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The current and potential future uses of platelet-rich plasma in orthodontics

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Abstract

Platelets are a rich source of growth factors and by careful preparation of venous blood it is possible to derive Platelet-Rich Plasma (PRP) as well as Platelet-Rich Fibrin (PRF). The last few decades has seen a growth in the use of PRP and PRF in dentistry, predominantly related to dental implants, oral surgery and periodontology. There is emerging literature on the use of these derivatives in orthodontics and some promising animal studies have been reported that suggest faster tooth movement and therefore shorter treatment time. Enhanced wound healing and reduced pain experience in corticotomy patients has also been reported as well as varying outcomes in the treatment of secondary alveolar cleft repairs. As clinical trials get underway, we may one day be using PRP and PRF to enhance our orthodontic outcomes.

Introduction

Platelets are a component of blood and are produced in the bone marrow. These cells are one of the initiators in both soft and hard tissue wound healing. Amongst other growth factors, they contain platelet-derived growth factor, transforming growth factor and endothelium growth factor.

The preparation of platelet-rich plasma (PRP) for use in dentistry involves the drawing of whole venous blood in a tube usually containing an anticoagulant (Figure 1). The blood is checked for platelet counts and centrifuged to produce three layers: red blood cells at the bottom, the platelets in the middle and platelet-poor plasma at the top (Figure 2). The platelets and platelet-poor plasma are collected and centrifuged again after which most of the platelet-poor plasma is discarded and PRP remains.

Whilst peripheral blood contains 94% red blood cells, 6% platelets and less than 1% white blood cells, PRP contains 5% red blood cells, 1% white blood cells and 94% platelets [1].

PRP was introduced in the dental literature twenty years ago when used in autogenous bone grafts for the reconstruction of mandibular defects with reports that the addition of PRP to bone grafts resulted in a faster radiographic maturation rate and a higher bone density than bone grafts alone [2]. The ability for PRP to act as fibrin glue has also been documented [3].

The potential benefits of PRP, however, remain controversial. Some authors have found increased bone formation and maturation rates [4,5], others have not found this to be the case [6,7].

Few clinical procedures are risk free and one disadvantage of PRP is that its use may be unsuitable in the needle-phobic pa-

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tient. Since the patient's own blood is used, allergy or immune reaction is not considered to be an area of concern. However, local infection and pain, both at the site of drawing blood and injecting PRP may occur, although this is thought to be extremely rare.

The application of PRP in dentistry initially focussed on implant dentistry and ranged from enhancing osseointegration to augmentation of alveolar bone height in maxillary sinus lifts [8, 9, 10, 11, 12, 13, 14, 15].

In oral surgery, PRP has shown to speed alveolar bone repair after extraction of impacted third molars [16,17]. Similarly, in the treatment of temporomandibular joint disorders, PRP has shown promising results in pain reduction [18, 19].

In periodontal surgery, PRP has shown to accelerate the healing process of wounds and reduce healing time [20] as well as result in significantly more favourable clinical improvements in intraosseous periodontal defects [21].

In dentistry, PRP is usually prepared by mixing with calcium chloride and thrombin to coagulate the platelets into a gel form and activate the growth factors and then is applied to the region of interest; however, some consider this preparation unsuitable for orthodontics [1] since a burst release of all the growth factors results in the PRP being short-acting.

For orthodontics, an injectable form has been considered more suitable without the use of calcium chloride and thrombin so it can be maintained in liquid form and has a longer lasting effect [1]. Platelet-Rich Fibrin (PRF), a second-generation product that can have a more solid form and different characteristics has been reviewed for use in alveolar ridge preservation and guided bone regeneration [22].

PRP applications in orthodontics include its potential use to accelerate tooth movement without any other accelerators of treatment as well the use of PRF to accelerate wound healing and reducing post-surgical pain in patients treated with periodontally accelerated osteogenic orthodontics. It has also been used to potentially promote bone formation in alveolar cleft repair patients. This article will review these uses of PRP and PRF in orthodontics.

PRP and tooth movement

Orthodontic tooth movement is caused by a gradual remodelling of supporting alveolar bone. The process of bone remodelling involves resorption of established bone by osteoclasts and formation of new bone by osteoblasts [23].

Mechanical loads, in particular, orthodontic forces, can also affect the bone remodelling process. The turnover rate of alveolar bone determines the quality and quantity of orthodontic tooth movement. To move teeth faster and to shorten orthodontic treatment duration, the balance between resorption and apposition needs to be altered.

Several non-invasive as well as invasive techniques have been proposed both clinically and experimentally for accelerating orthodontic tooth movement [24]. Non-invasive techniques include the biomechanical approach of using self-ligation brackets [25] or modern aligning wires [26] whereas physiological approaches include direct electric current stimulation [27], low dose laser therapy [28] and vibrational stimulation [29]. There are also pharmacological approaches such as the injection of prostaglandin [30,31] and relaxin [32]. Invasive methods have focussed mainly on corticotomy-facilitated tooth movement [33].

The increasing awareness of orthodontic treatment in all age groups of society with an emphasis on enhancing the rate of tooth movement has been raised by [34]. The methods for generating PRP and the effects on orthodontic tooth movement have been summarised. [34] found the effect of PRP in the localized acceleration of tooth movement to be dependent on the concentration used and advised the method of synthesis is critical to the success of accelerating tooth movement.

Effects of PRP on the rate of orthodontic tooth movement have been investigated by [35] in six skeletally mature male mongrel dogs. The maxillary second premolar in each dog was extracted bilaterally. PRP was prepared and injected around the first premolar in one randomly selected maxillary quadrant while the other quadrant served as the control. Coil springs (150 g) were used to distalise the first premolars for 63 days using temporary anchorage devices. The results showed total maxillary tooth movement was significantly faster on the experimental side compared to the control side (mean movement of 15.60mm versus 9.46mm). Local injection of PRP in this animal study resulted in accelerated orthodontic tooth movement with no obvious clinical or microscopic side effects.

[36] have studied the effects of different concentrations of PRP on alveolar bone density and orthodontic tooth movement. Seventy-six rats were divided into 2 groups: A moderate concentration PRP injection group and a high concentration PRP injection group. In each group, 5-time points were studied: 3, 7, 14, 21, and 60 days. Before orthodontic mesialization of the maxillary first molar, moderate and high concentrations of PRP were injected on the right sides of the molar buccal sulcus, and the left sides served as the controls. Tooth movements were measured on 3-dimensional digital models. Alveolar bone volume density and osteoclastic activity in the first molar intraradicular areas were evaluated by histomorphometric analysis.

The results showed alveolar bone density was decreased in the experimental groups compared with the control groups at 3, 7, 14, and 21 days. On day 3, the osteoclastic activity of the experimental groups was higher than that of the controls. On day 21, the amount of tooth movement in the high-concentration experimental group were 1.7 times greater than in the high-concentration control group and 1.4 times greater than in the moderate-concentration experimental group. On day 60, alveolar bone density increased to original levels in all groups. The study found injection of both moderate and high concentrations of PRP might accelerate orthodontic tooth movement by decreasing alveolar bone density on para-dental tissues by enhancing osteoclastic activity in a transient way.

Faster tooth movement is often not without risk, primarily related to increased risk of root resorption. The rate of root resorption with and without the use of PRP is likely to need investigation with well-conducted clinical trials.

PRP and alveolar bone grafting in cleft patients

Cleft lip and/or palate are one of the commonest congenital anomalies to affect the orofacial region. The use of PRP in the management of these conditions is based on the premise that the platelets release statistically significant quantities of growth factors to aid in bone graft maturation.

In a preliminary study, 20 patients with unilateral or bilateral cleft lip and palate were studied to evaluate the efficacy of PRP for secondary alveolar bone graft procedures [37]. Twenty patients between the ages of 8 and 30 were randomly allocated to receive cancellous bone grafts from the anterior iliac crest mixed with PRP whilst the control group received the same without PRP. No statistically significant differences were found in rates of primary healing and although pain and swelling persisted for longer in the control group; this too was not statistically significant. Bone grafts with the use of PRP did however show significantly more bone density up to 6-months post-surgery (1028.00 +/- 11.30 HU versus 859.50 +/- 27.73 HU). The authors admit that a limitation of this study is the short follow-up period and the small sample size of only 20 participants further limits the findings.

[38] studied bone regeneration and soft tissue healing in 16 patients aged between 9 and 11 years of age with unilateral alveolar clefts. The patients were equally split between those treated with autologous bone grafts alone and autologous bone grafts with PRP and then followed up for 36 months. The authors found that the autologous bone graft group with PRP were able to undergo significantly earlier and shorter orthodontic treatment with mean time to orthodontics 155.0 days compared to 298.4 days and mean duration of orthodontics 294.5 days compared to 356.0 day.

The preceding study evaluated bone changes using plain film radiography, however, [39] used computed tomography. The authors acknowledge the low numbers in their study, with 23 patients receiving autologous iliac cancellous bone and marrow grafts with PRP and 6 patients the same intervention without PRP. All patients were aged between 7 and 8 and were not randomly allocated. Results of the quantitative analysis of the graft sites showed the mean remaining bone was not significantly different between those treated with PRP and those without at 1 year post-surgery.

This is consistent with earlier work that suggested PRP may enhance bone remodelling in the early phase but it seems to be insufficient as a counter measure against bone resorption following secondary bone grafts in the long term [40].

PRF and periodontally accelerated osteogenic orthodontics

Periodontally Accelerated Osteogenic Orthodontics (PAOO) is a procedure that is thought to accelerate tooth movement by combining orthodontic forces with corticotomies and grafting of alveolar bone plates. Such corticotomy/osteotomy procedures are not new and were described over half a century ago [41].

[42] have studied post-operative pain, inflammation, infection and post-orthodontic stability by using Leukocyte and Platelet-Rich Fibrin (L-PRF) in PAOO. Eleven patients in need of orthodontic treatment whom were considered periodontally suitable were monitored immediately post-operatively and then 2 years post-treatment.

Accelerated wounding healing with no signs of infection or adverse reactions was observed and post-surgical pain was described as mild or moderate. Complete resolution was achieved in all patients by day 8 and active orthodontic treatment time was reported to be 9.3 months. All cases were deemed stable for 2 years. While these results are promising, the small number of patients enrolled in the study and the absence of a control group will warrant further studies in this area.

A case report has also been presented in the literature of a patient with a high buccal canine and bimaxillary protrusion where PRF was used alongside other treatment modalities. This was thought to enhance the healing of a segmental osteotomy and a localised single tooth corticotomy around the canine, all of which were performed under local anaesthesia. The authors conclude that this resulted in a decrease in canine retraction time [43].

PRF and alveolar ridge preservation in orthodontics

[22] have proposed the use of PRF to mimimize resorption of hard tissues immediately post-extraction. The authors put forward that by preserving the alveolar ridge at this time in orthodontic cases, the problems of orthodontic tooth movement, root resorption, alveolar bone cleft and gingival invagination could be minized. This would be achieved by ensuring there is sufficient alveolar bone during space closure. Similarly, where extractions are followed by pre-prosthetic orthodontics, PRF use may contribute to preservation of hard tissue morphology improving the condition of implant sites and making for more aesthetic restorations.

Conclusion

The application of PRP and PRF is becoming well established in many fields of both medicine and dentistry. While use in areas such as implant dentistry and oral surgery may seem obvious, in orthodontics, we are only just starting to see the publication of a handful of studies. It is anticipated the use of PRP and PRF is likely to extend beyond just tooth movement however, the clinical efficacy of this rapidly evolving area will need to be carefully watched as laboratory based studies are undertaken in clinical practice. Where clinical studies have been done already, these are often limited to small numbers of patients and this may, for the time being, limit the widespread use of PRP and PRF in orthodontics. Further studies should involve well-planned randomised controlled trials investigating not only the potential benefits of PRP and PRF but also any potential risks or complications.

Figures

Figure 1: The drawing of venous blood.

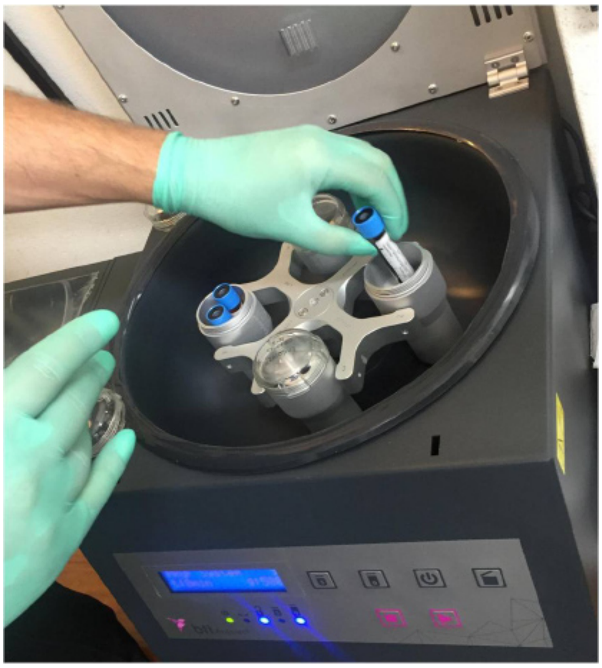

Figure 2: The centrifuging of blood.

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