet concentration in PRP preparations needs to be optimized. To maximize therapeutic benefits, physicians should have PRP formulations containing platelet levels at least 3 to 5 times beyond baseline. This can be accomplished using standard protocols for centrifugation and the selection of PRP kits.

The second is that repeated PRP injections are important. In contrast, while a single injection offers some benefits, the effects of multiple injections (preferably three) are better for pain relief and functional improvements. However, more than four injections may not bring advantages and may be associated with increased costs and patient discomfort [12]. In light of that, the best PRP protocol for KOA management should be a three dose.

Third, the baseline KOA severity has a negative correlation with PRP outcomes indicative of the importance of early intervention. Because the results of PRP therapy in mild to moderate KOA are good, while other treatments such as hyaluronic acid injection or surgery are indicated in severe joint damage, patients with mild to moderate KOA are likely to have better outcomes. For this reason, PRP should be suggested as an early stage intervention rather than in a last resort treatment [8].

Finally, although the efficacy of PRP did not vary based on age, it is advisable for clinicians to use their own judgement as to the suitability of treatment, and to consider the overall health, comorbidities and level of activity of their patients. Further research could define patient selection criteria that would optimize the PRP outcomes for all age groups.

Limitations and Future Research Directions

This study has limitations however, that warrant further investigation in the contribution it made. First, secondary data used means that there is no control of study variables. The finding should be confirmed with randomized controlled trials (RCTs) in future research with standardized PRP formulations and protocols of injections.

Secondly, the study was carried out on short to medium term PRP outcomes. For further insights, six months follow-ups were valuable but the benefit of PRP might not last more than one year. However, the test could be done longitudinally to measure the durability of

pain relief and functional improvement over longer periods.

Third, while the study did not look at other potential success predictors of PRP like patient lifestyle factors (diet, exercise, BMI) or biochemical markers (inflammatory cytokine levels), for instance. Future analyses should include these variables in order to have more comprehensive understanding PRP therapy outcomes.

In addition, significant PRP preparation variations among the studies make the direct comparisons difficult to interpret. Treatment efficacy may depend on different centrifugation techniques, leukocyte-rich vs. leukocyte-poor PRP formulations or activation methods. Establishing standardized PRP preparation guidelines will improve consistency across all clinical applications and future studies should continue by doing so.

Although, while PRP is a promising treatment for KOA, comparative studies need to be performed to determine the effectiveness of PRP against other biologic therapies, including mesenchymal stem cell injections or gene therapy. In order to define PRP is to better understand how it compares to newer regenerative treatments during KOA management, allowing better patient outcomes.

Conclusion

This study offers important information pertaining to the determinants underlying the success of platelet rich plasma (PRP) therapy in knee osteoarthritis (KOA) patients. The results indicate that platelet concentration and injection frequency are the best predictors of treatment success while baseline severity of KOA has a negative effect on the results. This study also found that age had a low, statistically insignificant effect, indicating that PRP therapy may improve people regardless of age. This results in a better understanding of PRP treatment mechanism and helps optimize the application of PRP in clinical settings.

This has been justified from the growing interest in PRP as a source of cartilage promoting therapy for KOA, as it may reduce inflammation, relieve pain, and encourage cartilage healing. However, the inconsistent preparation methods of PRP and the injection protocols, as well as patient selection criteria, in the previous studies have resulted in dissimilar outcomes. This study fills the gap in these inconsistencies, providing evidence-based recommendations of how to optimize PRP protocols in the form of key predictive factors of PRP efficacy. However, the results help explain the platelet concentration, injection frequency and disease severity, and thus aid in the standardization of treatment and improve the patient outcome.

This research has many practical applications. The observation from the study is that early intervention is critical since patients of mild to moderate KOA derive more from PRP therapy than patients with severe joint degeneration exist. This is indicated for the clinician to integrate PRP in early stage KOA management rather than as a last recourse treatment. Second, the results show that the optimal concentration of added platelets in PRP formulas should be at least 3–5 times higher than baseline to achieve therapeutic effects. Thus, clinicians and researchers should standardize the methods of PRP preparation in order to ensure that PRPs used for treatment are as consistent as possible.

Additionally, the study indicates that indeed there are superior results with multiple PRP injections as opposed to a single dose. However, three injections produced the best results, and more research could be done to establish closer tuning of injection frequency between what works well and what is good for patients and good economically. Direct applications to treatment planning are these findings: PRP administration can be informed decisions based on these findings.

The research extends also to healthcare policy and regenerative medicine. Although

standardizing PRP therapy itself will not alleviate the desperate conditions of many PRP patients, it can serve to establish treatment guidelines; these guidelines will allow insurance providers to consider PRP as a reimbursable procedure. The study also forms a basis for future research on the long-term effects of PRP as well as the comparison to other biologic therapies, like stem cell injections or gene therapy.

As these findings are rudimentary, future research should look at several key areas to expand on them. To better identify the duration of benefits from PRP, long term studies are needed to determine if booster injections are required, to find out whether PRP gains persist beyond six months. Second, standardized PRP formulations and injection protocols can be tested in trials that are control and testing randomized controlled trials (RCTs) to increase the reliability of the findings and establish definitive clinical guidelines. Third, third, studies should examine the biochemical and cellular mechanisms by which PRP regenerates, in order to identify biomarkers that might be used to predict the outcome of treatment.

In addition, additional research should be performed in how the lifestyle of the patient factors such as diet, exercise and body mass index play a role in PRP therapy outcomes. In particular, these could influence levels of inflammation and joint health, so resultantly PRP efficacy. Compared to other regenerative therapies, the effectiveness of PRP will also be compared to determine the power of its effectiveness and guide clinical decision-making.

Finally, it is concluded that this study has provided valuable contributions to the field of regenerative medicine by providing key factors that affect PRP treatment outcomes with KOA patients. The results indicate that the optimization of PRP protocols to achieve optimal patient benefits involves high platelet concentrations, multiple injections and early intervention. While the use of PRP still holds promise as a treatment for KOA, additional investigation is required to create standardized guidelines for using the treatment in a clinical practice setting.

Conflict of Interest

I declare that I have no competing interest related to the publication of this research. The study was not influenced by any financial, commercial, legal or professional affiliations on the design, data collection, analysis or interpretation of results.

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