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GRADUATION PROJECT

Degree in Dentistry

PLATELET RICH PLASMA:

APPLICATIONS IN DENTAL IMPLANTS AND ORAL SURGERY AND BENEFITS

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RESUMEN

Introducción: El Plasma Rico en Plaquetas presenta un recurso importante en cirugía oral e implantología debido a sus propiedades curativas, las cuales son un aspecto crucial en procedimientos quirúrgicos donde la cicatrización es determinante para el éxito del tratamiento. Su capacidad regenerativa ha sido ampliamente estudiada y su uso es ya más común, por lo que es fundamental mantenerse al día con la investigación para proporcionar a los cirujanos orales datos completos que respalden o desaconsejen su uso habitual. **Objetivos:** Esta revisión tiene como objetivo principal analizar si usar Plasma Rico en Plaquetas es más beneficioso que su ausencia en implantes dentales y cirugía oral, evaluando la cicatrización de tejidos duros y blandos. Como objetivos secundarios, se pretende identificar posibles limitaciones y desafíos asociados a su aplicación, permitiendo así la toma de decisiones informadas antes de intervenciones quirúrgicas al comparar el Plasma Rico en Plaquetas con otras terapias regenerativas. **Métodos:** Se realizó una búsqueda exhaustiva aplicando criterios de inclusión y exclusión para encontrar estudios que evaluaran los efectos del Plasma Rico en Plaquetas. Se utilizó un sistema de puntuación para analizar los resultados de cada estudio incluido. **Resultados:** Se analizaron 15 artículos para obtener una conclusión integral sobre los beneficios del uso del Plasma Rico en Plaquetas. **Conclusiones:** Los estudios demostraron que el uso de Plasma Rico en Plaquetas puede facilitar el desarrollo de procedimientos quirúrgicos orales. Se posee capacidades regenerativas en tejidos duros y blandos, lo que puede garantizar mejores resultados en términos de cicatrización y éxito del procedimiento.

PALABRAS CLAVE
Odontología, Plasma Rico en Plaquetas, cirugía oral, implantología, cicatrización de tejidos duros y blandos.

ABSTRACT

Introduction: Platelet Rich Plasma has become an important safeguard during oral surgery and implantology due to its healing properties, which is a crucial aspect during surgical procedures, where the healing of the surgical area is key for the success of the procedure. As its healing capacity has been widely studied, and its use is becoming very common, it is therefore important to keep up with the research to provide oral surgeons with comprehensive data that either support or are against its habitual use. **Objectives:** This review aims to analyze whether using Platelet Rich Plasma is better than not using it in dental implants and other procedures in oral surgery by analyzing hard and soft tissue healing. Secondary objectives include the identification of any limitations and challenges that can arise to allow the formulation of informed decisions prior to surgical interventions by comparing the use of platelet rich plasma with other regenerative therapies. **Methods:** An intensive search was conducted, applying inclusion and exclusion criteria to find appropriate research studies, that evaluated the results on the use of Platelet Rich Plasma. A point system was applied to evaluate the results of each study included in the review. **Results**: 15 articles were found and analyzed to reach a comprehensive conclusion on the benefits of using Platelet Rich Plasma. **Conclusions:** Overall, the studies support the use of Platelet Rich Plasma can make an oral surgical procedure go smoother. Platelet Rich Plasma has hard and soft tissue healing capacities that can generally ensure better results.

KEYWORDS
Dentistry, Platelet Rich Plasma, oral surgery, implantology, hard and soft tissue healing.

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1. INTRODUCTION

The dental field is in continuous evolution where advancements in technology have made pivotal improvements in techniques that primarily have the goal of providing optimal oral health (1). The oral cavity is composed of hard and soft tissues that undergo continuous changes throughout our life that make it less functional and less aesthetic (2). Patients may present with complete or partial edentulism, periodontal problems that lead to bone defects and soft tissue problems, in which cases rehabilitation becomes the important objective for treatment, following a surgical approach (3). Rehabilitation of the oral environment that has suffered changes due to variable factors does not only involve the teeth, but also the surrounding tissues, therefore requiring a multidisciplinary approach from the field of dentistry (4). The success of a treatment, whether it is for aesthetics or function, is something that is an important building block for the health and stability of the bone and the surrounding soft tissues (4). Protocols are constantly being updated due to extensive research that transforms what was once thought as impossible into something that is achievable with successful outcomes (1).

In dentistry, and more specifically, in implantology and oral surgery, the use of Platelet Rich Plasma (PRP) has started to gain attention as a biologic material with promising utilization involving tissue regeneration and healing (5). To restore the function and aesthetic aspects of the oral cavity we require healthy, strong, stable bone with optimal density and good anatomy (4). Equally important is the health of the soft tissues that ultimately protect the bone and enhance the aesthetics of the smile (6). After a surgical procedure it is therefore of the essence to ensure desirable healing of both hard and soft tissues for the success of the overall treatment, as a dysfunctional oral cavity can have numerous undesirable effects on a patient (6). Therefore, in this review we will encounter as much information as possible regarding the uses of PRP technology in the dental field, to analyze, assess and compare its effectiveness, usefulness and whether its use can be considered a valuable tool during oral surgery.

1.1. Platelet Rich Plasma: What is it and what is its mechanism of action?

Platelets in general are one of the crucial components in our blood and while they only make up around 2% of our blood, they play an essential part in maintaining health and balance, through the repair process by the release of mediators (7). They are responsible for numerous actions including hemostasis by the release of clotting factors that in turn form blood clots and ultimately favor wound healing (8). PRP, as suggested by the name, is a plasma concentrate that is obtained from one's own body (autologous) and is vastly rich in platelets (9). It is obtained exclusively from blood in its liquid form (neither in serum nor clotted form) (10). This blood is collected, isolated, centrifuged and processed before use (8).

The composition of PRP also incorporates cytokines, chemokines, various plasma proteins and principally growth factors (GFs) like transforming growth factor beta (TGF-β), platelet-derived growth factor (PDGF), insulin-like growth factor I (IGF-I), vascular endothelial growth factor (VEGF) and epidermal growth factor (EGF) (5,9,10). Generally, PRP was found to accelerate healing by the release of the aforementioned GFs that subsequently enhance collagen synthesis, angiogenesis and ultimately tissue regeneration and remodeling by processes like inflammation followed by proliferation, cell differentiation and migration (11). Furthermore, the clot formation made of fibrin, is another advantage given by PRP since it has shown the ability to stabilize graft materials and finally promote the closure of the wound (12). It has been used in different forms, such as Pure Platelet Rich Plasma (P-PRP), Platelet Rich Fibrin (PRF), Platelet Rich in Growth Factors (PRGF), Platelet Poor Plasma (PPP) and many more (13). They generally differ from one another based on the concentration of platelets in plasma that results from the different protocols of preparation. These will later be compared between each other as well as with other autologous concentrates, while analyzing whether they have been shown to provide more or less desirable outcomes, or even insignificant.

1.1.1. PRP Preparation Techniques

PRP is prepared using different protocols according the professional's choice, ultimately aiming for a concentrate containing over 1 000 000 platelets per µL/5 mL, which has been linked to desirable healing properties (10). Blood drawn from the patient's body can be venous blood obtained from the antecubital fossa, brachial vein, cubital vein as long as it is taken in its liquid form as previously mentioned (14–21). This sample is usually mixed with an anticoagulant solution like citrate-phosphate-dextrose-adenine (CPDA), sodium citrate, trisodium citrate or anticoagulant citrate dextrose solution A (ACD-A), which is responsible for the inhibition of a clotting cascade (10). Jovani et al., has also mentioned the use of EDTA as anticoagulant, however it is not considered a good one due to the fact that it causes the inhibition of platelets and therefore their activity (22). It is later placed inside a centrifuge machine which is responsible for the separation of the blood components according to weight (14–16,18,19,21,23–25). The centrifuging process follows various protocols according to the researcher's preferences and it can either use single or double spin (with variations in revolutions per minute – rpm), or be standardized or non-standardized (14–21,23–27). The standardized kits that exist that have been mentioned in the studies include the Curasan, the PRGF System by BTI Biotechnology Institute, Biofixette and the Harvest SmartPrep systems (15,24,25,27). SmartPrep systems have been compared with others and were found to have no disease transmission risk (28). Thereafter, from the centrifuged sample where two clearly

separated layers are formed (upper – plasma, middle – white blood cells, lower – red blood cells), the upper layer is subdivided in two fractions (upper – fraction 1 rich in fibrin, lower – fraction 2 rich in growth factors) and carefully pipetted separately in test tubes. These test tubes are subjected to solutions of $CaCl_2$ with or without thrombin, or calcium gluconate for its activation right before application in order to induce clotting and activate the platelets (14–20,23–26) (figures 1-3).

Step-by-step Protocol:

1. Correct and complete medical history necessary to ensure patient safety.
2. Extract 20-40cc's of blood under antiseptic conditions
    - Place elastic band to stop blood flow
    - Locate the easiest vein to extract the blood
    - Apply alcohol with a gauze to disinfect the extraction site
    - Palpate the vein and maintain it at a fixed position so that it doesn't move while inserting the butterfly needle.
    - Insert the Butterfly needle inside the vein at a 45° angle with the bevel downwards. Blood should start flowing through the tube. DO NOT let go of the wings of the needle as it can be ejected with the pressure exerted by the blood flow.
    - Have 8 test tubes nearby and labeled, connected to the tube attached to the butterfly needle.
        - 4 for centrifugation purposes
        - 4 for separation of desired layer
    - Once all 4 test tubes have been filled, remove the elastic band BEFORE removing the needle.
    - Immediately after removing the needle apply pressure to the wound with a gauze and then a band-aid.
3. Centrifuge the blood samples
    - Place the test tubes inside the centrifuge machine making sure that it is balanced
    - Follow manufacturer's instructions for the duration of centrifugation
4. Separate the layers in separation test tubes containing the anticoagulant
    - There are 2 layers of interest. It is recommended to mark the test tube approximately at the separation points with safety margins so that layers do not mix. All upper layers from the 4 samples collected using a pipette, in 1 tube and all lower layers collected in another.
        - Fraction 1 (upper) – rich in fibrin
        - Fraction 2 (lower) – rich in growth factor
5. Activation with $CaCl_2$ just before applying it to the surgical site. Mix it well with the sample and place it in a dappen glass.
6. Incubate according to manufacturer's instructions.
7. Ready to use in liquid, gel or membrane form.

Figure 1: A proposed protocol formulated after the analysis of the articles.

Figure 2: Image guide of the different steps and equipment for the proposed protocol (part 1). *images obtained by the author*

Figure 3: Image guide of the different steps and equipment for the proposed protocol (part 2). *images obtained by the author*

1.2. Applications of Platelet Rich Plasma

PRP has a wide range of applications in the medical field, including dermatology, cardiothoracic and plastic surgery, gynecology, ophthalmology, urology, maxillofacial and oral surgery as well as in the treatment of temporomandibular joint osteoarthritis (8,11). The healing abilities PRP has to offer are therefore highlighted by the extent through which it is used in medicine and not just dentistry (11). PRP has proven to provide an extensive variety of benefits one of which is its easy use (7). This review will focus on PRP's applications in dental implants and generally in oral surgery.

1.2.1. Dental Implants

Dental implants have become a very routine procedure by now, which to come to this point, a variety of developments and advancements needed to be made. They play an important role in restoring function and aesthetics (29). For the jaws to hold an implant, a biocompatible material with the appropriate design needed to be produced that would integrate well into the bone. In addition, the bone had to be studied extensively in order to be in a satisfactory condition to accept the implant (29,30). The role of PRP in dental implants arose in order to facilitate better, stronger and sufficient bone structure to accept an implant, due to its regenerative properties and healing capabilities (8).

For a successful implant placement, we need to achieve good osseointegration which is explained as the complete integration of the bone to the body of the implant by the process of contact and distant osteogenesis (31,32). Osseointegration, is a variable in the success of implant placement that, is affected by various factors, related to the procedure, the materials used as well as the patients themselves (10). PRP was proven as a useful tool to enable osseointegration not directly, as it is primarily involved in the healing process, therefore enhancing the process as a whole, and not merely osseointegration, since scaffolds of synthetic bone need to accompany PRP (34). Whether PRP has osteogenic abilities still remains unclear, even though there are some studies mentioning that it has the ability to induce osteogenic differentiation in the periodontal ligament and dental pulp stem cells, initiating cascade reactions that can lead to bone formation (35).

Another area where PRP has been used is sinus lift procedures in both immediate and delayed implant placements with promising results (36). It has been compared with the use of deproteinized bovine bone matrix (DBBM)+P-PRP as well as venous blood, in which cases it was found to be as successful (37,38). A sinus lift procedure is a delicate one, as we are working against a very thin and vulnerable membrane which we push apically towards the sinus with the

help of a graft in order to place an implant with a more desirable height, without perforating the sinus membrane that could lead to infections (sinusitis) (36).

1.2.2. Oral Surgery

Oral surgery generally involves procedures on soft and hard tissues of the oral cavity. In oral surgery, PRP has proven to be of great assistance that can nudge towards the success of either placing an implant or improving function and aesthetics (13). For example, after an extraction, when the alveolar ridge is left with an empty socket, it is sometimes preferred or even recommended to apply bone regenerating materials that will patch it up in order to preserve the shape and anatomy of the original structure of the ridge (39). This is usually done where an implant is going to be placed. More regenerative procedures exist in oral surgery either for aesthetic or functional problems or both. Procedures like Guided Bone Regeneration (GBR) help create a better structural environment to accept an implant. Areas holding an implant where the implant has suffered bone recession, autologous bone grafts can be placed to help increase the lifespan of an implant (12). Autologous bone grafts are especially useful for aesthetic purposes in anterior regions (not necessarily in areas holding implants) but also in edentulous regions where bone resorption becomes noticeable due to factors like aging (40). These grafts may sometimes also be accompanied by soft tissue surgeries. Even though now considered routine, these procedures are still risky and the help of PRP can sometimes make the healing process faster and safer (41).

1.3. Benefits (11,42)

- Enhanced wound healing
- Less postoperative pain, inflammation and swelling → better quality of life
- Lower probability of post-extraction dry socket
- Tissue regeneration
- Angiogenesis
- Antimicrobial
- Hemostasia

1.4. General Considerations and Contraindications

Like every procedure in dentistry and generally in medicine there are things to consider before moving forward with a procedure, following a risk-benefit attitude. It is very well established that taking a full medical history is of the utmost importance prior to all dental

procedures that will help assess the overall health status of the patient (43). In addition, another consideration is the PRP preparation, as different preparation protocols provide different platelet concentrations that consequently influence the effectiveness of PRP (44). Furthermore, the procedure needs to be planned in such manner that PRP achieves the most desirable result possible (45). PRP is more effective when used during the surgery and, as previously mentioned, when used accompanied by a bone graft (34). It is also important to note that managing patient expectations is crucial as the use of PRP does not always guarantee better outcomes (18,38).

As far as contraindications are concerned, there are some absolute contraindications, some that are considered as relative contraindications and finally some that involve lifestyle factors that can influence the procedure. Absolute contraindications include systemic diseases like, for example, blood diseases including severe thrombocytopenia, severe coagulopathies and hemophilia (42). In addition, it is considered that an active infection (local or systemic) could potentially be aggravated with the use of PRP (16,24). Cancer (patients undergoing radiotherapy or chemotherapy) is also another contraindication since the use of PRP could promote the growth of the cancer due to the growth factors it contains (42). Relative contraindications include autoimmune conditions like rheumatoid arthritis and lupus as they could impair the healing process, and some autoimmune responses may be exacerbated by PRP's immune-modulatory effects (16,24). Pregnancy and breastfeeding are also considered relative contraindications and even though there is still not enough research that it could be a contraindication, it is generally avoided (42). Patients undergoing long treatments with anticoagulants like heparin or warfarin are thought to be in a disadvantageous position for the use of PRP as it may not show optimal results due to platelet function alteration (16,24,46). Such patients may need to temporarily stop their treatment to allow the proper function of PRP. Furthermore, diabetes appears to be another condition that may present as a relative contraindication for autologous PRP usage due to the alterations diabetes causes on the platelets that diminish the healing capabilities of a wound (47). Finally, lifestyle habits are also considered when the surgery involves PRP. Smokers, for example, are generally known to have impaired healing capabilities and reduced PRP effectiveness as they have limited blood flow and therefore less oxygenation of tissue (25,48).

Therefore, it is safe to hypothesize that any contraindications mentioned in research papers were referring to the surgical procedure itself and not the use of PRP, suggesting that PRP itself is not a contraindication and the only aspect that could exclude a patient from being part of any clinical trial would involve whether their general health could withstand the surgical procedure.

2. OBJECTIVE

This paper will attempt to shed light on the most common applications of platelet rich plasma (PRP) cells in the dental field and more specifically dental implants and oral surgery. This review will aim to provide a more comprehensive understanding of PRP technology from the moment of its collection up to the moment it is used in the oral cavity. The objectives below will be followed:

1. To analyze whether using PRP is better than not using it in dental implants and other procedures in oral surgery following the question: In patients (P) receiving oral surgery and/or implants, how does using PRP (I) compare to not using it (C) for the success of the oral intervention (O)?
2. To answer whether PRP is more beneficial in hard or soft tissues.
3. To evaluate limitations and challenges that can arise to allow the formulation of informed decisions prior to surgery.
4. To provide a protocol for the preparation of PRP based on the research conducted and present it in the introduction.
5. To highlight any future directions that PRP may present within the dental field and help dental professionals make decisions more confidently on whether PRP is trustworthy and valuable enough for their practice.

3. MATERIALS AND METHODS

The main objective was formulated by choosing a population (P) being patients undergoing various oral surgeries or implant placements that were performed (I – intervention) using PRP as an additional step for their procedures. Secondly, a comparison (C) was established to produce an outcome (O), by choosing to focus on whether using PRP is better than not using it, either comparing it to simply using and not using it or comparing it with another technique, therefore answering two important questions a dental surgeon could have before investing into PRP technology systems: 1. Is it really better/worth using it at all?, 2. Do I choose PRP or other techniques?.

To reach a conclusion on the objectives, it is important to analyze whether the procedures involving PRP are successful enough to be considered for habitual use in dental surgery. To do this the main parameters evaluated in research articles will be further analyzed to narrow down whether using it is better than not using it. Furthermore, its effectiveness on hard and soft tissue healing will be extracted to later compare and criticize. Other regenerative therapies will also be included as means of comparison to PRP, to be able to further analyze and criticize PRP. A

protocol will be formulated as a step-by-step guide to prepare PRP by collecting all the information provided by the studies.

To conduct this review, multiple resources have been utilized, primarily including databases like Medline, PubMed, Dentistry and Oral Sciences Source. These databases mainly served as the resource for past research that has been done on the matter at hand. Meanwhile, resources like Visible Body Suite were also utilized to more effectively explain mechanisms that could make the understanding of simple processes easier. Articles ranged from reviews (systematic and meta-analyses) that helped introduce the topic, to research papers, that were the ones further analyzed in later sections.

Numerous keywords were used to encounter the suitable articles for this review represented by the final formulas that utilized Boolean words AND, OR, NOT to narrow down the search. The following formula was applied in PubMed to retrieve one of the articles analyzed in this review: ((platelet rich plasma) AND (alveolar ridge preservation)) AND (tooth extraction). Th rest of the articles were retrieved from Medline and Dentistry and Oral Sciences Source using the following formula and applying various filters to narrow down the search (platelet rich plasma or prp) AND (alveolar ridge preservation AND tooth extraction OR tooth socket) OR (platelet rich plasma or prp AND wound healing) OR (platelet rich plasma or prp AND alveolar bone grafting OR bone graft) OR (platelet rich plasma or prp AND alveolar clefts) OR (platelet rich plasma or prp AND infrabony defects AND intrabony defect) OR (platelet rich plasma or prp AND regeneration AND bone regeneration OR periodontal regeneration) OR (platelet rich plasma or prp AND sinus lift augmentation) OR (platelet-rich plasma or prp AND implants) AND dentistry.

The final articles specifically chosen for analysis included Clinical Trials and Randomized Controlled Trials. The search includes articles dated from 2010-2024. One of the main exclusion criteria in the selection was the search for human trials exclusively. These articles were either exclusively comparing using PRP or not using it or comparing its use with another technique. PRP will primarily be viewed separately to assess its value and effectiveness. Later, any other techniques compared with PRP will be analyzed to identify any superior ones that could either be more desirable. Such comparison could potentially inform dental professionals and help them make more confident decisions when choosing between PRP and any other technique. The parameters used in each article to analyze the success of the treatment were identified and served as a criterion in the selection of those articles. Other exclusion criteria that helped narrow down the search, included whether studies focused on genetics, microbiology, in vitro studies, studies on unhealthy subjects and general relevance to this review, which rendered those studies irrelevant.

The articles were analyzed to find a common parameter that all of them used to assess their results and evaluate the effectiveness of the procedures. The results from these parameters were later evaluated according to the following point system that helped analyze them further:

Point system:

- 3: Improvement with significant difference between groups
- 2: Improvement with no significant difference between groups
- 1: Improvement but with a slightly worse result than the other technique
- 0: No improvement

Finally, an overall analysis of the results of each study will be presented to provide a more comprehensive understanding of the review at hand, by calculating overall average improvements of the studies included.

4. RESULTS

Platelet Rich Plasma (PRP) has been researched extensively and through this review we analyze 15 research articles that have been published in the last 14 years (figure 4). The aim of each study is briefly presented (table 1).

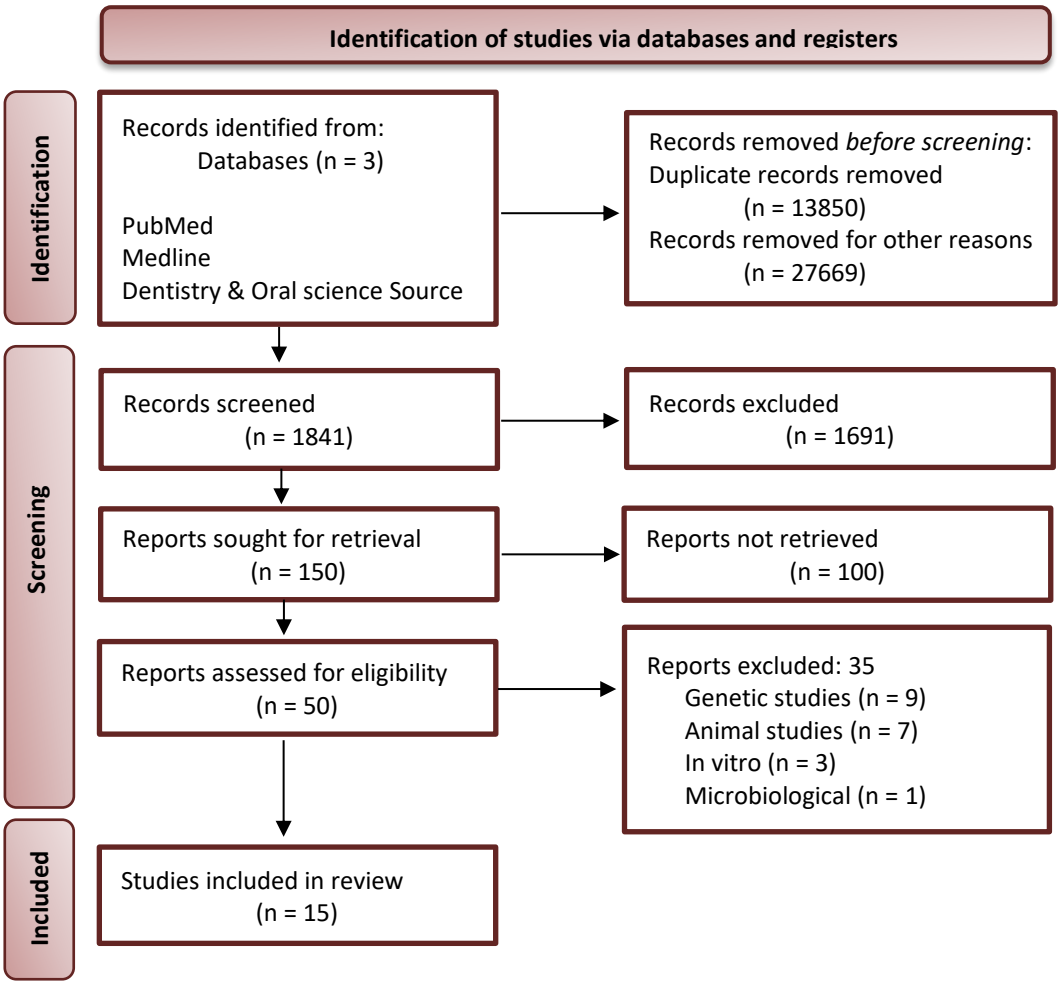

Figure 4: PRISMA flowchart summarizing the retrieval of the 15 articles chosen for further analysis (49).

Table 1: Table showing the list of 15 articles analyzed and discussed in this review. In this table the aim of study is presented.

Author (year)	Type of study	Aim of study
Sharma et al., 2024 (20)	Prospective, single-blinded clinical trial	Mainly compares the use of PRP and PRF in bony defects in children
Badge et al., 2024 (50)	Randomized Clinical Trial	Compares receiving PRP along with bone grafting or not
Dőri et al., 2022 (27)	Randomized Clinical Trial	Study I: Compares the use of PRP with natural bone mineral and a non-resorbable membrane with not using it NBM + GTR *Vs* PRP + NBM + GTR Study II: Compares the use of PRP with β-tricalcium phosphate and a non-resorbable membrane with not using it β-TCP + GTR *Vs* PRP + β-TCP + GTR
Ferreira et al., 2021 (15)	Clinical Trial	Uses allogenic bone grafts reinforced with PRP and compares it to the use of autologous bone grafts alone in cleft palate defects
Nisar et al., 2020 (18)	Randomized Clinical Trial	Highlights the effect of using collagen plug with PRP over just suturing an extraction site
Bezerra et al., 2019 (26)	Pilot study Clinical trial	Uses allogenic bone grafts reinforced with PRP and compares it to the use of autologous bone grafts alone in alveolar cleft defects
Taschieri et al., 2017 (24)	Retrospective analysis (cohort)	Uses P-PRP on extraction sites that receive immediate implant placement
Dutta et al., 2016 (14)	Randomized Clinical Trial	Compares the use of PRP, PRF and HA during post extraction procedures
Suchetha et al., 2016 (19)	Randomized and longitudinal interventional study	Compares PRP and PRF for periodontal regeneration
Schwartz-Arad et al., 2016 (25)	Consecutive retrospective study	Evaluates the combination of PPP and PRP for onlay bone grafts
Agarwal et al., 2016 (17)	Randomized Clinical Trial	Compares the use of PRP and/or demineralized freeze-dried bone graft (DFDBA)
Nathani et al., 2015 (16)	Clinical Trial	Compares the use of PRP and HA during bilateral post extraction procedures

Kumar et al., 2015 (38)	Comparative study Clinical Trial	Compares PRP and Venous Blood in sinus augmentation procedures
Daif, 2013 (23)	Randomized Clinical Trial	Compares whether PRP use is better than not using it
Rutkowski et al., 2010 (21)	Pilot study Clinical trial	PRP on fascilitating wound healing after tooth extractions

Tables 2 and 3 summarize all the information gathered from each article that was considered important for including in this review. The main procedures being described, the number of patients in the studies, how these patients were grouped, the different PRP preparation techniques used, the parameters evaluated, and a summary of the results were all considered as important information to include in this review for further analysis.

Table 2: Summary of the procedure experimented on in each article following the number of patients involved and the groups that were tested and compared between each other. This table also presents the PRP preparation technique utilized by each article and the parameters they focused on to draw their conclusions on.

Author (year)	Procedure	Nº of patients	Groups	PRP Preparation technique	Parameters evaluated
Sharma et al., 2024 (20)	Bone grafting	20	Group I: PRP + nanocrystalline HA and β-TCP Group II: PRF + nanocrystalline HA and β-TCP	Double spin method automated machine PRP activated with $CaCl_2$ and thrombin Later mixed with Sybograft Plus in 1:1 ratio 1300rpm/10min 2000rpm/10min	Color of mucosa Sinus formation Pus discharge Seepage Bone defect density (BDD)
Badge et al., 2024 (50)	ARP	60	Bone graft alone *Vs* Bone graft + PRP	Commercially available PRP kit (no further details were specified)	Bone density Bone height
Dőri et al., 2022 (27)	Bone grafting	72	Study I NBM + GTR *Vs* PRP + NBM + GTR Study II β-TCP + GTR *Vs* PRP + β-TCP + GTR	Curasan double spin Standardized Kit Usually uses: 1500rpm/5-10min 3500-4000rpm 10-15min (time not specified)	Tissue integration of ePTFE membanes Barrier function efficiency CAL Periodontal healing PD

Ferreira et al., 2021 (15)	Bone grafting	30	ALBGs + PRP *Vs* ATBGs	Biofixette system 1000rpm/7min Sodium citrate was used as the anticoagulant	Defect closure Bone augmentation Bone support Bridge formation Stability Aesthetic result Hospital stay
Nisar et al., 2020 (18)	Post-extraction ARP	30 patients 60 sites	Suture *Vs* Collagen plug + PRP	Double spin method 2500rpm/10min 3400rpm/10min Activated by calcium gluconate	Soft tissue healing Bone height Bone width
Bezerra et al., 2019 (26)	Bone grafting	20	ABG *Vs* BBG + PRP	Double spin method (rpm's not specified) activated with $CaCl_2$ and incubated at 37^{o}C for 3mins	Area Volume
Taschieri et al., 2017 (24)	Immediat e implants	109 patients 126 sites	Control P-PRP P-PRP + bone graft	PRGF System, single spin method by BTI Biotechnology Institute 580xg/8min	Implant survival Patient satisfaction Soft tissue healing Complications Bone level
Dutta et al., 2016 (14)	Post-extraction ARP	40	Control PRP PRF HA	Double spin method with venous blood sample combined with CPDA and activated with $CaCl_2$ 2000rpm/15min 3000rpm/10min	Pain Swelling Dry socket Soft tissue healing Bone density
Suchetha et al., 2016 (19)	Bone regenerati on	11 patients 20 defects	PRP *Vs* PRF	Double spin method mixed with citrate and activated by calcium gluconate 2400rpm/10min 3600rpm/15min	PPD CAL Gingival recession Bone length
Schwartz-Arad et al., 2016 (25)	Bone grafting	214 Patients 224 Bone grafts	PRP + PPP	Harvest SmartPrep technique (automated and standardized single spin method) mixing blood with ACD-A 3800rpm/14min	Tissue healing Inflammation Graft integration Bone formation

Agarwal et al., 2016 (17)	Bone grafting	10 patients 28 defects	OFD alone *Vs* PRP alone *Vs* PRP + DFDBA	Single spin method of 3000rpm/10min PRP activated with $CaCl_2$ and thrombin obtained from PPP	PD CAL GI, PI and GI DDR Resolution Crestal bone level
Nathani et al., 2015 (16)	Post-extraction ARP	10 patients 20 sites	PRP *Vs* HA	Double spin method mixed with sodium citrate and activated by $CaCl_2$ 2400rpm/10min 3600rpm/15min	Pain Soft tissue healing Bone density
Kumar et al., 2015 (38)	Sinus lift procedure	50	PRP *Vs* VB	PRP preparation procedure not specified	Implant survival Bone healing
Daif, 2013 (23)	Bone regeneration in trauma sites	24	PRP	Double spin method mixed with sodium citrate and activated by $CaCl_2$ and bovine thrombin 1200rpm/20min 2000rpm/15min	Bone density Wound healing
Rutkowski et al., 2010 (21)	Post-extraction ARP	6 patients 12 sites	PRP	Single spin method mixed with tri-sodium citrate 1150xg/10min	Bone density Pain Bleeding Numbness Facial edema Tempreature Inflammation

Table 3: This table presents each study included and summarizes the results.

Author (year)	**Groups**	**Parameters evaluated**	**Results**
Sharma et al., 2024 (20)	Group I: PRP+ nanocrystalline HA and β-TCP Group II: PRF+ nanocrystalline HA and β-TCP	Color of mucosa Sinus formation Pus discharge Seepage BDD	Evaluated at different time intervals (7 days, 14 days and 1 month). By the 1st month both groups showed satisfactory results in the 1st four parameters. BDD evaluated at 1st, 3rd and 5th month, where, by the 5th month PRF showed more reduction in residual bone defect.

Badge et al., 2024 (50)	Bone graft alone *Vs* Bone graft + PRP	Bone density Bone height	Both bone density and height increased when bone graft was accompanied with PRP, while decrease in both parameters was observed in the group that did not receive PRP with the bone graft.
Dőri et al., 2022 (27)	Study I NBM + GTR *Vs* PRP + NBM + GTR Study II β-TCP + GTR *Vs* PRP + β-TCP + GTR	Histological: Tissue integration of ePTFE membanes Barrier function efficiency Clinical: CAL Periodontal healing PD	Histological: PRP membranes showed less desireable results than the ones treated with β-TCP. Clinical: CAL imporved after 1 year in both studies however no significant difference was observed between each group.
Ferreira et al., 2021 (15)	ALBGs + PRP *Vs* ATBGs	Defect closure Bone augmentation Bone support Bridge formation Stability Hospital stay	The results indicated that the defects treated with PRP showed promising results as far as hospital stay, morbidity and the need for further donor sites.
Nisar et al., 2020 (18)	Suture *Vs* Collagen plug + PRP	Soft tissue healing Bone height Bone width	No significant difference was observed on tissue healing. Grafted sides showed better bone height but not as desirable bone width results.
Bezerra et al., 2019 (26)	ABG *Vs* BBG + PRP	Area Volume	3D radiographical analysis showed favorable for both groups.
Taschieri et al., 2017 (24)	Control P-PRP P-PRP + bone graft	Implant survival Patient satisfaction Soft tissue healing Complications Bone level	2 implants failed in the test groups and no statistical significant difference in the groups regarding survival was observed. 5 P-PRP patients presented biological complications. Soft tissue healing was superior in P-PRP treated groups.
Dutta et al., 2016 (14)	Control PRP PRF HA	Pain, Swelling Dry socket prevention Soft tissue healing Bone density	PRP and PRF showed - Less pain and swelling - Dry socket prevention - Better tissue healing HA was superior in bone density results
Suchetha et al., 2016 (19)	PRP *Vs* PRF	PPD CAL GR Bone length	PRP and PRF showed similar and favorable results with PRF being only slightly better.
Schwartz-Arad et al., 2016 (25)	PRP + PPP	Tissue healing Inflammation Graft integration Bone formation	This study concluded that combining PPP with PRP proves as a safe and reliable method for favorable results for the parameters evaluated.

Agarwal et al., 2016 (17)	OFD alone *Vs* PRP alone *Vs* PRP + DFDBA	PD CAL GR, PI and GI DDR Resolution Crestal bone level	Comparable wound healing at first but uneventful thereof. Improved GI and PI. PRP and PRP+DFDBA both showed good PD reduction, DDR and CAL gain. DDR and resolution were better in PRP+DFDBA group.
Nathani et al., 2015 (16)	PRP *Vs* HA	Pain Soft tissue healing Bone density	Pain, soft tissue healing and radiographical evaluation showed better results on PRP site.
Kumar et al., 2015 (38)	PRP *Vs* VB	Implant survival Hard tissue healing Soft tissue healing	VB showed slightly better results than PRP.
Daif, 2013 (23)	PRP	Bone density Wound healing	PRP showed positive results compared to not using it in both parameters.
Rutkowski et al., 2010 (21)	PRP	Bone density Pain Bleeding Numbness Facial edema Temperature Inflammation	Bone density appeared to be favored by PRP, while the other parameters showed no significant statistical difference except from inflammation.

From the above general tables (tables 2 and 3), further data was extrapolated to encounter possible trends. Out of these 15 articles, 6 were specific to bone grafts, 5 assessed alveolar ridge preservation procedures, 1 evaluated implant survival, 2 were specific to bone regeneration and 1 talked about sinus lift procedure (table 4, figure 5).

Table 4: Summary of the different procedures encountered.

Procedure	Author (year)	Number of studies
Bone grafting	Sharma et al., 2024 Dőri et al., 2022 Ferreira et al., 2021 Bezerra et al., 2019 Schwartz-Arad et al., 2016 Agarwal et al., 2016	6
ARP	Badge et al., 2024 Nisar et al., 2020 Dutta et al., 2016 Nathani et al., 2015 Rutkowski et al., 2010	5
Implant placement	Taschieri et al., 2017	1
Bone regeneration	Suchetha et al., 2016 Daif, 2013	2
Sinus lift procedure	Kumar et al., 2015	1
Total		**15**

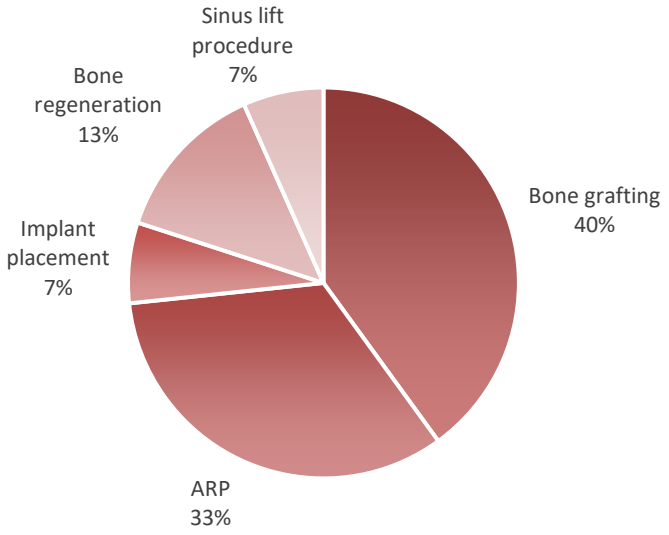

Figure 5: Pie chart representation of the various procedures encountered.

Furthermore, the aim of each study was classified in three groups and summarized in table 5 and figure 6. Eight studies compared using PRP and not using PRP, five of them compared using PRP with other techniques including PRF, HA and VB, while 2 articles introduced other techniques (P-PRP and PPP).

Table 5: Classification of the articles according to the overall aim of their study.

Type of comparison	Author (year)	Number of studies
Using PRP vs not using PRP	Dőri et al., 2022 Ferreira et al., 2021 Badge et al., 2024 Nisar et al., 2020 Bezerra et al., 2019 Agarwal et al., 2016 Daif, 2013 Rutkowski et al., 2010	8
Using PRP vs other techniques		
• PRP vs PRF	Sharma et al., 2024 and Suchetha et al., 2016	2
• PRP vs PRF vs HA	Dutta et al., 2016	1
• PRP vs HA	Nathani et al., 2015	1
• PRP vs VB	Kumar et al., 2015	1
Other techniques		
• P-PRP	Taschieri et al., 2017	1
• Combination of PPP and PRP	Schwartz-Arad et al., 2016	1
Total		**15**

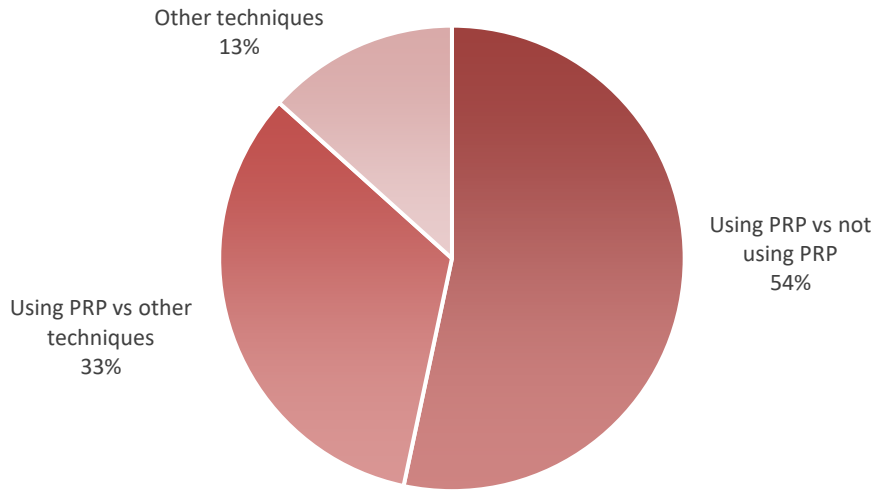

Figure 6: Pie chart representation of the types of comparisons made in the research articles included in the review.

The total number of patients of all the articles used sums up to 706, while the total number of sites which were experimented on sums up to 806, as some of the studies operated on more than one sites on some patients (table 6). Additionally, double spin PRP preparation technique was used by most of the studies (54%), followed by single spin (33%) and lastly only 2 studies did not specify their technique in detail (table 7, figure 7).

Table 6: Table summing up the total number of patients and total number of sites represented by the articles included.

Total Nº of patients	Total Nº of sites
706	806

Table 7: Table summarizing the PRP preparation technique of choice by the articles included.

Double spin	Single spin	Unspecified
8	5	2

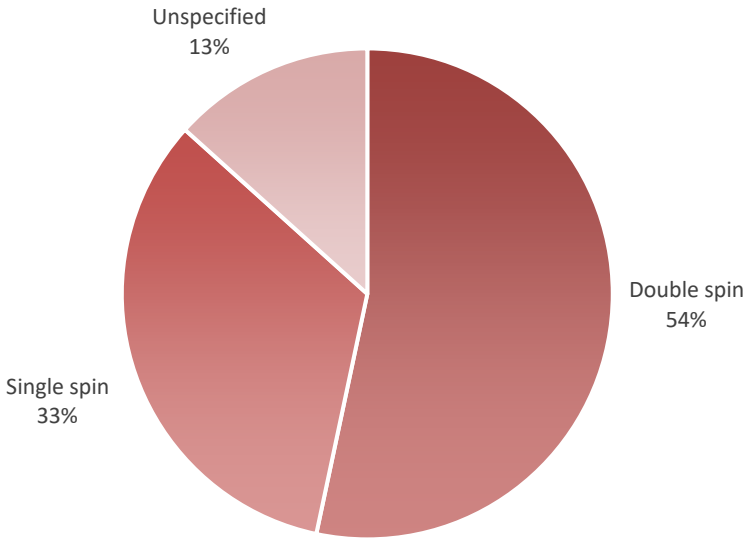

Figure 7: Pie chart representation of the different PRP preparation techniques utilized by the articles included.

According to the most common paramenters evaluated by every article hard and soft tissue healing was further analyzed. Out of the 15 studies, all of them evaluated hard tissue healing, while 13 of them evaluated soft tissue healing. Taking into account the previously mentioned (Materials and Methods) point system, hard tissue healing, showed improvement with significant difference between the study groups in 5 studies, receiving 3 points from the point system, while the majority showed improvement but with slightly worse results than the other technique used, receiving 1 point. The remaining 4 studies received 2 points representing the studies that showed improvement with no significant difference between groups and therefore none of the articles showed no improvement on their results (table 8, figure 8).

Table 8: Results of hard tissue healing parameter following the point system.

Hard tissue healing	Number of studies	Result
Using PRP vs not using PRP	8/8	
Badge et al., 2024		3
Dőri et al., 2022		2
Ferreira et al., 2021		2
Nisar et al., 2020		2
Bezerra et al., 2019		2
Agarwal et al., 2016		1
Daif, 2013		3
Rutkowski et al., 2010		3
Using PRP vs other techniques		
• PRP vs PRF	2/2	
Sharma et al., 2024		1
Suchetha et al., 2016		1
• PRP vs PRF vs HA	1/1	
Dutta et al., 2016		1
• PRP vs HA	1/1	
Nathani et al., 2015		3
• PRP vs VB	1/1	
Kumar et al., 2015		1
Other techniques		
• P-PRP	1/1	
Taschieri et al., 2017		1
• Combination of PPP and PRP	1/1	
Schwartz-Arad et al., 2016		3
Total	**15/15**	

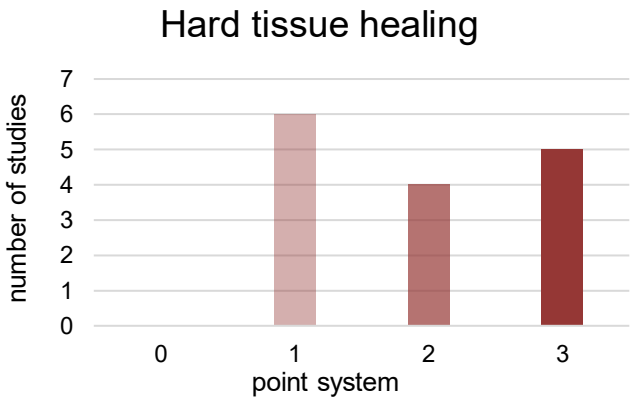

Figure 8: Representation of the number of studies receiving scores from the point system in table 8.

Soft tissue healing, on the other hand, was evaluated by 13 out of 15 articles, and following the point system the majority received 3 points indicating improvement with significant difference between groups and 4 received 2 points indicating improvement with no significant difference between groups. Only 2 studies received 1 point (improvement but with a slightly worse result than the other technique) and 1 received 0 points indicating no improvement (table 9, figure 9).

Table 9: Results of soft tissue healing parameter following the point system.

Soft tissue healing	Number of studies	Result
Using PRP vs not using PRP	6/8	
Dőri et al., 2022		0
Ferreira et al., 2021		3
Nisar et al., 2020		2
Agarwal et al., 2016		2
Daif, 2013		3
Rutkowski et al., 2010		3
Using PRP vs other techniques		
• PRP vs PRF	2/2	
Sharma et al., 2024		2
Suchetha et al., 2016		1
• PRP vs PRF vs HA	1/1	
Dutta et al., 2016		2
• PRP vs HA	1/1	
Nathani et al., 2015		3
• PRP vs VB	1/1	
Kumar et al., 2015		1
Other techniques		
• P-PRP	1/1	
Taschieri et al., 2017		3
• Combination of PPP and PRP	1/1	
Schwartz-Arad et al., 2016		3
Total	**13/15**	

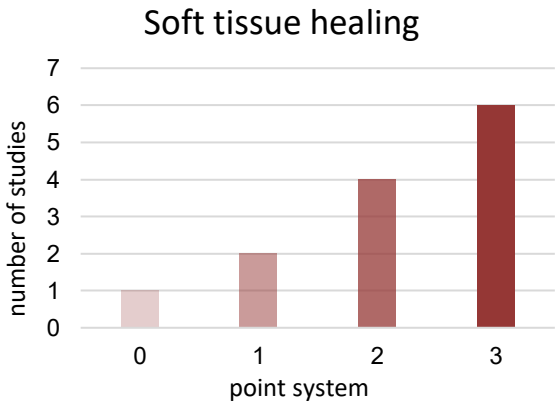

Figure 9: Representation of the number of studies receiving scores from the point system in table 9.

Lastly, the relevant data from each article was extracted and presented in table 10 and figure 10. The average of improvement in hard tissue healing in the different interventions show an improvement of 49.5% in the controls, 71.2% in PRP, 167% in PRF, 112.1% in P-PRP, 533.3% in HA and 245.3% in VB (figure 10A). Soft tissues improved by 49.7% in the controls, 83.9% in PRP, 42.9% in PRF, 95.6% in P-PRP, 48.2% in HA and 245.3% in VB (figure 10B). Having in mind that these are averages that in some cases were taken by only one value, therefore creating considerable differences. Figure 10C represents the overall healing from each intervention with values of 49.6%, 77.6%, 105.2%, 103.9%, 290.8% and 245.3% (in controls, PRP, PRF, P-PRP, HA and VB respectively).

Table 10: Table summarizing the average hard and soft tissue healing of all the articles included.

Author (year)	**Hard tissue healing**			**Soft tissue healing**		
Sharma et al., 2024 (20)		PRP	PRF	100% success in both groups by the 1st month		
	BDD:	77.99	86.14			
	Bone formation:	80.5%	92.3%			
Badge et al., 2024 (50)		Control	PRP	Not evaluated		
	Density:	-0.5	0.9			
	Height:	-1.2	0.8			
Dőri et al., 2022 (27)		Control	PRP		Control	PRP
	Study I	53.6%	61.0%	Study I	56.7%	60.0%
	Study II	51.6%	55.1%	Study II	83.3%	73.3%
	Average	**52.6%**	**58.1%**	**Average**	**70%**	**66.7%**
Ferreira et al., 2021 (15)	Control 79.9%		PRP 79.9%	Improved in test group without a numerical evaluation		

Nisar et al., 2020 (18)		Control	PRP	Equal improvement				
	Length:	32.8%	15.8%					
	Width:	24.7%	14.7%					
	Average	**28.8 ↓**	**0.5% ↑**					
Bezerra et al., 2019 (26)		Control	PRP	Not evaluated				
	Area:	31% ↓	52% ↓					
	Volume:	41% ↓	64% ↓					
	Average	**36% ↓**	**58% ↓**					
Taschieri et al., 2017 (24)		Control	P-PRP	Control	P-PRP			
	Bone loss:	152.8%	112.1%	70.6%	95.6%			
Dutta et al., 2016 (14)	Control	PRP	PRF	HA	Control	PRP	PRF	HA
	105.3%	131.3%	400%	533.3%	47.6%	73.1%	71.4%	48.2%
Suchetha et al., 2016 (19)		PRP	PRF		PRP	PRF		
	PPD:	27.37%	10.2%	CAL:	22.9%	14.4%		
Schwartz-Arad et al., 2016 (25)	82.8% success in all parameters		1.1% failure in bone specific parameters		2.5% failure involving both soft and hard tissue issues		11.1% failure in soft tissue parameters	
Agarwal et al., 2016 (17)		A	B	C		A	B	C
	PD:	52.2%	53.2%	28%	CAL:	33.2%	34.4%	10.4%
	Average	**52.7%**			**Average**	**33.8% ↓**		
Nathani et al., 2015 (16)	PRP		HA		PRP		HA	
	144.29		138.04		44.12%		48.2%	
Kumar et al., 2015 (38)		PRP				VB		
		263%				245.3%		
Daif, 2013 (23)	Bone density	PRP	Control	Improved in test group without a numerical evaluation				
		88.9%	46.8%					
Rutkowski et al., 2010 (21)	Bone density	Control	PRP	Improved inflammation on PRP group				
		45.0%	59.0%					

Average hard tissue healing	Controls	PRP	PRF	P-PRP	HA	VB
	49.5%	71.2%	167.5%	112.1%	533.3%	245.3%
Average soft tissue healing	Controls	PRP	PRF	P-PRP	HA	VB
	49.7%	83.9%	42.9%	95.6%	48.2%	245.3%
Overall healing	Controls	PRP	PRF	P-PRP	HA	VB
	49.6%	77.6%	105.2%	103.9%	290.8%	245.3%

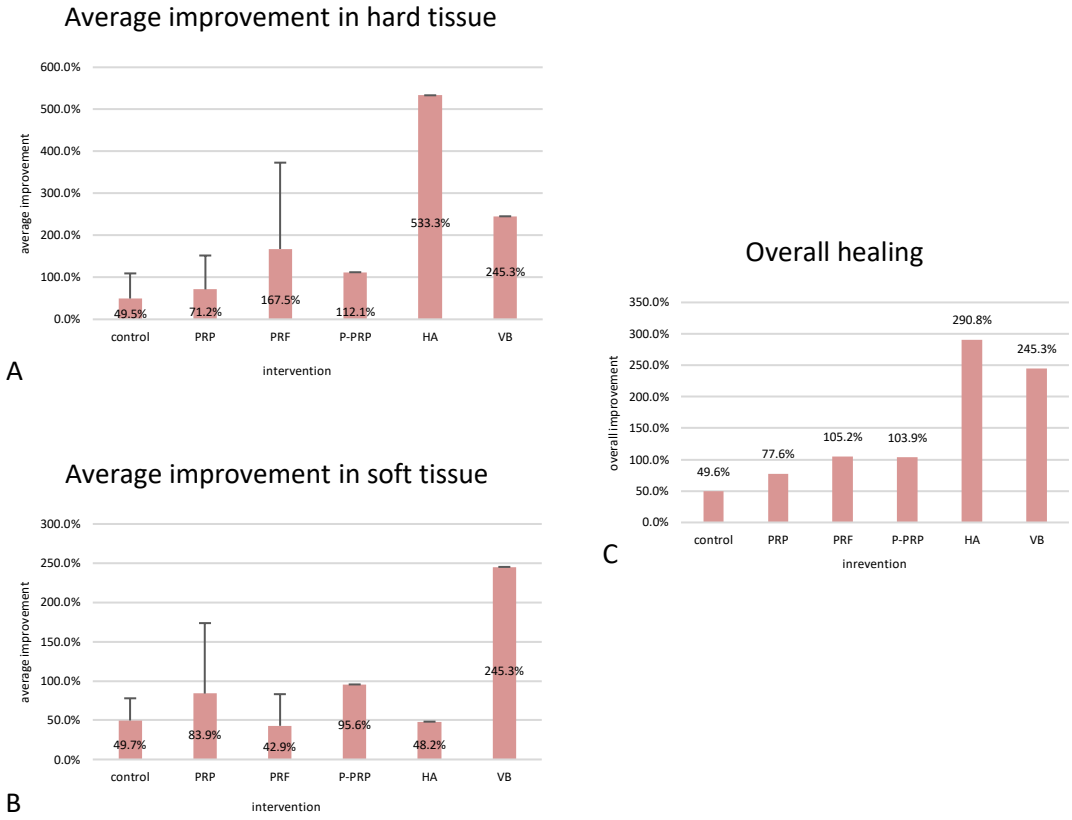

Figure 10: Tables representing the average and overall healing by data extraction from the articles included. (A – hard tissue healing, B – soft tissue healing, C – overall healing).

5. DISCUSSION

Platelet rich plasma (PRP) has been widely investigated in the field of medicine and has made its way into the dental field with a positive attitude. This review encountered studies that involved PRP in procedures like defect regeneration (either periodontal or congenital), post extraction alveolar ridge preservation procedures that may have or may have not been followed by implant placements and finally sinus lift procedures. These studies were either comparing using PRP with not using it or comparing it with other techniques. Generally speaking, using PRP showed positive outcomes, some similar or inferior to other techniques but still beneficial. Overall, the parameters used by each study to evaluate their results shared similar characteristics, mostly surrounding postoperative quality involving soft tissue healing and regenerative outcome.

Focusing on the studies that compared using PRP and not using it we could clearly conclude that PRP showed beneficial outcomes. Badge et al., produced a study about alveolar ridge preservation (ARP) that examined bone grafting alone or accompanied with PRP on extraction sites of 60 patients (tables 1 and 2). Commercially available PRP kit was used, however no further details were shared regarding its protocol. They evaluated bone density and height,

both of which showed favorable results when the graft was accompanied by PRP, while a decrease in these parameters was observed in the group that did not incorporate PRP in the graft (tables 2 and 3). Badge et al. did not only find that using PRP is a good choice, but also indicated that non-PRP sites showed decrease in bone density and height (50). Daif, exclusively evaluated whether using PRP is better than not using it for bone regeneration in trauma sites of 24 patients (tables 1 and 2). PRP was prepared with a double spin method (1200rpm/20min, 2000rpm/15min), mixed with sodium citrate and activated by $CaCl_2$ and bovine thrombin. This study evaluated bone density and concluded that using PRP is better than not using it (tables 2 and 3) (23). Rutkowski et al., evaluated PRP on fascilitating wound healing after tooth extractions on 6 patients and 12 sites (tables 1 and 2). They prepared PRP using a single spin method (1150xg/10min) that was later mixed with tri-sodium citrate. Bone density, pain, bleeding, numbness, facial edema and tempreature were the parameters evaluated and the results showed that bone density appeared to be favored by PRP, while the other parameters showed no significant statistical difference (tables 2 and 3) (21).

Meanwhile, Agarwal et al., compared the use of PRP and/or demineralized freeze-dried bone graft (DFDBA) on 10 patients and a total of 28 defects (tables 1 and 2). The groups included: OFD alone, PRP alone and PRP+DFDBA. PRP was prepared using a single spin method of 3000rpm/10min (PRP activated with $CaCl_2$, and thrombin obtained from PPP). PD, CAL, gingival recession, DDR, resolution and crestal bone level were evaluated, where PRP alone and PRP+DFDBA showed good PD reduction, DDR and CAL gain, while DDR and resolution were better in the PRP+DFDBA group (tables 2 and 3). Overall, the two PRP treated groups, therefore, showed better results than the control group in all parameters with only DDR and resolution favoring the PRP+DFDBA group, proving that PRP is indeed helpful, but more successful when accompanied by a graft (17). Nisar et al., on the other hand compared using collagen plug with PRP with just suturing an extraction site on 30 patients that required bilateral extractions treating one site as the control and the other as the experimental (tables 1 and 2). The PRP preparation technique followed a double spin method (2500rpm/10min and 3400rpm/10min) which was later activated by calcium gluconate. Soft tissue healing, bone height and width were evaluated. This study found no significant difference on tissue healing, while grafted sites showed better bone height and not as desirable bone width results, concluding that PRP is a reasonable option for alveolar ridge preservation procedures (tables 2 and 3). By using 2 different technique on bilateral post extraction ARP procedures where each side, in the same patient was treated differently, eliminated interpatient variables (18).

Dőri et al., was slightly more complex to analyze because they performed their study diving their 72 periodontal patients, that required at least one bone grafting on intrabony

defects, in two groups where each compared using PRP in combination with either NMB+GTR or β-TCP+GTR and compared them with non-PRP treated groups (also represented in tables 1-3). Study I compared the use of PRP with natural bone mineral and a non-resorbable membrane with not using it (NBM+GTR *Vs* PRP+NBM+GTR), while Study II: compared the use of PRP with β-tricalcium phosphate and a non-resorbable membrane with not using it (β-TCP+GTR *Vs* PRP+β-TCP+GTR). They used the Curasan double spin Standardized Kit that usually uses 1500rpm/5-10min and 3500-4000rpm 10-15min, however details were not specified. The parameters evaluated included histological (tissue integration of ePTFE membanes, barrier function efficiency) and clinical (CAL, periodontal healing and PD) findings (table 2). Histologically, NMB membranes were not significantly enhanced by the addition of PRP compared to β-TCP membranes. Clinically, CAL imporved after 1 year in both studies, however no significant difference was observed with or without the addition of PRP. Overall, PRP showed more desirable results when combinated with β-TCP membranes (table 3). Eventhough, this study showed that PRP gave more desireble results when combined with β-TCP+GTR, the clear effect of PRP was not easy to detect due to all the additional variables that were included in each group (27). Nevertheless, it was still an insightful study as it introduced information on another technique.

Moreover, Ferreira et al. and Bezerra et al., also compared using PRP with not using while introducing other protocols. Ferreira et al., used allogenic bone grafts reinforced with PRP and compared it to the use of autologous bone grafts alone in cleft palate defects (table 1). PRP was prepared using the Biofixette system 1000rpm/7min and sodium citrate was used as the anticoagulant. The parameters evaluated included defect closure, bone augmentation, bone support, bridge formation, stability and aesthetic result, where defects treated with PRP proved it to be a useful tool (tables 2 and 3). Ferreira et al., combined their PRP group with ALBGs and compared with using ATBGs alone, where ALBG+PRP showed more favorable results, emphasizing that even though ATBGs have been considered as the gold standard, they present more intraoperative risks, as they are harvested from the patient, by increasing surgery time and involving an additional surgical site. Therefore, they concluded that ALBGs appear to be a good alternative that can be optimized by the help of PRP (15). Bezerra et al.'s study used allogenic bone grafts reinforced with PRP and compared it to the use of autologous bone grafts alone in alveolar cleft defects of 20 patients (tables 1 and 2). Double spin method (rpm's not specified) was utilized to prepare the PRP that was activated with $CaCl_2$ and incubated at 37^{o}C for 3mins. Results were evaluated according to area and volume showing favorable outcomes on both groups, proving that in cases of difficulty in obtaining ABG's, BBG is a good option (tables 2 and 3). In Bezerra et al., even though they technically examined the same idea as Ferreira

(autologous alone Vs allogenous+PRP) and found no significant difference in their outcomes proving that both are successful options, we can conclude that based on the argument that using autologous bone grafts presents more risks and discomfort, they also prove that using allogenous bone grafts accompanied with PRP can be a safer alternative (26).

Suchetha et al., compared PRP and PRF, that differ in their preparation process which influences their platelet concentration (in this study PRP showed higher platelet concentration than PRF), for periodontal regeneration on 11 patients with a total of 20 defects, using a double spin method (2400rpm/10min and 3600rpm/15min) for PRP and PRF preparation that was then mixed with citrate and activated by calcium gluconate (tables 1 and 2). They evaluated each group accoding to PPD, CAL, gingival recession and bone length where PRP and PRF showed similar and favorable results with PRF being only slightly better (tables 2 and 3) (19). The other study that showed better results in the reduction of residual bone defect when PRF was used was Sharma et al., which combined PRP and PRF with nanocrystalline HA and β-TCP to compare them. Sharma et al., performed bone grafts in 20 patients (table 1), that were divided into two groups, where one received PRP+nanocrystalline hydroxyapatite (HA) and β-TCP and the other PRF+nanocrystalline HA and β-TCP. Therefore, their main objective was to compare PRP with PRF. PRP was prepared using a double spin method at 1300rpm/10min and 2000rpm/10min and was later activated with $CaCl_2$ and thrombin and mixed with Sybograft Plus in 1:1 ratio. The parameters they used to analyze each group were the color of the mucosa in the first and second week, and, sinus formation, presence of pus discharge and seepage in the second week and at the post operative month. Bone defect density (BDD) was another parameter that was analyzed at the first, third and fifth month (table 2). Table 3 summarizes that both PRP and PRF showed satisfactory results in the first four parameters by the 1st month. PRF showed slightly superior results over PRP in the reduction of the residual defect (BDD). From Suchetha et al. and Sharma et al., can therefore be concluded that PRP still remains a good auxiliary for tissue regeneration and that it is comparable with PRF with PRF being only slightly superior (20).

On the other hand, Dutta et al., compared the use of PRP, PRF and HA during post extraction procedures on 40 patients, therefore introducing HA in their comparison (tables 1 and 2). Double spin method (2000rpm/15min, 3000rpm/10min) was utilized for PRP and PRF preparation that was combined with CPDA and activated with $CaCl_2$. Evaluation parameters included pain, presence of dry socket, swelling, soft tissue healing and bone density. PRP and PRF proved useful regarding pain, wound healing, dry socket prevention and swelling. Regarding bone density, HA was the one that showed superior results to PRP and PRF, suggesting that it presents better bone conductivity, but it is important to mention that PRP and PRF were superior to the control sites, proving that their use remains a good option (tables 2 and 3). They

further explained that HA's porosity is what allows osteogenic cells to grow (14). Nathani et al., compared the use of PRP and HA during bilateral post extraction procedures on 10 patients with a total of 20 sites (tables 1 and 2). Double spin method (2400rpm/10min, 3600rpm/15min) was used for PRP preparation that was then mixed with sodium citrate and activated by $CaCl_2$. Pain, soft tissue healing and bone density were evaluated where all parameters showed better results on PRP site (tables 2 and 3) (16). One difference these studies present (Dutta et al. and Nathani et al.) is the PRP preparation method, which is a variable that influences the outcomes. Therefore, a study that evaluates PRP preparation methods and compares the outcomes could be of great importance.

A sinus lift procedure study was conducted by Kumar et al. on 50 patients to compare PRP and venous blood outcomes (tables 1 and 2). While they did not specify their PRP preparation technique, we were provided with insightful information on implant survival, soft and hard tissue healing slightly favoring the use of VB over PRP (tables 2 and 3). They argued that VB could be a cheaper alternative to PRP, that is also less time consuming as it does not require any complex devices for its preparation while also eliminating the use of anticoagulants, risk of infection and it can be used globally (38). Furthermore, the study conducted by Schwartz-Arad et al., evaluated the combination of PPP and PRP for onlay bone grafts on 214 patients with a total of 224 bone grafts (tables 1 and 2). Harvest SmartPrep technique which is an automated and standardized single spin method (3800rpm/14min) was used mixing the blood with ACD-A. Tissue healing, inflammation, graft integration and bone formation were evaluated, proving that combining PPP with PRP proves as a safe and reliable method for favorable results for the parameters evaluated (tables 2 and 3). Donor and recipient sites were treated with PRP and later covered with PPP proving that the addition of PPP enhanced the integration of the bone graft and therefore improved bone formation (25). Taschieri et al., used P-PRP on extraction sites that received immediate implant placement on 109 patients and a total of 126 implants (tables 1 and 2). The patients were divided in a control, P-PRP and a P-PRP with bone graft groups. They used the PRGF System for their P-PRP preparation, which is a single spin method by BTI Biotechnology Institute (580xg/8min). They evaluated implant survival, patient satisfaction, soft tissue healing and the presence of complications. Two implants failed in the test groups and no statistical significant difference regarding survival was observed. Five P-PRP patients presented biological complications and soft tissue healing was superior in P-PRP treated groups (tables 2 and 3). Using P-PRP instead of PRP, that only differ in their composition, where P-PRP does not include leucocytes or fibrin, which is responsible for activating catabolic reactions due to the high pro-inflammatory cytokine presence (51). Tissue healing was superior in P-PRP treated groups proving it to be another beneficial version of PRP (24).

The aforementioned studies, as previously mentioned, more or less have evaluation parameters that mainly focus on the same aspects. A review study has mentioned that another important parameter that could be evaluated is neural regeneration (52). Implant placement and tooth extractions are procedures that face the risk of nerve damage. They mentioned the use of PRF to induce limited but fair motor and sensory recovery on a 12cm gap caused by trauma on the ulnar nerve. They imply that with an improvement of technique, a protocol could be formulated to implement it more often, as they observed reduction of pain and avoided amputation of said extremity (53). It was also mentioned that there have been animal and in vitro studies that implement the use of PRP to investigate its effects on neural regeneration, emphasizing the encouragement of further studies that could provide insightful results for further implementation of such protocol (52).

Overall, this review demonstrates that deciding on whether PRP is valuable for use in oral surgery and implantology, clearly leans towards the use of PRP. Furthermore, the effectiveness of PRP is more evident in soft tissues rather than hard tissues was highlighted. Comparing PRP with other regenerative techniques bring PRP to a slight disadvantage compared to PRF and VB. The objective of formulating a recommended protocol for the preparation of PRP was also achieved, however, it is important to mention that it is only a guide, therefore further familiarity with the different systems in the market is strongly advised.

6. CONCLUSIONS

The benefits of using PRP and derivatives prove to outweigh the drawbacks in the majority of the studies included, therefore inviting dental practitioners to consider its use during implant placements and generally in a variety of other oral surgical procedures. Soft tissue healing, postoperative pain and swelling, as well as bone regeneration appear to be the main benefits of using PRP. Along with the above benefits we reach the following conclusions:

1. Overall, using PRP is indeed better than not using it.
2. The results demonstrated that PRP is more effective in soft rather than hard tissues.
3. Limitations and challenges assessed by comparing the use of PRP with other regenerative techniques, lead to the conclusion that PRF and VB showed similar or slightly superior outcomes.
4. A step-by-step protocol was formulated to help visualize the process of preparing PRP and be able familiarize professionals that would use the procedure for the first time.
5. Among the evaluation parameters encountered in the studies investigated in this review, neural regeneration was not one of them. PRP and derivatives have proven to be safe, promising and show fast and positive outcomes, therefore, further

investigations could now focus on nerve regeneration procedures that could prove significant advancements in oral surgery to either avoid complications or to potentially face them when they do appear.

7. SUSTAINABILITY

Economically, PRP appears to offer a cost-effective solution by promoting faster recovery using a cheaper auxiliary help for ensuring positive outcomes in implantology and oral surgery. It reduces treatment durations by often avoiding additional surgeries and consequently reduces healthcare costs. Environmentally speaking, PRP systems implement autologous materials, decreasing the morbidity in cases of animal-derived or synthetic products, or completely avoiding the use of allogenous materials when it is either used alone or accompanied with autologous bone grafts, reducing the environmental impact due to waste produced by the production of biomaterial. Socially, PRP enhances patient satisfaction by improving tissue healing time, minimizing or preventing complications. From an ethical point, PRP preparation is performed from the patient's blood, therefore risk of infection transmittance is eliminated.

This review reflects a commitment to sustainable healthcare through the promotion of treatments that are innovative and exhibit responsibility towards the economic, environmental, social as well as ethical standpoints, therefore contributing to the sustainable advancement of the dental field providing broader goals.

Abbreviations:

- ABG: Autologous Bone Graft
- ACD-A: Anticoagulant Citrate Dextrose Solution A
- ALBG: Allogenic Bone Graft
- ARP: Alveolar Ridge Preservation
- ATBG: Autogenous Bone Graft
- BBG: Bovine Bone Graft
- β-TCP: β-Tricalcium Phosphate
- CAL: Clinical Attachment Level
- CPDA: Citrate-Phosphate-Dextrose-Adenine
- DDR: Defect Depth Reduction
- DFDBA: Demineralized Freeze-Dried Bone Graft
- GI: Gingival Index
- GR: Gingival Recession
- GTR: Guided Tissue Regeneration
- HA: Hydroxyapaptite
- NMB: Natural Bone Mineral
- OFD: Open Flap Debridement
- P-PRP: Pure Platelet Rich Plasma
- PD: Probing Depth
- PI: Periodontal Index
- PPD: Probing Pocket Depth
- PPP: Platelet Poor Plasma
- PRF: Platelet Rich Fibrin
- PRP: Platelet Rich Plasma
- VB: Venous Blood

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