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Background: This case report describes extraction of a fractured right maxillary central incisor tooth, followed by immediate placement of a dental implant in the prepared socket and temporization by a bonded restoration.

Materials and Methods: The tooth was extracted with minimal hard and soft tissue trauma and without flap reflection. The socket was prepared to the required depth and a Straumann Implant was inserted. An impression was made 4 months after implant insertion, and a definitive restoration was placed.

Results: The atraumatic operating technique and the immediate insertion of the Implant resulted in the preservation of the hard and soft tissues at the extraction site. The patient exhibited no clinical or radiologic complications through two years of clinical monitoring after loading.

Conclusion: The dental implant and provisional restoration provided the patient with immediate esthetics, function, comfort and most importantly preservation of tissues.

KEY WORDS: Implant, Immediate placement, Temporization.
INTRODUCTION

Endosseous dental implant therapy is rapidly becoming the prosthetic standard of care for a vast array of clinical applications, however, despite the high success rate of endosseous implant therapy, it has yet to achieve wide public acceptance and utilization. Endosseous implant therapy in the mandible (parasympyseal mandible) has repeatedly been reported at a success rate of 95% or better, yet public utilization of endosseous implant therapy has not exceeded 5%. The most frequently cited reasons for underutilization of endosseous implant therapy are that treatment cost is perceived to be too high and treatment takes too long (Branemark’s original treatment protocols required up to a year or more to complete treatment). An obvious area of focus has been to decrease the amount of time necessary to complete implant therapy. Approaches to achieve this goal have dominated clinical research and practice: delayed/immediate implant loading, improving implant surface technology (promotion of quicker healing and better osseointegration), and immediate placement of an endosseous implant after extraction of a natural tooth. In this paper a case presentation supporting the last of these three approaches will be shown.

The definition for an immediate endosseous implant is extraction of a natural tooth followed by immediate placement of an endosseous dental implant. Immediate implants have become widely accepted despite controversial beginnings and the available literature consistently cites high levels of success (ranging from 94-100% on average), immediate implants provide clinically recognizable benefits. Broadly speaking, these benefits include reduction of morbidity, reduction of alveolar bone resorption. Controlled clinical studies have demonstrated an average of 4.4mm of horizontal and 1.2mm of vertical bone resorption six months after tooth extraction, preservation of gingival tissues, preservation of the papilla in the esthetic zone, and reduction of treatment cost and time. With the extraction socket as a guide, the surgeon can also more easily determine the appropriate parallelism and alignment relative to the adjacent and opposing residual dentition. To maximize the advantage of these benefits and to minimize implant failure, case selection must be based on sound clinical and research criteria. Immediate placement and provisionalization for single tooth replacement allows for minimal disruption of the marginal soft tissues, providing immediate prosthetic support for the peri-implant tissues through the use of a carefully crafted provisional restoration. Primary implantation is fundamentally indicated for replacing teeth with pathologies not amenable to treatment, such as caries or fractures. Immediate implants are also indicated simultaneous to the removal of impacted canines. Immediate implantation can be carried out on extracting teeth with chronic apical lesions which are not likely to improve with endodontic treatment and apical surgery.

The surgical requirements for immediate implantation include extraction with the least trauma possible, preservation of the extraction socket walls and thorough alveolar curettage to eliminate all pathological material. Primary stability is an essential requirement, and is achieved with an implant exceeding the alveolar apex by 3-5 mm, or by placing an
implant of greater diameter than the remnant alveolus. Esthetic emergence in the anterior zone is achieved by 1-3 mm sub-crest implantation. The existence of an acute periapical inflammatory process constitutes an absolute contraindication to immediate implantation.8,9

In the case of socket-implant diameter discrepancies in excess of 5 mm, which would leave most of the implant without bone contact, prior bone regeneration and delayed implantation may be considered.10 Avoid teeth with large or acute periapical infection; Teeth with labial bony dehiscence or fenestration defects; Insufficient bone apically to ensure primary stability of the implant; Systemic factors that may impair healing (e.g. smoking); Large bulbous root morphology, Interproximal bone loss (aesthetic zone), active periodontitis.
A 45-year-old male patient presented with a history of trauma and crown fracture at the cervical area of tooth FDI 11 (figs. 1-2) and requested an immediate solution. Clinical and radiological evaluation revealed adequate alveolar bone, absence of periapical pathology but fracture line was below the crest of alveolar bone and was limited to the tooth. So, it was decided to extract and place endosseous implant immediately and place a provisional restoration to avail the benefits like
After administering appropriate antibiotic and analgesic, induction of local anesthesia was carried out using xylocaine 2% with adrenaline 1:200,000. As preservation of alveolar bone is key to success of immediate implants, extraction of tooth has to be atraumatic, so using periotomes and small periosteal elevators the fragment was luxated without excessive enlargement of the socket, and using an innovative method where endodontic file was used to engage the canal wall and tooth fragment was slowly luxated and pulled out of the socket using the file (figs. 3, 4).

The sockets were debrided with curettes and a dental implant was planned (Straumann 4.1x14mm). The drilling sequence was carried out (fig. 5) and after checking for primary stability (fig. 6), which was achieved by advancing the implant into the bone beyond the apex of the socket, a provisional crown was attached to the implant (figs. 7, 8). Xenograft was then packed between the implant and labial socket wall and covered with a guided bone regeneration barrier.
Interrupted sutures were placed to close the flap (fig. 11). A radiograph was taken to see the implant placement and was found to be satisfactory. Post operative instructions were given to the patient, and was asked to report after 1 week. The sutures were removed after 7 days and the patient received temporary acrylic crown bonded to the adjacent teeth with fibre-reinforced composite on the same day. The patient was recalled after four months for the prosthetic procedures and was given porcelain fused to metal crown over the implant. He was recalled for prophylaxis and follow up every three months. The clinical and radiographic appearances at six months and after one year show good aesthetic result and acceptable osseointegration of the implant (figs. 12-14).

**DISCUSSION**

Implant placement subsequent to tooth extraction in conjunction with the use of provisional restorations in the anterior maxillary region is certainly challenging for the dental practitioner. However, this treatment modality offers several advantages, including reduced clinical time, a single local anesthetic injection, a flapless procedure and immediate placement of the implants. From the patient’s point of view, the immediate incorporation of a fixed implant supported provisional restoration is very acceptable and even requested. With the clinical procedure described here, both dentist and patient can evaluate the aesthetics of the restoration. Soft-tissue support is enhanced and achievement of the desired result is facilitated. With initial implant stability, proper tissue management and correct use of the available implant components, a predictable aesthetic result can be produced. On the other hand, occlusal control, oral hygiene and a regular
recall program should be considered prerequisites for maintaining a long-lasting restoration.

Single-tooth implants have shown high success rates in both the anterior and the posterior regions of the maxilla and the mandible. Immediate post-extraction implant placement has been done since the early years of the clinical application of implants with very good clinical outcomes. Decisive factors for immediate implant placement are lack of infection in the periodontal tissues and an intact tooth socket. Immediate incorporation of a temporary restoration has been presented in the literature with encouraging results. Although clinical experiences have advocated this clinical technique for many years, more extended long term clinical studies are necessary to prove the efficacy of the method and establish a stable clinical protocol.

**CONCLUSION**

This case report describes a technique to preserve and augment anterior aesthetics by combining atraumatic teeth extraction, hard and soft tissue augmentation, immediate provisionalization and using the platform switching concept to preserve the buccal plate. The gingival tissue surrounding the implants has remained stable with no recession two years following final crowns placement (fig. 14). The implant therapy must fulfill both functional and esthetic requirements to be considered a primary treatment modality. Aiming to reduce the process of alveolar bone resorption and treatment time, the immediate placement of endosseous implants into extraction sockets achieved high success rate of between 94-100%, compared to the delayed placement.

**Disclosure:**
The authors report no conflicts of interest with anything mentioned within this article.

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In the mid-1990’s, a fortuitous experience realized by utilizing a small diameter abutment with a larger diameter dental implant established a “switch” in platform diameter between the abutment and the endosseous dental implant. This relocation of platform-to-abutment diameter, referred to as a Platform Switch, has been found to reduce marginal loss of crestal bone, provides better implant stress distribution, and offers favorable results in biological width. Certainly, there are numerous clinical advantages to dental implant systems with a Platform Switch macrostructural design feature. Unfortunately, a Platform Switch does not resolve problems related to tissue recession, dental implant exposure, and deficiency in vertical bone height due to lack of flexibility for clinicians to change the crown margin location. The purpose of this article is to review clinical benefits of the Platform Switch as well as to provide additional perspective on the macrostructure design problems that account for the remaining clinical issues such as tissue recession and implant exposure that have yet to be solved. A new concept with respect to a reduction of platform diameter is introduced.

**KEY WORDS:** Dental implants, platform switching, micro-gap, gingival recession, implant design

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INTRODUCTION
Contributing factors that lead to minor or advanced recession of hard and soft tissue will invariably result in the failure of an endosseous implant placement. Generally, facial/buccal plates resorb 1.5 mm-2 mm\(^1,2\) within the first year after surgery which means that, in combination with subsequent bone loss, it may result in implant thread exposure and subsequent implant failure.\(^3,4\) An expectation of 0.1 mm - 0.2 mm of bone resorption will apply to each subsequent year.\(^5,6\)

Lazzara and Porter were the first to develop an ideology of shifting an implant-abutment junction towards a centralized location to confine the inflammatory cell infiltrations within a 90-degree region which reduces the loss of marginal bone loss.\(^7\) By relocating the interfacing region between abutment and implant surface area toward a central axis, the micro gap is relocated away from the contacting surface of the crestal bone.\(^8\) This design limits concentrations of infiltration zone (Figure 1).

OVERVIEW OF PLATFORM SWITCHING
There are specific benefits of a Platform Switch design that include an enhanced prevention in micro gap infiltrations, reduced tissue exposure/recession, and an advantage against dental implant exposure. These are contributing factors that serve to significantly reduce resorption of crestal bone.\(^9,10\) Platform Switch is the concept of utilizing a smaller diameter abutment in relation to the interfacing surface of the implant platform diameter.\(^11,12\) Post-restorative biologic process resulting in the loss of crestal bone height is altered when the outer edge of the implant-abutment interface is horizontally repositioned inward.\(^13\) Platform Switch offers the additional benefit of maintaining biological width and offers better stress distribution to a myriad of clinical
applications. Additionally, a decrease in crestal bone loss ensures a greater chance of success for the duration of a placed implant in alveolar bone when using the Platform Switch design. Canullo et al., stated that Platform Switch on marginal bone level was discovered to be “dose-dependent”, meaning a greater platform-abutment mismatch resulted in the least marginal bone loss. It was concluded the degree of abutment-to-implant interface may significantly change the outcome of peri-implant marginal bone remodeling.

**BENEFITS OF A PLATFORM SWITCH**

**Micro Gap**

At the time of implant insertion, surfaces of an implant and adjoining components are unpol- luted and uninhabited by indigenous microbiota. When utilizing a two-piece implant system, a microscopic gap resides between the contacting surfaces of the implant and the abutment (Figure 2). Although surface contact is established between both components (implant and abutment), infiltration of bacteria is generally unavoidable. Numerous clinical issues may result from colonization of bacteria within a “micro gap.” They include soft tissue inflammation/migration and a potential shift in the innate apical reestablishment of a biologic width. Colonization of bacteria or microbial will ultimately lead to resorption of crestal bone. A deterioration of hard tissue will often resorb crestal bone to the first thread of an endosseous dental implant and invariably lead to implant failure. The degree of inflammation in peri-implant tissues is less around one-piece dental implants because of the lack of micro gap when compared to two-piece implants with a micro gap which results in a significant loss in crestal bone. Furthermore, the cervical portion of endosseous implants typically exhibits a degree of bone resorption. However, in the case of a Platform Switch, a saucerization (in surgical applications) creates an evacuation of tissue to form a shallow shelving depression to facilitate drainage. Confining and draining areas established serve to prevent excessive bone resorption. This design is particularly critical for achieving good results in maxillary aesthetic zones. It also ensures an enhanced stability for dental implants within alveolar bone.

**Biological Width**

In order to obtain a satisfactory esthetic and functional result of an implant placement, the preservation of crestal bone around endosseous implants and maintenance of the gingival papilla is imperative. Numerous factors including excessive occlusal stress can cause bone resorption or even failure of dental implant–bone interface. However, an absence of stress could also result in atrophy or even bone loss. Not only does a Platform Switch design confine bacte-
rial infiltration, but it also provides a better result in maintaining aesthetic and structural integrity of gingival tissue. Junctional epithelium and connective tissue adjacent to the tooth, referring to the area between the deepest point of the gingival sulcus and the alveolar bone crest, is known as the biologic width (Figure 3). When fabricating dental restorations, this distance is important to consider because they must respect the natural architecture of the gingival attachment if harmful consequences are to be avoided. The biologic width is patient specific and may vary from 0.75-4.3 mm. Becker et al., could not differentiate the Platform Switch and the control groups statistically in an animal study and found that Platform Switch could prevent apical downgrowth of the barrier epithelium in 28 days.37, 38

Since a Platform Switch macrostructure helps prevent crestal bone resorption as well as an apical recession of the gingival sulcus and junctional epithelium, it can be concluded that Platform Switch may help to maintain biological width and prevent excessive tissue recession which can lead to a higher probability of implant success.39-42

Cappiello et al. offered a clinical and radiographic prospective study in a control group that showed a reduction in bone resorption to 0.95 mm compared to 1.67 mm of a control group. The Platform Switch design was responsible for the resulting benefit of limited bone loss.43

**Better Stress Distribution**

Platform Switch allows for bone remodeling around an implant, enhancing the ability for maintenance of the bone crest with a reduction in stress in the cervical region of the dental implant.44-46 Maeda et al. suggested that the platform-switching configuration has the biomechanical advantage of shifting the stress concentration area away from the cervical bone-implant interface, resulting in less post-loading bone resorption.47

Maeda et al. in a 3D finite element analysis, found the biomechanical advantages of platform switching. They noted that this design feature shifts the stress concentration away from the bone-implant interface, however these forces then increased in the abutment or the abutment screw as well.48

**Remaining Clinical Issues**

Implant exposure and tissue recession generally arises out of issues of infection and rough implant surfaces at the neck area of the dental implant.49-52 Features of Platform Switch serve to solve many clinical implications, but more is needed to ensure an improved clinical result. The Platform Switch design offers a beneficial result with a relocations of micro gap bacteria colonization, a more effective preservation/maintenance of a biologic width and an improved distribution of stress to cortical bone. However, issues with respect to soft tissue recession and implant thread exposure (Figures 4a, 4b) are still not completely resolved. Furthermore, dental implants with a Platform Switch design feature offer limited clinical benefits with respect to patients that may have deficiency in vertical bone height and horizontal bone width.

**SOFT TISSUE RECESSION AND IMPLANT EXPOSURE**

**Infection**

A major contributor for progressive tissue recession is the presence of an infection, either within an extraction zone or bacteria infiltration from an exposed implant thread or micro gap.53 Due to design parameters, Platform Switch
Figure 4a: Radiograph of resorption of alveolar bone leading to implant thread exposure.

Figures 4b, 4c, 4d: Radiographs of dental implants resulting in crestal bone loss.
Endosseous implants require bone-level placement to ensure that the implant platform will not exceed an equal-crestal position in vertical height. This bone-level placement of the implant platform prohibitively affects the limited ability to drain and abate accumulations of bacteria and is not able to compensate for the typical post-extraction bone resorption. When the rough surface area of dental implant threads are inevitably exposed, it tends to accumulate 25 times more plaque than on smooth surfaces.

**Deficiency in Bone Width**

Another clinical issue to consider is when the alveolar crest is thin, establishing any crestal bone loss with subsequent accumulation of bacteria on implant surfaces will lead to secondary peri-implantitis and more bone deterioration. During dental implant site preparation, a surgical application of tapping may result in buccal/facial dehiscence and fenestration. This can aggravate a resorption of thin alveolar crest. Furthermore, this condition could potentially be aggravated by a patient with occlusal overload, which further damages crestal bone (Figure 5a).

**Deficiency in Bone Height**

When limitations in mandibular alveolar bone height exist, placing an implant at bone level may cause damage to the inferior alveolar nerve. If such a deficiency of vertical height prohibits an ability to place an implant at bone level, you cannot sink the platform. Furthermore, exposure of thread surface of a dental implant is unavoidable. This will prove to be an automatic failure if the necessary bone height is not available (Figure 5b). Regarding clinical cases with implant thread exposure or advanced tissue recession, the current designs of most dental implant systems do not allow clinicians to change crown margin location and to accommodate crestal bone loss or tissue recession. In these clinical cases, dentists will have to remove the dental implants or to graft the areas involved, which may involve more complications. Therefore, a new dental implant design is needed to solve these problems in a convenient manner.
A NEW CONCEPT OF PROPOSED PLATFORM REDUCTION DESIGN

The concept of Platform Reduction refers to a reduction in implant platform diameter in relation to the widest area on an implant body. This reduction in diameter of platform creates a slope or steps, which start from the widest portion of dental implant (it locates a couple of millimeters apical to the platform) to the platform surface of a dental implant (Figure 6). The design benefits for clinical implications may include a potential solution regarding thin buccal-lingual plates, a solution to tissue recession, and ability to place implants with minimum vertical bone height. It offers an option to change crown margin locations in case of dental implant exposure or tissue recession.

Thin Buccal Plate – Alveolar Crest
Alveolar bone tends to exhibit a pattern of bone resorption both in vertical and horizontal dimension which results in a more lingually positioned narrow ridge after surgical tooth extraction.\textsuperscript{62,63} This establishment of marginal bone loss is commonly associated with buccal dehiscence and fenestrations.\textsuperscript{64-66} According to Rodríguez-Ciurana et al., 1-2 mm of crestal bone is required to maintain the integrity of tissue to avoid tissue recession.\textsuperscript{67} In order to limit the effect of this marginal bone loss, the intent of a dental implant macrostructural design concept should strive to replicate the natural biological contour of the alveolar ridge, preserving the maximum amount of bone. Since Platform Reduction design does not require tapping and it may allow slight under preparation of implant site during implant surgery, thereby preserving more thin crestal bone facially and lingually (Figures 7, 8a, 8b).
Solving Issues with Tissue Exposure
Based on our clinical experience, Platform Reduction may also provide the added benefit of a “tenting” effect where the surrounding gingiva would rest along the slope of the implant head providing gingival contact along the coronal section of an endosseous implant. This outcome may result in a reduction in apical migration of the biological width, with respect to the gingival sulcus and junctional epithelium, providing a better aesthetic and healthy result. For this concept, the slope (or steps) of the Platform Reduction may serve to prevent unnecessary tissue recession while accommodating the natural biological contour of an alveolar ridge. This possible benefit will require further clinical investigation.

Reducing Negative Effect of Micro Gap
The one-piece dental implant design does not have micro gap. Therefore, there is no horizontal bacteria infiltration.68 With a Platform Reduction design, there may be another potential benefit of placing an implant more coronally, which may allow for intra-oral drainage coronally of bacteria infiltration. This design

Figures 8a,b: Platform Reduction dental implant was placed in narrow ridge to preserve thin buccal or lingual plate.
may drastically prohibit colonization of bacteria infiltrates horizontally which usually leads to bone resorption to the first thread (Figure 9).69

**Change Margin Locations**

Once a dental implant is placed and a crown is affixed to an abutment, in a two-piece implant system, it is difficult to properly accommodate problems related to bone resorption and tissue recession. If a patient is afflicted with issues, such as periodontal disease, deterioration of alveolar bone, or other clinical issues, then these factors may invariably lead to subsequent implant thread exposure. Then, how should a dentist or oral surgeon proceed? Therefore, it is important to design a dental implant that may be placed supragingivally, subgingivally or equal crestally which means there are more options for dentists to position dental implants according to pre-existing alveolar bone deficiencies in vertical height to avoid nerve injury. In other words, the platform design of a dental implant with a Platform Reduction may provide surgeons an advantage of flexibility to compensate for minimum available bone height to prevent nerve injury by allowing the platform of dental implant to be placed supragingivally or supra-crestally (Figure 10). In addition, reduction of an implant platform diameter along a slope or steps also provides an advantage of maximum flexibility for restorative dentists to perform prosthetic correction. In other words, a restorative dentist can assign multiple crown margin locations according to soft tissue level to achieve aesthetic and functional demand (Figure 11).

**CONCLUSION**

After systemic review of Platform Switch design, we found that it is an effective option to reduce marginal bone loss, provide better implant stress distribution and offer favorable results in maintaining biological width. However, a Platform Switch leaves many unsolved problems to many clinical issues. Progressions in technological advancement of dental implant systems will invariably continue. The proposed concept of a reduction in platform diameter may offer numerous clinical benefits to maintain the integrity of gingival tissue and crestal bone. A dental implant with a Platform Reduction macrostructure may be the viable solution to
Figure 10: Placement of dental implant platform at different levels to avoid inferior alveolar nerve damage.

Figure 11: Platform reduction design would allow the dentist to sit crown margins at different steps to prevent injury to the inferior alveolar nerve.
accommodate for tissue recession and implant exposure because it can provide the added benefit of crown margin relocation without requiring dental implant replacement. Since the coronal portion of dental implant body is angled toward a central axis, it follows the biological contour (thinner at coronal portion) of the alveolar ridge. The Platform Reduction architecture may help to preserve a thin buccal plate and prevent crestal bone loss. This should provide additional room for maintaining alveolar bone, building thicker soft tissue and maintaining the tissue structure. However, more clinical studies are needed to prove the proposed benefits.

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Background: Various periodontal surgical procedures have evolved over time for obtaining complete root coverage of gingival recession defects. A latest addition to these procedures is Mahajan’s periosteal pedicle graft which uses a pedicled autogenous periosteum for root coverage. The aim of this study was to evaluate the effectiveness of periosteal pedicle graft in treating Millers Class I and II isolated defects.

Methods: Ten isolated Millers Class I/II recession defects were treated using periosteal pedicle graft (PPG). The clinical parameters were measured presurgically, 3 and 6 months postsurgically.

Results: There was a reduction in the recession depth, probing depth and clinical attachment loss. There was an improvement in the width of keratinised gingival. On an average 85% of root coverage was achieved at the end of 6 months.

Conclusion: Periosteal pedicle graft is effective in achieving root coverage in isolated Millers Class I and II recession defects.

KEY WORDS: Gingival recession, gingival grafting, pedicle graft, root coverage
Gingival recession is defined as the displacement of the gingival marginal tissue apical to the cement enamel junction (CEJ).\textsuperscript{1} In most of the cases, patients with gingival recession generally have complaints regarding aesthetics, dentin hypersensitivity, or inability to perform proper oral hygiene procedures. In addition, if the exposure of root cementum and/or dentin to the oral environment due to recession is not addressed it can lead to root caries and other problems such as abrasions and chemical erosion. Predisposing factors for gingival recession are a thin gingival biotype, prominence of teeth, and patients with obsessive oral hygiene. Miller, based on anatomical considerations, has classified the recession defects into 4 types.\textsuperscript{2}

Over time, various periodontal surgical procedures have evolved for treating recession defects such as rotational and advanced gingival flaps, free gingival or connective tissue grafts, and guided tissue regeneration (GTR).\textsuperscript{3} The main goal of these periodontal plastic surgery procedures is to obtain an optimal aesthetic appearance with complete root coverage and blending of the mucosa and/or gingiva. Although the predictability of the various surgical treatment modalities varies, almost complete coverage can be anticipated in Miller’s Class I and Class II defects, while coverage expected in Miller’s Class III and IV defects is much less. Over the years, clinicians are continually seeking new procedures which are less morbid and more predictable for root coverage. One such new procedure for recession coverage as patented by Mahajan is the utilisation of the periosteal pedicle graft (PPG) technique (Figure 1).\textsuperscript{4} PPG is a GTR based treatment which avails the osteogenic potential of the periosteum due to its highly vascular nature, presence of fibroblasts, osteoblasts and stem cells.\textsuperscript{5} But the query that arises is
weather PPG is really effective in covering recession defects as other procedures mentioned above. To concoct this contention the following study was conducted to evaluate the effectiveness of using PPG in treatment of isolated Millers Class I and II recession defects.

MATERIAL AND METHODS

Subject Selection
Ten patients (7 males and 3 females) between the ages of 20 to 45 years attending the outpatient department of Department of Dental Surgery, AFMC were randomly selected for the study. The criterion for inclusion into the study was the presence of isolated Millers Class I or II recession defects (Figure 2) in the labial aspect of either maxillary or mandibular anterior tooth which was vital and did not have any periapical pathology. Patients with any systemic condition which would influence the course of periodontal disease or treatment, who were smokers/tobacco consumers, who had orthodontic appliances, who had previously undergone surgery for recession coverage of the defect, and pregnant or lactating women were excluded from the study. All subjects were verbally informed and written informed consent was obtained for their participation in the study.
Pre-surgical Evaluation
Proper case history was recorded for all the patients. Routine hematological and urine investigations were performed. Intraoral peri-apical radiographs of the concerned tooth were recorded. Phase I therapy was instituted to all the patients and after the maintenance phase they were taken up for surgery. The clinical parameters measured before the surgery (baseline), 3 months and 6 months after the surgery with the help of a UNC-15 probe were: Probing depth (PD) which was the distance the probe penetrated the depth of the gingival sulcus, Recession depth (RD) which was the distance between cementoenamel junction to the apical most margin of the gingiva, Clinical attachment level (CAL) in which the PD was added to the RD, Width of keratinized gingival (KG) which was the distance measured between the mucogingival junction to the apical most margin of gingiva.

Surgical Procedure
One month after the initiation of Phase I therapy, the patients were seen for root coverage surgical procedures utilizing the PPG technique. The clinical parameters were recorded presurgically for the concerned tooth. The facial

Figure 4a: Rotated periosteum is stabilized.

Figure 4b: Coronally advanced flap sutured.
skin all around the oral cavity was scrubbed with 7.5% povidone iodine solution and the intra oral surgical site was painted with 5% povidone iodine solution. The surgical site was locally anaesthetised using 2% Lignocaine with 1:80,000 adrenaline. After profound anaesthesia was achieved, an intrasulcular incision was made with No. 11 Bard Parker surgical blade in the tooth with recession. Two horizontal incisions were made perpendicular to the adjacent interdental papillae, slightly coronal to CEJ preserving the gingival margin of the neighbouring teeth. Two vertical incisions were given starting at the terminal ends of the horizontal incisions which extended beyond the mucogingival junction. A full thickness mucoperiosteal flap was raised about 2 mm apical to the osseous crest (Figure 3a). Tension was created by pulling the flap bucally and incision was continued through the periosteum to create a partial thickness flap. The overall raised flap was a combination of both full thickness and a partial thickness flap. Two vertical incisions were made in the periosteum starting 2 mm apical to the point from where the partial thickness incision was performed. The vertical incisions were then be joined by a single horizontal incision on the apical most part of periosteum. The periosteum was then raised with a periosteal elevator starting from the horizontal incision (Figure 3b). Care was taken not to detach the periosteum at the coronal portion. Root planning was thoroughly done and depapillation was done on adjacent papilla. The pedicled periosteum obtained was then rotated to cover the recession defect and secured using and 5-0 absorbable suture (Figure 4a). The flap was then coronally advanced over the recession defect and secured using 3-0 non absorbable sutures (Figure 4b). Periodontal pack and post-operative instructions were given to the patients. Patients were prescribed antibiotics, analgesics and were instructed for oral rinsing with 0.2% chlorhexidine mouth wash twice daily. Both the sutures and pack were removed one week later. Patients were recalled and assessed postoperatively every 30 days for six months. At the end of 3 and 6 months all the clinical parameters were recorded again (Figure 5). The pre and post-surgical parameters recorded were tabulated and presented as mean

Figure 5: Post-Op 6 months result of root coverage using periosteal pedicle graft.
+/- standard deviation. The statistical analysis was done by setting the ‘P’ value at 0.05.

**RESULTS**

Ten patients (mean age: 32.2 +/- 9.0 years) with isolated Miller’s Class I or II recession defects were enrolled into the study. All the 10 patients (7 males & 3 females) completed the study. The data set was complete with no missing data. Six patients had defects in the maxillary arch and 4 had defects in the mandibular arch and all were in the anterior region. Of the 10 defects 4 were localized to canine, 4 were localized to central incisor and 2 were localized to lateral incisor.

All the patients showed significant post-surgical improvement in recession coverage when compared with baseline. The mean RD decreased significantly from 3.4 +/- 0.7 mm at baseline to 0.3 +/- 0.35 mm in 3 months and slightly increased to 0.5 +/- 0.55 mm in 6 months, with slight variations for measurements at the other time intervals (Table 1). When the results were expressed as a percentage of root coverage, the amount obtained was 91.2% in 3 months and reduced to 85.6% in 6 months. The mean PD which was 2.7 +/- 1.03 mm at baseline was 1.1 +/- 0.45 mm and 1.4 +/- 0.56 mm in 3 and 6 months respectively. The mean CAL was 5.3 +/- 1.86 mm at baseline and improved to 1.5 +/- 0.52 mm in 3 months and finally to 1.8 +/- 0.92 mm in 6 months. The mean KW which was measured at 2.3 +/- 1.90 mm at baseline increased to 5.6 +/- 1.70 mm in 3 months and slightly reduced to 5.4 +/- 1.4 mm in 6 months (Table 1).

The intergroup comparison using ANOVA was done at different stages and for all the clinical parameters. This showed that the intergroup comparisons for all were highly signifi-

<table>
<thead>
<tr>
<th>Clinical Parameters</th>
<th>Recession depth (Mean +/-SD)</th>
<th>Probing depth (Mean +/-SD)</th>
<th>Clinical attachment level (Mean +/-SD)</th>
<th>Keratinized gingiva width (Mean +/-SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline (Presurgical)</td>
<td>3.4 +/-0.51mm</td>
<td>2.7 +/-1.03</td>
<td>5.3 +/-1.86</td>
<td>2.3 +/-1.90</td>
</tr>
<tr>
<td>3 months</td>
<td>0.3 +/-0.35mm</td>
<td>1.1 +/-0.45</td>
<td>1.5 +/-0.52</td>
<td>5.6 +/-1.70</td>
</tr>
<tr>
<td>6 months</td>
<td>0.5 +/-0.55mm</td>
<td>1.4 +/-0.56</td>
<td>1.8 +/-0.92</td>
<td>5.4 +/-1.4</td>
</tr>
<tr>
<td>Intergroup comparison ‘P’ value</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Table 1: Statistical Comparison of Clinical Parameters using ANOVA.
Table 2: Inter Group Comparison using Student’s T-test.

<table>
<thead>
<tr>
<th>Inter group comparison</th>
<th>Baseline v/s 3 months ‘P’ value</th>
<th>Baseline v/s 6 months ‘P’ value</th>
<th>3 months v/s 6 months ‘P’ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recession depth (Mean +/-SD)</td>
<td>0.001</td>
<td>0.002</td>
<td>0.240</td>
</tr>
<tr>
<td>Probing depth (Mean +/-SD)</td>
<td>0.015</td>
<td>0.012</td>
<td>0.140</td>
</tr>
<tr>
<td>Clinical attachment level (Mean +/-SD)</td>
<td>0.001</td>
<td>0.002</td>
<td>0.160</td>
</tr>
<tr>
<td>Keratinized gingiva width (Mean +/-SD)</td>
<td>0.001</td>
<td>0.002</td>
<td>0.140</td>
</tr>
</tbody>
</table>

cant (< 0.05) (Table 1). The student’s t-test when applied revealed that the ‘P’ value was significant (<0.05) in baseline & 3 months and baseline & 6 months for all the clinical parameters except for the PD in which the values were not significant (>0.05) [Table 2]. The comparison between 3 and 6 months for all the clinical parameters were not significant (Table 2).

DISCUSSION

The aim of the current study evaluated the effectiveness of PPG in coverage of Miller’s Class I and II recession defects. Various techniques over the years have been used to obtain root coverage in patients with gingival recession defects. Some structured reviews have revealed a superior root coverage in Miller Class I and II recession defects with the sub-epithelial connective tissue grafts (SCTG) which is considered the gold standard. But it does have shortcomings like secondary surgical site and limited quantity of graft. Mahajan was the first to use this PPG for recession coverage and achieve complete root coverage. Only very few case reports and particularly one study is are available about PPG. The pedicled periosteum which is a latest addition comprises of at least two layers, an inner cellular or cambium layer and an outer fibrous layer. The inner layer contains numerous osteoblasts and osteoprogenitor cells and the outer layer is composed of dense collagen fibers, fibroblasts and their progenitor cells. Hence the regenerative potential of the periosteum is immense. Since the periosteum is rich in vascular plexus it makes a predictable and viable graft over an
avascular root surface. Studies have been conducted using periosteum as a barrier membrane for the treatment of periodontal defects.\textsuperscript{10,11}

As PPG is fairly a new technique for recession coverage, we decided to do a pilot study of just 10 cases to visualize its potential in achieving root coverage. We decided for studying only isolated defects since mostly the principal reason for isolated defects are faulty tooth brushing and hence the bone loss associated will be minimal, which becomes a crucial factor in ensuring the success of the surgical procedure. Selection of cases becomes an important criterion here as a patient with a thin biotype gingiva or a malposed tooth is not a suitable candidate for PPG. Either the gingiva has to be augmented or the malposition corrected before root coverage. In our study almost complete root coverage was achievable in most of the cases. The mean RD reduced from 3.4 +/- 0.7 mm to 0.5 +/- 0.55 mm at the end of six months giving us around 85% root coverage. This result is in comparison to a PPG study by Mahajan, slightly higher than SCTG study by Ricci et al and lower than an SCTG study by Rachlin et al.\textsuperscript{8,12,13} Even though the average root coverage was around 85% in two of the cases the root coverage obtained was just around 72%. This partial coverage achieved may be because of the non-compliance of the patient towards proper oral hygiene protocols as advised by our team. Since the results of PPG is in par with that of SCTG, it definitely has an upper hand over the disadvantages of the later.

The mean PD pre and post surgically when compared even though was not statistically significant but slight improvement of about 1 mm was seen. This result does not match with studies by Trombelli et al and Muller et al wherein the PD increased post surgically.\textsuperscript{14,15} Our PD results were in par with study by Harris.\textsuperscript{16} The PD did not alter much as the etiological The mean CAL drastically improved from 5.3 +/- 1.86 mm at baseline to 1.8 +/- 0.92 mm post surgically. This result is in par with studies by Mahajan and Jepsen et al.\textsuperscript{8,17} But studies by Zucchelli et al and Harris have proved otherwise in which the gain in CAL in not that much.\textsuperscript{16,18} As expected like in studies by Jepsen et al and Harris, the mean KW improved to around 5.4 mm postsurgically from pre-surgical 2.8 mm.\textsuperscript{16,17} The healing in all the cases was uneventful. No necrosis of the graft was observed postoperatively in any of our cases. This characteristic advantage is because of the pedicle attachment to the bone and the coronally positioning of the flap over the graft ensuring good protection of the graft. In two cases the gingival contour obtained after six months was bulkier than normal. This may be attributable to the excessive thickness of the periosteum harvested which was more than actually required. So it becomes evident that the thickness of the graft harvested is a very important criterion for success. The overall advantages of this technique are: Presence of periosteum adjacent to the defect and in sufficient quantity avoiding two surgical sites resulting in less surgical trauma, postoperative complications and better patient satisfaction. More than one adjacent recession defects may be addressed in a single surgery using this technique.

CONCLUSION

The PPG technique opens a new vista in the techniques used for root coverage. The
PPG technique requires certain prerequisites such as good surgical dexterity on the part of the operator, especially during the lifting up of the periosteum which is firmly adherent to the underlying bone. Any long term complications with the PPG technique are yet to be assessed. Histological studies revealing the exact type of healing as well as randomized controlled trials comparing the results of this technique with already established techniques should be undertaken in a larger scale in order to use it on regular basis for root coverage.

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Disclosure
The authors report no conflicts of interest with anything mentioned in this article.

References
ATTENTION PROSPECTIVE AUTHORS

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or email us at:
editors@jicad.com
Objective: The aim of this study was to assess and compare the ability of Tooth Mousse (CPP-ACP containing toothpaste), Tooth Mousse Plus (CPP-ACP/fluoride 900 ppm containing toothpaste) and Novamin (calcium sodium phosphosilicate containing toothpaste) to remineralize early enamel lesion in vitro.

Materials and Methods: In this study, twenty intact caries free extracted human premolars were collected. The coronal part of each tooth was sectioned into four parts. The surface microhardness (SMH) was measured using Vickers microhardness (VHN) testing machine before as well as after demineralization. Artificial enamel carious lesions were created on each enamel specimen by suspending them in demineralization solution. Enamel specimens were then subjected to different remineralization products i.e. calcium sodium phosphosilicate, casein phosphopeptide - amorphous calcium phosphate (CPP-ACP), and combination of casein phosphopeptide - amorphous calcium phosphate and fluoride (CPP-ACP). A caries progression test (pH cycling) was carried out and surface microhardness was measured again. Cross-sectional microhardness (CSMH) was evaluated to assess any subsurface remineralization.

Results: Combination of casein phosphopeptide - amorphous calcium phosphate and fluoride (CPP-ACP) has better remineralizing properties as compared to the other remineralizing agents.

Conclusion: CPP-ACP paste significantly remineralized the artificial enamel lesion in vitro. The surface hardness increases with application of CPP-ACP, CPP-ACP and Novamin separately on induced demineralized enamel in vitro. The surface hardness increase is maximum in CPP-ACP and least in control group.

KEY WORDS: CPP-ACP; Demineralization; Novamin.; Remineralization

1. Senior Lecturer, B.J.S. Dental College, Ludhiana, Punjab, India
2. Professor & Head, GNDDC, Sunam, Punjab, India
INTRODUCTION

Despite worldwide improvements in the oral health, dental caries is still a major oral health problem in most industrialized countries, affecting 60-90% of school children and the vast majority of adults. Dental caries is a pathological condition that results from an imbalance in the physiological process of remineralization/demineralization of the dental structure. Different preventive therapies have been studied to enhance remineralization, decrease demineralization and therefore, arrest the active caries lesions. Fluoride is recognized as a remineralizing agent.

Amorphous calcium phosphate (ACP) provides the benefit of having both calcium and phosphate ions close to each other in an amorphous phase. The beneficial effect obtained with CPP-ACP is associated with ability to localize calcium and phosphate in the dental plaque in the proximity of the tooth, thus making it available when needed. In the presence of an acid environment, such as after eating, when pH of the mouth decreases, the casein phosphopeptide proteins release amorphous calcium and phosphate, creating a supersaturated state of calcium and phosphate around the tooth. Novamin: the active ingredient is a calcium sodium phosphosilicate that reacts when...
exposed to aqueous media, thus providing calcium and phosphate ions to the applied surface.

**MATERIALS & METHODS**
Twenty extracted premolars free of caries, were cleaned of any surface debris & stored in normal saline. The coronal part sectioned buccolingually and mesio-distally into four sections. Custom made cylindrical molds were made then each enamel specimen with enamel surface exposed was embedded on the top of partially set acrylic resin mold, nail varnish was applied around the exposed enamel surface leaving a window of 3mm × 3mm of enamel exposed at the centre. Then the prepared samples were subjected to Vickers microhardness test to evaluate surface microhardness. After testing the surface microhardness, the samples were subjected to the process of demineralization.

**Caries Lesion Formation**
Caries lesions representing preliminary stage of subsurface enamel demineralization were produced by suspending four sections of each tooth into glass tubes containing 50 ml of demineralization solution, for 72 hours, in an incubator at a temperature of 35°C. After induction of enamel lesions, all the speci-
mens were evaluated for surface microhardness. Later, these samples were subjected to the process of remineralization and pH cycling.

**Experimental Procedure**

**Section 1** - a generous layer of Calcium Sodium Phosphosilicate agent was applied with applicator brush and left undisturbed for 20 minutes.

**Section 2** - a generous layer of CPP-ACP agent was applied with applicator brush and left undisturbed for 20 minutes.

**Section 3** - a generous layer of CPP-ACPF agent was applied with applicator brush and left undisturbed for 20 minutes.

**Section 4** - this served as the control group where no surface treatment was performed.

**pH Cycling**

A pH cycling regimen included surface treatment, alternative demineralization (three hours) and remineralization (21 hours) for five consecutive days. For demineralization phase, the demineralization solution used for induction of enamel lesion was used and for remineralization phase, synthetic saliva preparation was carried out. After pH cycling again Vickers microhardness number was assessed for all the specimens under 100g load for 20 seconds and data was recorded.
Cross Sectional Microhardness
Each specimen was longitudinally sectioned into two halves through center of the window. All the sections were evaluated for the measurement of cross sectional microhardness.

Surface Microhardness Recovery Percentage
\[
\% \text{ SMHR} = \frac{\text{Treated Enamel (VHN)} - \text{Demineralized Enamel DE (VHN)}}{\text{Initial Enamel TE (VHN)} - \text{Demineralized Enamel DE (VHN)}} \times 100
\]

The data thus obtained was collected and analyzed statistically.

RESULTS

- **Surface Hardness of Sound Enamel:**
The mean hardness value of sound enamel is 307.70 VHN.

- **Surface Microhardness of Enamel after Demineralization:** The mean hardness of enamel after demineralization in Group 1, 2, 3 and 4 was 162.75 VHN.

- **Surface Microhardness values after Remineralization:** Group 1 shows the mean surface microhardness score of 194.90 VHN. In Group 2, a mean value of 203.70 VHN, while Group 3 had a mean value of 275.25 VHN. Group 4 had a mean value of 167.60 VHN. ANOVA test results showed that there is statistically highly significant difference between the mean scores of 4 different groups contained in the study (P <0.001). So, among the microhardness values obtained, the values of Group 3 were statistically highly significant when compared to Group 1, Group 2 and Group 4.

- **Cross Sectional Microhardness (Subsurface)**
Each specimen was longitudinally sectioned into two halves through center of the window. A row of five indentations was made at approximately 100 microns below the enamel surface and microhardness was measured. The subsurface hardness in Group 1 had a mean value of 152.05 VHN, Group 2 had a mean value of 152.45 VHN, Group 3 had a mean value of 154.15 VHN and Group 4 had a mean value of 149.20 VHN.

- **Inter-Group Comparison of Cross Sectional Microhardness**
The samples of group 1 and group 2 does not show any significant difference among the remineralization scores (p = .982) The test shows no significant difference (P =.217) in remineralization values among the samples of Group 1 and Group 3. On comparing the samples of Group 1 and Group 4 significant difference

![Figure 4: Mean subsurface microhardness after remineralization](image-url)
Table 1: Surface Microhardness Scores of Sound Enamel

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
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<tbody>
<tr>
<td>1</td>
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<td>370</td>
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</tbody>
</table>
among remineralization score has been observed ($p = .048$) Group 3, Group 2, Group 1 shows statistically significant difference than Group 4.

**% Recovery**
The % Recovery in Group 1 had a mean value of 21.05% For Group 2 mean value obtained is 26.95% in Group 3 had a mean value of 69.30% While Group 4 showed the mean value of 2.84%. ANOVA test results showed that there is statistically highly significant difference between the mean scores of 4 different groups contained in the study ($P < 0.001$).

**DISCUSSION**
In the present field of Preventive Dentistry, a number of dental materials used for the prevention of dental diseases are available. The main approaches available for the prevention of dental caries at present include, plaque control, systemic and topical fluorides, pit and fissure sealants and caries vaccines which are the area being subjected to in depth research work.

Enriching the mineral content of the tooth by means of continued supply of Calcium, Phosphate and Fluoride. Fluorides have been proved to be successful in preventing tooth demineralization in smooth surface areas. Schemethorn et al. 1999 stated that, although saliva is a natural source of all these mineral ions, the absence of fluoride and relatively less amount of calcium phosphate ions available to replace the lost ions from the tooth makes it, a poor medium for the remineralization process. These ions can be supplemented in different ways like through mouth rinses, topical application, dentifrices etc. The dissolving calcium ions and phosphate ions form various calcium phosphate salts that either diffuse to the exterior or provide an environment that facilitates the repair of the faulty crystallites beneath the surface of enamel facilitating remineralization. Mineral loss or demineralization proceeds as long as sufficient acid is available. As more enamel dissolves, concentration of the calcium and phosphate ion increases. As calcium and phosphate ions diffuse outwards, remineralization at the surface becomes more and more likely. This leads to the formation of an apparently intact enamel surface layer about 20-40 microns where the mineral content is higher than the body of the lesion.

<table>
<thead>
<tr>
<th>Surface Hardness</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>20</td>
<td>194.90</td>
<td>24.881</td>
<td>5.563</td>
</tr>
<tr>
<td>Group 2</td>
<td>20</td>
<td>203.70</td>
<td>29.727</td>
<td>6.647</td>
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<tr>
<td>Group 3</td>
<td>20</td>
<td>275.25</td>
<td>38.214</td>
<td>8.545</td>
</tr>
<tr>
<td>Group 4</td>
<td>20</td>
<td>167.60</td>
<td>31.398</td>
<td>7.021</td>
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Table 2: Mean microhardness scores after remineralization
<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Group 1 Novamin</th>
<th>Group 2 Tooth Mousse</th>
<th>Group 3 Tooth Mousse Plus</th>
<th>Group 4 Control</th>
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In the present study, 80 sectioned samples premolars were kept in the demineralization solution (CaCl2, NaH2 PO4, Lactic acid and Fluoride) for 72 hours at 37° C which created a subsurface demineralization of approximately 150 microns width with an intact surface simulating an early enamel lesion. The surface microhardness values for each group of the enamel specimens were decreased to 162-183 at the end of 72 hours of demineralization which is in accordance with the study conducted by Maupome et al 1999. The samples were then subjected to pH cycling using three different materials. The period for demineralization in the pH cycling phase is for three hours, which was to stimulate the duration of demineralization that occurs in the oral cavity. The test materials were applied on enamel blocks to simulate the normal recommended daily oral prophylaxis.

The remineralization process involves diffusion of calcium and phosphate ions through the protein/water-filled pores of the carious surface enamel into the body of the enamel lesion. Once in the body of the enamel lesion, these calcium and phosphate species increase the activities of Ca 𝔏 and PO4 𝔏, thereby increasing the degree of saturation with respect to hydroxyapatite. The formation of hydroxyapatite in the lesion would lead to the generation of acid and phosphate, which would diffuse out of the lesion along a concentration gradient. By stabilizing calcium phosphate in a metastable solution, the CPP facilitates high concentrations of calcium and phosphate ions, which can then diffuse into the enamel subsurface lesion. The CPP will also maintain high activities of the free calcium and phosphate ions during remineralization through the reservoir of the bound ACP. By being in dynamic equilibrium with free calcium and phosphate ions, the bound ACP will maintain the concentrations of the species involved in diffusion into the lesion. Furthermore, dissociation of the CPP-bound ACP will be facilitated by the acid generated during enamel remineralization. This would explain why CPP-supported, metastable calcium phosphate solutions are such efficient remineralizing solutions, as they would consume the acid generated dur-

---

**Table 4: Mean Subsurface Microhardness After Remineralization**

<table>
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<tr>
<th>Recovery</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Standard Error</th>
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<td>3.1502</td>
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<td></td>
<td>20</td>
<td>2.84</td>
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<td>.475</td>
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ing enamel lesion remineralization by generating more calcium and phosphate ions, thus maintaining their high concentration gradients into the lesion. CPP-ACP localizes ACP on the tooth surface, and buffers the free calcium and phosphate ion activities, helping to maintain a state of supersaturation with respect to the enamel by suppressing demineralization and enhancing remineralization. The CPP has a substantial ability to stabilize calcium phosphate in solution. CPP can stabilize over 100 times more calcium phosphate than is normally possible in aqueous solution at neutral or alkaline pH before spontaneous precipitation occurs. CPP-ACPF has, in addition, fluoride. Studies have shown that remineralization of small lesions with low-dose fluoride therapy is more efficient. The fluoride ions are adsorbed onto the surface of enamel crystals, inhibiting dissolution and increasing remineralization. The softened surface lesions remineralize faster and more completely than subsurface lesions. With the use of low fluoride concentration as is present in CPP-ACPF (0.2% or 900 ppm of NaF), there is a complex localization of free calcium phosphate and fluoride ion activities, which helps in maintaining a state of super-saturation by suppressing demineralization. Thus CPP-ACPF (Tooth Mousse Plus) is an excellent local slow-delivery system to treat the white spot lesion. Novamin deposits fine particles onto the dentin or enamel surface and a series of reactions occurs over time that results in the formation of a crystalline, hydroxycarbonate apatite (HCA) layer. This HCA layer is chemically and structurally similar to natural enamel and dentin and is more resistant to acid challenges.

The results of present study are in accordance with study done by N Srinivasan et al,²¹ who showed the remineralization effect of CPP–ACP with 900 ppm of fluoride to be superior to that of CPP–ACP alone. It is likely that a combination of CPP–ACP and fluoride resulted in co-localization of calcium and phosphate ions with fluoride ions at the enamel surface, presumably as CPP–ACFP nanocomplexes.

Of all 21 remineralizing products used by F. Cai et al. in their study, only Tooth Mousse Plus containing casein phosphopeptide (CPP), exhibited high levels of water soluble calcium, phosphate and fluoride ions. These high levels of water-soluble ions were attributed to the presence of the CPP in CPP-ACP (Recaldent). These high levels of water-soluble calcium, phosphate and fluoride ions are consistent with the recent clinical trials of Tooth Mousse and CPP-ACP / fluoride toothpastes showing enhanced remineralization of caries lesions. There is no increase in microhardness at the enamel subsurface, which is accordance with the study done by S Lata et al.⁹ There is no remineralization at subsurface level and all the treatment groups failed to remineralize the subsurface lesion in depth. Nevertheless, fluoride, fluoride + ACP-CPP and to a lesser extent ACP-CPP can remineralize the surface lesion. There was no increase in CSMH at the subsurface level and the values suggested that, that none of the surface treatment agents could penetrate the demineralized enamel at the subsurface level. The reason could be; fluoride ions and ACP-CPP were not able to penetrate the subsurface enamel area, the in vitro set up is not exactly mimicking the in vivo conditions occurring in the mouth and duration of the experimental set up (eight days) is too short.
CONCLUSION

CPP-ACP paste significantly remineralized the artificial enamel lesion in vitro. The surface hardness increases with application of CPP-ACP, CPP-ACP and novamin separately on induced demineralized enamel in vitro. The surface hardness increase is maximum in CPP-ACP and least in control group.

Disclosure
The authors report no conflict of interest with anything mentioned in this article.

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