WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

ASSESSMENT OF PLATELET-RICH PLASMA IN ACCELERATING BONE HEALING IN MAXILLOFACIAL SURGERY: A REVIEW

Dr. Senthil Kumar .K1,Dr Sowmiya .G.B [2*], Dr Tushar.S[2] ,Dr. Mohammed Afradh .K[3], Dr. Sathish Kumar[3]

[1] Professor ,
[2]Junior Resident, Department of Oral and Maxillofacial Surgery, Thai Moogambigai Dental College and hospital, Chennai.
Corresponding author:
[2*]Dr Sowmiya.G.B,
Junior Resident,
Department of Oral and Maxillofacial Surgery
Thai Moogambigai Dental College and hospital,
Chennai.
Mail id: sowmiyabrindhaavanan@gmail.com
Contact number: 9445544870
[3] Reader

ABSTRACT :

This review assesses the efficacy of platelet-rich plasma (PRP) in enhancing bone healing within maxillofacial surgery. PRP, a blood derivative rich in growth factors, is utilized to accelerate bone regeneration through various mechanisms, including promoting cellular proliferation and collagen synthesis. The review explores clinical applications of PRP, such as its role in mandibular fractures, sinus lifts, and dental implant procedures. It highlights studies showing PRP's potential to improve soft tissue healing and augment bone density, although results are mixed regarding its impact on long-term outcomes and bone quality. Key findings indicate that while PRP can benefit initial healing phases, its effectiveness varies based on application methods and biomaterials used in conjunction. The review also addresses limitations, such as inconsistent results and the need for standardized protocols. Future research should focus on optimizing PRP preparation and application techniques, understanding its interaction with different biomaterials, and conducting larger, well-designed clinical trials to confirm its benefits and define best practices.

Keywords: Platelet-rich plasma (PRP), bone healing, maxillofacial surgery, mandibular fractures, sinus lift, dental implants, clinical outcomes, growth factors.

INTRODUCTION :

Platelet-rich plasma (PRP) is a therapeutic modality derived from a patient's own blood, which is processed through centrifugation to concentrate platelets and growth factors. This concentration is pivotal for its application in maxillofacial surgery, where PRP is utilized to accelerate bone healing.[1] The centrifugation process must be performed with precision and under sterile conditions to ensure the effective separation of platelets from red blood cells, maintaining their integrity and avoiding any damage that could impair their functionality. PRP was first introduced to the oral surgery field by Whitman et al., and has since gained prominence for its role in enhancing bone regeneration.[2] The therapeutic efficacy of PRP is largely attributed to its rich content of growth factors, including Platelet-Derived Growth Factor (PDGF), Transforming Growth Factor-Beta (TGF-β), Vascular Endothelial Growth Factor (VEGF), and Epidermal Growth Factor (EGF). These factors are essential for promoting cellular proliferation, collagen synthesis, and angiogenesis—key processes in bone repair and regeneration. PRP, particularly when used as Platelet-Rich Growth Factor (PRGF), has demonstrated remarkable clinical success in oral and maxillofacial surgeries by improving outcomes such as bone integration in grafts, enhancing the healing of fractures, and increasing the success rates of dental implants.[3] The utilization of PRP in these contexts is based on the premise that higher concentrations of platelets and their growth factors significantly contribute to more efficient and effective bone healing by stimulating the body's natural regenerative processes.[4] Platelets are crucial for hemostasis and wound healing, playing a key role in the repair process across various types of wounds. The growth factors contained in platelet α-granules are vital for the differentiation and proliferation of cells at the wound site, such as fibroblasts, endothelial cells, and osteoblasts, which are essential for effective healing. Given their significant role, extensive research is being conducted on the impact of platelets in different fields, including maxillofacial surgery, oral implantology.[5] Platelet-Rich Plasma (PRP) is a cost-effective and easily prepared treatment that can be used in outpatient

settings due to advancements in machinery. However, the blood collection required for PRP preparation is invasive, which may limit its routine use for all patients. Additionally, while PRP offers numerous benefits, it is important to consider potential inhibitory effects, such as those from the TSP-1 factor, which can negatively impact the healing process.[6] This review article offers a detailed assessment of the role of PRP in accelerating bone healing within the realm of maxillofacial surgery, evaluating its impact, clinical outcomes, and the underlying mechanisms that contribute to its therapeutic benefits.

PRP: GENERAL APPLICATIONS IN ORAL AND MAXILLOFACIAL SURGERY

Platelet-rich plasma (PRP) has frequently been tested for bone reconstruction in dental implant surgery, yet its applications extend beyond this field. Despite its potential, the literature on general PRP applications remains limited. The initial interest in PRP began with Marx et al.'s study on its use in large bone grafts for maxillofacial reconstructive surgery.[6,7] PRP has been evaluated in various situations, such as treating alveolar clefts, bone defects after tumor resections, and fibrous dysplasia. Results have been mixed, with some studies showing benefits while others do not. The impact of PRP in stimulating bone healing remains debated. PRP may offer significant advantages in specific clinical scenarios.[8] For patients on bisphosphonates, PRP could help mitigate delayed bone and soft tissue healing, potentially preventing bisphosphonate-induced osteonecrosis. Similarly, PRP's coagulation factors might aid in managing delayed bleeding and promoting early healing in anticoagulated patients. Additionally, PRP could be beneficial in post-tumoral bone defect reconstruction in irradiated tissues. Though PRP's benefits are evident in compromised tissue conditions, its use in healthy tissues remains less clear.[9] PRP has shown promise in soft tissue healing and bone regeneration but lacks conclusive evidence for its efficacy in other maxillofacial applications. In contrast, leukocyte- and platelet-rich fibrin (L-PRF), a newer technology, has demonstrated positive results, particularly in treating anticoagulated patients and bisphosphonate-induced osteonecrosis. L-PRF's solid form allows it to fill cavities effectively and support tissue regeneration.[10,11]

REVIEW OF LITERATURE

In a study by Niimi, K, the effectiveness of PRP was evaluated for managing tooth extraction sockets. Fischer rats had three upper molars extracted, and PRP was prepared from the blood of other rats. PRP was applied to the bone defects in the experimental group, while the control group received no treatment. On day 3, the experimental group showed a fibrin network and granulation tissue rich in blood capillaries under the PRP layer, whereas the control group only had inflammatory cells and a fibrin network. By day 7, both groups exhibited granulation tissue, but the control group had less development. The study concluded that PRP promotes early inflammatory reactions and the formation of a rich, vessel-dense granulation tissue, suggesting it can enhance wound healing in tooth extraction sites and improve outcomes.[12] In a review by Yangming Zhang, preclinical studies demonstrated a generally positive impact of PRP on osteoblast-like cells in vitro and on bone healing in animal models. The combination of fixation surgery and PRP injection is commonly used for treating bone fractures in both animal and clinical studies. Clinical findings indicate that PRP can reduce the duration of bone healing but does not significantly enhance the healing rate of closed fractures. The functional outcomes of PRP treatment remain debated. Furthermore, compared to control groups, PRP does not increase the rate of postoperative wound infections.[13] In a study by Mohanty, Liza, PRP was applied to the surgical area, with follow-ups at 2, 4, and 6 months. Soft tissue healing was assessed by measuring probing depth in adjacent teeth, while hard tissue healing was evaluated through changes in alveolar bone density and height.[14] The PRP group showed greater reductions in probing depth and increases in alveolar height and density compared to the control group, indicating faster healing. Additionally, complications such as trismus and pain were less frequent in PRP-treated patients. Overall, PRP enhanced wound healing and reduced complications in oral surgical procedures. In a study by Iwona Niedzielska involving 50 patients, PRF was placed in one alveolus following the extraction of two maxillary or mandibular teeth, while the other alveolus was left untreated. Surgical management was performed using a split flap technique. Evaluations on extraction day, after 10 days, and at 6 months showed better soft tissue healing in the PRF group. After 6 months, the newly formed bone in the PRF group had higher grayscale values on CBCT imaging, indicating improved bone quality and reduced alveolar atrophy at the extraction site.[15] In a study by Maidah Hanif involving 130 patients, the effectiveness of PRP in managing pain and trismus after impacted mandibular wisdom tooth removal was assessed over 6 months. Patients were divided into two equal groups, with pain measured using the Visual Analogue Scale (VAS) and trismus assessed with a Vernier caliper at various time points. Results showed significantly lower pain levels and reduced trismus in the PRP group by the 7th day post-surgery, indicating that PRP is effective in alleviating these symptoms. In a study by Kailas T. Gawai, platelet-rich plasma (PRP) was applied to one of two extraction sockets in patients with bilateral impacted mandibular third molars, while the other socket was left untreated. Clinical and radiological evaluations using digital OPG were conducted at 1 week, 1 month, 2 months, and 4 months. PRP enhanced early bone healing at 1 month but showed no additional benefit for bone healing by 4 months. However, PRP significantly improved soft tissue healing compared to the untreated control group.[16] In a study by Syed Akbar Abbas Zaid, the use of PRP in the alveolar socket following tooth extraction was found to enhance soft tissue healing and positively influence bone regeneration. The application of PRP resulted in increased root lengthening, apex closure, and dentin wall thickening, all of which support pulp tissue rejuvenation and further root development.[17]

ROLE OF GROWTH FACTORS AND CYTOKINES IN PRP FOR BONE REGENERATION

The quest for optimal bone healing strategies has led to the exploration of Platelet-Rich Plasma (PRP) therapy, valued for its concentrated autologous growth factors and cytokines. Research on PRP's role in bone healing focuses on three main areas: inflammatory cytokines, growth factors, and angiogenic factors. These elements coordinate cell signalling, tissue regeneration, and angiogenesis during bone repair. During bone healing, inflammation is critical. PRP's platelets release cytokines like IL-1, IL-6, and TNF-alpha, which regulate the inflammatory response, recruit immune cells, and initiate bone repair. IL-1 and TNF-alpha play significant roles in recruiting osteoblasts, while IL-6 is involved in callus remodeling and mineralization. PRP's growth factors, including PDGF, TGF-β, and IGF-1, are essential for bone healing. PDGF promotes blood vessel formation and collagen synthesis, enhancing ECM

formation and osteogenesis. TGF-β stimulates osteoprogenitor cells and supports ECM development, while IGF-1 regulates bone formation and resorption, improving bone tissue strength. Angiogenesis is crucial for supplying nutrients and oxygen to the injury site. VEGF in PRP drives new blood vessel formation, while angiogenin aids in collateral circulation. These factors ensure an adequate blood supply and support the healing process. PRP contains factors like serotonin, histamine, dopamine, calcium, and adenosine, which influence inflammation, cell function, and wound healing. These factors enhance immune response, blood clotting, and inflammation modulation.[19] Refining PRP preparation techniques focuses on optimizing platelet concentration, crucial for therapeutic effectiveness. Various methods, such as single-spin and double-spin centrifugation, affect platelet and leukocyte concentrations. Research indicates no consensus on the ideal concentration, as different methods produce varying effects on bone healing. Commercial PRP kits also show significant variability in platelet and leukocyte concentrations, highlighting the need for careful selection based on clinical needs.[20]

PREPARATION METHODS AND CLINICAL OUTCOMES

Over the past decade, considerable efforts have focused on refining PRP (Platelet-Rich Plasma) preparation techniques to optimize platelet concentration, crucial for its therapeutic effectiveness in bone healing. While PRP has been shown to positively affect osteoblast differentiation and proliferation, there is no consensus on the ideal platelet concentration. Marx et al. set a minimum platelet concentration of 1,000,000 platelets/μL, but the FDA requires a minimum of 250,000 platelets/mL. Some studies suggest that doubling the platelet concentration from peripheral blood improves osteoblast proliferation and reduces bone healing time. Conversely, Jovani-Sancho et al. found that four times the peripheral blood concentration was optimal, while other research has indicated that concentrations below 0.85 × 10^9/mL show no significant effect on osteogenesis. Lower PRP concentrations (1%-5% of peripheral blood levels) may stimulate osteoblast activity, but higher concentrations can cause adverse effects like reduced cell viability and increased pain. The role of leukocytes in PRP is also debated. Leukocyte-rich PRP (LR-PRP) is thought to enhance growth factor variability but may cause more pain and inflammation compared to leukocyte-poor PRP (LP-PRP). For intra-articular treatments, LP-PRP may be preferable, while LR-PRP has shown benefits for chronic tendinopathy. PRP preparation methods include plasma-based and buffy coat-based systems, with variations in single-spin and double-spin processes. Plasma-based systems typically yield lower platelet concentrations, while buffy coat-based systems can achieve higher concentrations but with more leukocytes.[21] Studies have shown mixed results regarding the efficacy of single-spin versus double-spin methods. Commercial PRP kits also vary widely in platelet and leukocyte concentrations, highlighting the need to select a system based on specific clinical needs. Ultimately, the optimal PRP platelet concentration is context-dependent, influenced by the nature of the injury and patient characteristics.[22]

ACTIVATION OF PRP

Activating Platelet-Rich Plasma (PRP) is crucial for its therapeutic effectiveness, transforming platelets into an active state that boosts regeneration. Activation involves two main processes: degranulating platelets to release growth factors (GFs) and converting fibrinogen into fibrin, forming a matrix that retains these factors at the target site. The choice of activator impacts the quantity and release rate of GFs, influencing PRP's efficacy. Traditionally, bovine thrombin is used to rapidly activate PRP. It quickly converts fibrinogen to fibrin, releasing about 70% of GFs within 10 minutes and nearly 100% within an hour. While this method offers fast activation, it can lead to rapid clearance of GFs, limiting their long-term effects and potentially causing immune-related complications. Calcium chloride is another activator that converts prothrombin to thrombin, creating a stable fibrin matrix. It results in a slower, more extended release of GFs, which is beneficial for prolonged healing processes. However, excessive calcium can trigger the clotting cascade too quickly and destabilize the fibrin clot. Type-1 collagen has been explored as an alternative to bovine thrombin, showing promise for sustained cytokine release. However, recent studies suggest it may not be as effective as thrombin or calcium chloride, with weaker activation and lower GF release. In some cases, PRP is used without exogenous activators, relying on natural thrombin present in the tissue. This method can lead to variable GF release and has shown less clinical improvement compared to activated PRP in some studies. Selecting the right activator is vital for optimizing PRP's therapeutic potential, particularly for bone healing where sustained GF release aligns with the slow, complex nature of bone regeneration. Ongoing research aims to refine PRP activation techniques to enhance patient outcomes.[23]

DELIVERY OF PRP

The method of delivering Platelet-Rich Plasma (PRP) significantly impacts its effectiveness for bone healing. PRP is commonly administered through direct injection, topical application, or alongside surgical procedures. Direct injections target growth factors precisely where needed, enhancing the regenerative process. Using ultrasound guidance can further improve delivery precision. Topical PRP application at wound or surgical sites can promote tissue repair and accelerate healing. Combining PRP with bone grafts, such as autografts or synthetic materials, aims to enhance graft integration and bone healing, though results can vary. To achieve sustained release of growth factors, researchers use scaffolds as delivery vehicles. Scaffolds like hydrogels, sponges, and nanofiber-based structures help maintain PRP at the injury site and control the release of growth factors. Hydrogels made from alginate or gelatin have shown effectiveness in bone regeneration, with studies demonstrating that PRP within these hydrogels can stimulate osteogenic differentiation and cell proliferation. Incorporating bioactive inorganic materials, such as carbonated hydroxyapatite (CHA), into PRP scaffolds has shown promise for enhancing bone formation. Research has indicated that combining PRP with CHA or calcium phosphate cement can improve bone healing and vascularization. Additionally, bonding PRP to plasma polymers or coating nanofibers with PRP can further enhance scaffold performance and support cell growth. These varied approaches highlight the potential for optimizing PRP delivery systems to enhance bone healing through controlled release and scaffold integration.[24]

PRP AND BONE REGENERATION

The impact of platelet-rich plasma (PRP) on bone regeneration has been inconsistent across various studies. While some research suggests that PRP

enhances osteoblast proliferation and bone healing, other studies report no significant benefits. The effectiveness of PRP is influenced by the type of bone graft biomaterial used, which can vary widely, including autologous, xenogeneic, allogeneic, and synthetic materials. The combination of PRP with these materials has produced mixed results, with some studies showing positive effects on bone healing and others indicating no improvement. In animal models, the results are equally varied. PRP gels have been reported to have no impact on bone regeneration alone or in combination with certain grafts, while other studies highlight significant benefits when used with autologous bone or synthetic materials.[25] These discrepancies might be attributed to differences in healing phases, the type of biomaterial, or the specific PRP formulation used. The optimal use of PRP might depend on the proportion and type of bone biomaterial, though this remains challenging to control in clinical practice. PRP's role may be more supportive, enhancing natural bone healing rather than directly stimulating bone growth. The effectiveness of PRP is also influenced by the quality of the PRP product and its compatibility with the bone graft.[26]

PRP DURING SINUS-LIFT SURGERY

Sinus-lift surgery is an effective model for studying bone healing. This procedure involves lifting the sinus membrane (Schneiderian membrane) after making a lateral osteotomy to create a subantral cavity. This cavity is filled with a bone graft, and after several months of healing, dental implants can be placed. Sinus-lift grafting is generally successful, with various bone materials (autologous, allogeneic, xenogeneic, or synthetic) typically providing good results for bone healing and implant survival. The subantral cavity acts as a natural regenerative chamber, protected from oral biomechanical forces by the Schneiderian membrane, which has osteogenic properties. Research often focuses on improving bone quality and accelerating healing for early implant placement. An alternative approach involves placing implants during the sinus-lift procedure, which eliminates the need for a second surgery. In this method, implants are used to maintain the sinus membrane in position, while the cavity is filled with bone material or a natural blood clot. A blood clot alone can provide adequate peri-implant bone volume. This technique underscores the importance of maintaining a regenerative chamber where the blood clot facilitates new blood vessel formation and bone cell proliferation. Adding PRP or L-PRF to this setup can be beneficial by enhancing these processes. Overall, sinus-lift surgery offers a valuable in vivo model for evaluating bone healing and biomaterials. After a few months, large bone samples can be collected for histological analysis when implants are placed, making it an excellent model for testing bone biomaterials. Despite this, results from studies using PRP in various configurations with different bone materials have been inconsistent.[27,28,29]

EFFECTS OF PRP ON HEALING THE ALVEOLAR SOCKET AFTER TOOTH EXTRACTION

Tooth extraction is a routine dental procedure often performed on severely damaged or impacted teeth. Postoperative issues such as pain and prolonged bleeding, especially in patients on anticoagulants, are common. Various methods, like fibrin sponges and laser biostimulation, have been used to aid recovery. Recently, Platelet-Rich Plasma (PRP) has been explored for its high concentration of growth factors to enhance tissue repair. This approach aims to improve healing quality and speed, though human studies have shown mixed results. Studies found that PRP significantly improved soft tissue healing and reduced complications like dry sockets and inflammation compared to untreated controls. Patients with PRP experienced less pain, particularly in the first three days after extraction. Some studies observed that PRP-treated sockets showed increased radiographic density and quicker bone healing within two weeks compared to control sites. Celio-Mariano et al. (2012) also noted better bone density in PRP-treated sockets after mandibular third molar extraction. In contrast, Arenaz-Bua et al. (2010) found no significant differences in bone formation, pain, swelling, or infection between PRP-treated and non-treated sites after six months. Similarly, Gurbuzer et al. (2008) using scintigraphy found no increased osteoblastic activity in PRP-treated sockets compared to controls. Overall, while PRP seems to improve soft tissue healing and accelerate early bone formation, its impact on long-term bone regeneration and pain relief remains inconclusive. The evidence suggests that PRP is beneficial in the initial healing phase but its effectiveness decreases over time.[29,30]

PRP IN ORAL SURGERY

PRP has shown promise in enhancing both soft tissue and bone regeneration in oral surgery. Studies indicate that PRP can accelerate healing and improve outcomes in procedures involving soft and hard tissues. In bone surgeries, Daif (2012) found that applying PRP to mandibular fractures can boost bone regeneration. Wojtowicz et al. (2007) observed increased bone formation when PRP was used alongside autologous bone marrow, outperforming treatments with stem cells alone. Khairy et al. (2012) noted that while PRP did not enhance bone density at 3 months, it did show benefits at 6 months post-grafting. Poeschl (2012) reported successful results using PRP in maxillary sinus augmentation. PRP can also be applied to implant surfaces to potentially enhance osseointegration. Anitua (2006) demonstrated improved implant integration with PRP-coated surfaces. Gentile et al. (2010) and Anand et al. (2012) found that PRP enhanced patient satisfaction and treatment outcomes in various oral surgeries, including implantology. Overall, PRP is effective for soft tissue healing and bone regeneration. Combining PRP with other biomaterials, especially in sinus lifting and implant surgery, shows promise, though results can vary depending on the materials used.[28-34]

RISK/BENEFIT RATIO OF PRP

PRP, made from a patient's own blood, is considered safe due to its autologous nature, with no reported risks of infection, disease transmission, or immunogenic reactions associated with allografts or xenografts. Historically, the use of bovine thrombin in PRP preparation posed risks of coagulopathy, but these were mainly linked to high doses. Modern PRP methods use calcium chloride for activation, which has not been associated with adverse effects. Concerns about overexpression of growth factors and potential tumor risks exist, but these are speculative. Continuous high doses of growth factors, rather than those in PRP, are needed to promote neoplastic growth. PRP should be avoided in patients with precancerous oral conditions or a history of

carcinogen exposure. The primary drawback of PRP is its cost versus the benefits. The expense of PRP processing systems and disposable kits might not always justify the outcomes, and patients must undergo a blood draw. However, PRP is relatively easy to obtain and doesn't significantly extend the duration of a surgical procedure. Preparation takes about 30 minutes and can be done concurrently with the surgery, minimizing additional chair time.[16,17]

CONCLUSION :

There is debate over PRP's benefits due to variability in study outcomes and PRP preparation methods. Some studies show significant improvements, while others report minimal or no benefits. The optimal platelet concentration and activation methods remain uncertain. Effective PRP preparation requires careful use of anticoagulants and coagulants. Calcium chloride is commonly used to activate PRP, but variations in activation methods do not significantly affect outcomes. PRP should be used soon after preparation to maximize growth factor benefits. Despite promising results, more research is needed to validate PRP's clinical efficacy and standardize preparation protocols. The potential of PRP in treating bone, cartilage, and soft tissue defects remains high, but more evidence is required to support its widespread clinical application. PRP has shown promise in aiding bone and tissue regeneration, but the variability in results and the need for further research make it crucial for clinicians to evaluate the benefits and limitations before adopting PRP widely in practice.

REFERENCES :

1. Anitua E. The use of plasma-rich growth factors (PRGF) in oral surgery. *Pract. Proc. Aesth. Dent.* 2001;13:487–493.
2. Bacevich BM, Smith RDJ, Reihl AM, Mazzocca AD, Hutchinson ID. Advances with Platelet-Rich Plasma for Bone Healing. *Biologics*. 2024;18:29-59
   https://doi.org/10.2147/BTT.S290341
3. Alisson, Moreira, Araújo., K., Mesquita., M., Azevedo., E., Ribeiro., K., Brígido., Jandenilson, Alves, Brígido. (2023). Use of platelet-rich fibrin (PRF) in dental surgical procedures. Research, Society and Development, doi: 10.33448/rsd-v12i2.39811
4. López S, Vilar JM, Sopena JJ, Damià E, Chicharro D, Carrillo JM, Cuervo B, Rubio AM. Assessment of the Efficacy of Platelet-Rich Plasma in the Treatment of Traumatic Canine Fractures. Int J Mol Sci. 2019 Mar 1;20(5):1075. doi: 10.3390/ijms20051075. PMID: 30832280; PMCID: PMC6429238.
5. Altaf, H, Malik., Ajaz, Shah., Rubeena, Tabasum., Manzoor, A., Malik. (2013). Use of platelet-rich plasma in the cystic lesions of the jaws: a comparative study. Egyptian Journal of Oral & Maxillofacial Surgery, doi: 10.1097/01.OMX.0000428092.16894.95
6. Marx, R.E., Carson, E.R., Eichstaedt, R.M., Schimmele, S.R., Strauss, J.E. and Geogeff, K.R. (1998) Platelet-Rich Plasma: Growth Factor Enhancement for Bone Grafts. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology, 85, 638-646.
7. Marx, R.E. (2001) Platelet-Rich Plasma (PRP): What Is PRP and What Is Not PRP? Implant Dentistry, 10, 225-228. https://doi.org/10.1097/00008505-200110000-00002
8. Hatakeyama, I., Marukawa, E., Takahashi, Y. and Omura, K. (2014) Effects of Platelet-Poor Plasma, Platelet-Rich Plasma, and Platelet-Rich Fibrin on Healing of Extraction Socket with Buccal Dehiscence in Dogs. Tissue Engineering: Part A, 20, 874-882.
9. Dutta, S.R., Singh, P., Passi, D. and Pattter, P. (2015) Mandiblar Third Molar Extraction Wound Healing with and without Platelet Rich Plasma: A Comparative Prospective Study. Journal of Oral and Maxillofacial Surgery, 14, 808-815.
10. Massimo, Franchini., Mario, Cruciani., Carlo, Mengoli., Francesca, Masiello., Giuseppe, Marano., Ernesto, D'Aloja., Cristina, Dell'Aringa., Ilaria, Pati., Eva, Veropalumbo., Simonetta, Pupella., Stefania, Vaglio., Stefania, Vaglio., Giancarlo, M., Liumbruno. (2019). The use of platelet-rich plasma in oral surgery: a systematic review and meta-analysis.. Vox Sanguinis, doi: 10.2450/2019.0177-19
11. (2022). Effect of Application of Platelet-Rich Plasma on Bone Regeneration after Removal of Jaw Cysts..
12. Niimi, K. , Yoshizawa, M. , Koyama, T. , Funayama, A. , Mikami, T. and Kobayashi, T. (2017) An Experimental Study on the Effects of Platelet Rich Plasma on the Wound Healing of Tooth Extraction-Related Bone Defects. *Open Journal of Stomatology*, **7**, 327-335. doi: 10.4236/ojst.2017.78027.
13. Zhang Yangming , Xing Fei , Luo Rong , Duan Xin , Platelet-Rich Plasma for Bone Fracture Treatment: A Systematic Review of Current Evidence in Preclinical and Clinical Studies, Frontiers in Medicine, 8, 2021 https://www.frontiersin.org/journals/medicine/articles/10.3389/fmed.2021.676033, DOI=10.3389/fmed.2021.676033
14. Mohanty, Liza[1]; Harish, Abhishek[2]; Mangalekar, Sachin B.[3]; Jethlia, Ankur[4]; Lunkad, Honey[5]; Jeevitha, Jessica Y.[6]; Makkad, Ramanpal S.[7]. Evaluating the Efficacy of Platelet-Rich Plasma (PRP) in Accelerating Healing and Reducing Complications in Oral Surgery. Journal of Pharmacy And Bioallied Sciences ():10.4103/jpbs.jpbs_84_24, April 24, 2024. | DOI: 10.4103/jpbs.jpbs_84_24
15. Niedzielska I, Ciapiński D, Bąk M, Niedzielski D. The Assessment of the Usefulness of Platelet-Rich Fibrin in the Healing Process Bone Resorption. *Coatings*. 2022; 12(2):247. https://doi.org/10.3390/coatings12020247
16. Hanif M, Sheikh MA. Efficacy of platelet rich plasma (PRP) on mouth opening and pain after surgical extraction of mandibular third molars. J Oral Med Oral Surg 2021;27:9.
17. Syed, Jaffar, Abbas, Zaidi., B., Arain., Nosheen, Khawar., Sana, Adeba, Islam., Alvina, Ali, Shaikh., Syed, Sajjad, Ali, Zaidi. (2023). Platelet Rich Plasma PRP in Dental and Oral Surgery: Wound Healing to Bone Regeneration. Pakistan Journal of Medical and Health Sciences, doi: 10.53350/pjmhs2023173287
18. Ajay, Premanand, Desai., N, Sahoo., Arani, Pal., S., Roy, Chowdhury. (2021). Efficacy of Platelet-Rich Plasma in Enhancing the Osteogenic Potential of Bone Graft in Oral and Maxillofacial Region. Journal of Maxillofacial and Oral Surgery, doi: 10.1007/S12663-020-01378-Z
19. Milind, R, Gharpinde., Aditya, Pundkar., Sandeep, Shrivastava., Hardik, Patel., Rohan, Chandanwale. (2024). A Comprehensive Review of Platelet-Rich Plasma and Its Emerging Role in Accelerating Bone Healing. Cureus, doi: 10.7759/cureus.54122

20. Gawai KT, Sobhana CR. Clinical evaluation of use of platelet rich plasma in bone healing. J Maxillofac Oral Surg. 2015 Mar;14(1):67-80. doi: 10.1007/s12663-013-0605-5. Epub 2014 Jan 9. PMID: 25729230; PMCID: PMC4339326.
21. A., Rahman. (2022). Effects of platelet-rich fibrin in the surgical extraction of mandibular third molar: A systematic review and meta-analysis. SRM Journal of Research in Dental Sciences, doi: 10.4103/srmjrds.srmjrds_46_22
22. Suthanraj, Ak., Nirmala, devar., V., P., D., V., M., V. (2023). Platelet Rich Fibrin (PRF) - A Novel Regenerative Material in oral and maxillofacial surgery - A LITERATURE REVIEW. Medical research archives, doi: 10.18103/mra.v11i1.3538
23. N, S, Kedarnath., P, R, Abhilash. (2011). Role of Platelet-Rich Plasma in Healing after ImpactedMandibular 3rd Molar Surgery.
24. Uma, Shanker, Pal., Shadab, Mohammad., Rakesh, Kumar, Singh., Somdipto, Das., Nimisha, Singh., Mayank, Singh. (2012). Platelet-rich growth factor in oral and maxillofacial surgery.. National journal of maxillofacial surgery, doi: 10.4103/0975-5950.111340
25. A, Albanese., Maria, Ester, Licata., Bianca, Polizzi., Giuseppina, Campisi. (2013). Platelet-rich plasma (PRP) in dental and oral surgery: from the wound healing to bone regeneration. Immunity & Ageing, doi: 10.1186/1742-4933-10-23
26. Daif ET: Effect of autologous platelet-rich plasma on bone regeneration in mandibular fractures. Dent Traumatol. in press.
27. Wojtowicz A, Chaberek S, Urbanowska E, Ostrowski K: Comparison of efficiency of platelet rich plasma, hematopoieic stem cells and bone marrow in augmentation of mandibular bone defects. NY State Dent J 2007, 73:41–45.
28. Esposito M, Grusovin MG, Rees J, Karasoulos D, Felice P, Alissa R, Worthington HV, Coulthard P: Interventions for replacing missing teeth: augmentation procedures of the maxillary sinus. Cochrane Database Syst Rev 2010, 17, CD008397.
29. Khairy NM, Shendy EE, Askar NA, El-Rouby DH: Effect of platelet rich plasma on bone regeneration in maxillary sinus augmentation (randomized clinical trial). Int J Oral Maxillofac Surg. in press.
30. Poeschl PW, Ziya-Ghazvini F, Schicho K, Buchta C, Moser D, Seemann R, Ewers R, Schopper C: Application of platelet-rich plasma for enhanced bone regeneration in grafted sinus. J Oral Maxillofac Surg 2012, 70:657–664.
31. Cabbar F, Güler N, Kürkcü M, Işeri U, Sençift K: The effect of bovine bone graft with or without platelet-rich plasma on maxillary sinus floor augmentation. J Oral Maxillofac Surg 2011, 69:2537–2547.
32. Anitua EA: Enhancement of osseointegration by generating a dynamic implant surface. J Oral Implantol 2006, 32:72–76.
33. Gentile P, Bottini DJ, Spallone D, Curcio BC, Cervelli V: Application of platelet-rich plasma in maxillofacial surgery: clinical evaluation. J Craniofac Surg 2010, 21:900–904.
34. Anand U, Mehta DS: Evaluation of immediately loaded dental implants bioactivated with platelet-rich plasma placed in the mandibular posterior region: a clinico-radiographic study. J Indian Soc Periodontol 2012, 16:89–95