



Sasha M Jankovic, Aleksic M Zoran, Lekovic M Vojislav, Dimitrijevic S Bozidar, Barry E Kenney

The use of platelet-rich plasma in combination with connective tissue grafts following treatment of gingival recessions



Sasha M Jankovic
Department of
Periodontology,
School of Dentistry,
Dr subotica 4.,
University of Belgrade,
Belgrade, 11000,
Serbia and Montenegro
Tel: 38 16 4112 0674
Email: drsale@yubc.net

Aleksic M Zoran
School of Dentistry,
University of Belgrade,
Belgrade

Lekovic M Vojislav
School of Dentistry,
University of Belgrade,
Belgrade

Dimitrijevic S Bozidar
School of Dentistry,
University of Belgrade,
Belgrade

Barry E Kenney
Section of Periodontics,
School of Dentistry,
UCLA, USA.

KEY WORDS *gingival recessions, growth factors, PRP, regeneration*

Background: The biologic mediators from platelet-rich plasma (PRP) modulate cell proliferation and differentiation in a cell type-specific manner, leading to enhanced tissue reparation and regeneration. It is conceivable that concentrated growth factors within PRP up-regulates cellular activity and subsequently promotes periodontal regeneration in vivo. This study was designed to evaluate and compare clinical effectiveness of activated PRP in the standard treatment of gingival recessions with connective tissue graft (CTG).

Methods: Basic surgical technique was based on the use of CTG and coronally advanced flap procedure. Fifteen gingival recessions Miller class I or II were treated with CTG and PRP (group CTG+PRP). After elevation of the flap, bone and root surfaces were smeared with activated PRP gel. The CTG was also irrigated with PRP gel before placement over the exposed root surface. After suturing, the CTG was covered with a coronally advanced flap. In the same patients, 15 other gingival recessions were treated with CTG in combination with a coronally advanced flap (group CTG). Clinical recordings were made of vertical recession depth (VRD), probing depth (PD), clinical attachment level (CAL) and keratinised tissue width (KTW) before and 6 months after mucogingival surgical treatment. Clinical evaluation of healing events was estimated with recordings of the healing index (HI). Recordings of HI were performed on the 1st, 2nd and 3rd week post-surgery.

Results: Mean values of VRD were significantly decreased from 3.61 ± 0.70 mm to 0.30 ± 0.45 mm ($p < 0.01$) in the group CTG+PRP (91.68%) and from 3.45 ± 0.84 mm to 0.38 ± 0.48 mm ($p < 0.01$) in the group CTG (mean root coverage 88.96 %). The difference between the two tested groups was not statistically significant. Results of the KTW showed significant increase from 1.32 ± 0.66 mm pre-surgery to 3.20 ± 0.54 mm ($p < 0.01$) 6 months after in group CTG+PRP, and from 1.41 ± 0.58 mm to 2.55 ± 0.45 mm in group CTG ($p < 0.01$). Results of KTW showed statistical significance of recorded differences obtained in the two evaluated groups ($p < 0.05$). There was no statistical significance in reduction of PD and CAL recorded in CTG+PRP and CTG group. The values of HI recorded on the 1st and 2nd week post-operatively were significantly enhanced in the CTG+PRP group (3.11 ± 0.32 and 4.20 ± 0.27) in reference with HI values recorded in control group (2.25 ± 0.54 and 3.05 ± 0.38).

Conclusions: The results of this study confirm both procedures as effective and highly predictable surgical techniques in solving gingival recession problems. The addition of PRP resulted in an increased width of keratinised tissue and advanced tissue healing.



■ Introduction

Obtaining predictable root coverage supported with significant levels of tissue regeneration has become an essential element of periodontal plastic surgery. It is conceivable that concentrated growth factors within platelet-rich plasma (PRP) up-regulate cellular activity and subsequently promote periodontal regeneration *in vivo*. The aim of this study was to evaluate and validate the clinical impact of activated PRP in the treatment of gingival recessions with connective tissue graft (CTG) as the basic surgical procedure. An important purpose of this study was to estimate the potential of PRP to accelerate wound healing¹.

Gingival recessions present with loss of both soft and hard tissues. A wide variety of periodontal plastic surgical procedures have been described to correct mucogingival problems and to cover denuded root surfaces. Aesthetic concerns are usually the reason to perform these procedures. Clinical studies have evaluated many of the techniques. During the 1970s, the coronally positioned flap² and laterally sliding flap³ were the most accepted techniques. Root coverage procedures became accepted as predictable procedures when Miller⁴ demonstrated high success rates with a thick autogenous masticatory graft (free gingival graft). His studies changed the approach of the periodontist to accept that predictable root coverage was possible with a single surgical procedure. However, the procedure was not without problems, as the aesthetics were usually not ideal. In an attempt to address these problems, Raetzke⁵ and Langer and Langer⁶ proposed techniques that used free CTGs. These techniques addressed the aesthetic problems with the free gingival graft, and the results were still predictable. Others have added different variations utilising a CTG and an overlaying pedicle graft or pouch⁷⁻⁹. Histological studies of CTGs show unpredictable results related with regeneration of periodontal tissues. There is only evidence of minimal bone formation found in the most apical portion of the treated region¹⁰.

Obtaining predictable root coverage supported with a significant level of periodontal tissue regeneration has become a demanding goal of periodontal plastic surgery. PRP is the fraction of plasma with the concentrated number of platelets, fibrin and cell adhesion molecules. If thrombin and calcium are

added to the PRP, platelets are activated and release many growth factors from the granules. The application of thrombin and calcium also begin rapid clotting. PRP has been applied and well studied in the fields of oral implant surgery and periodontal tissue regeneration¹¹⁻¹³. Okuda et al¹⁴ demonstrated that PRP contains platelet-derived growth factor (PDGF) and transforming growth factor beta (TGF- β) at high levels and that PRP stimulates fibroblastic and osteoblastic proliferation, but suppresses epithelial cell proliferation¹⁵. In a similar manner, TGF- β was found to stimulate fibroblastic and osteoblastic cell proliferation while suppressing epithelial cell proliferation. Moreover, the fibrin clot derived from PRP is able to stimulate high levels of type I collagen synthesis¹. Since PRP has a higher concentration of platelets, it is expected to contain a higher concentration of growth factors to accelerate or enhance regeneration¹⁶. The addition of PRP to the CTG procedure may enhance the results and has the potential to stimulate periodontal regeneration^{11,13,16}.

The present study was designed to evaluate the clinical impact and effectiveness of activated PRP following the treatment of gingival recessions with a CTG. Also, the authors wanted to compare the soft tissue healing and post-operative discomfort in the group of recessions treated with PRP and without.

■ Study design

Fifteen patients from the Clinic for Periodontology, School of Dentistry, University of Belgrade, were consecutively and randomly enrolled for this clinical study. They were 4 males and 11 females, between 18 and 45 years of age. Prior to their selection, all patients completed a routine questionnaire, from which the following data was obtained: general medical history, age, gender and smoking habits. All patients were systemically healthy and without any significant history of systemic diseases. Similarly, all patients underwent a full-mouth dental and periodontal examination, performed by the same examiner. Patients diagnosed with periodontitis were excluded. All patients received professional tooth cleaning consisting of prophylaxis, scaling and root planing, if needed, and oral hygiene instructions. Patients were informed of the characteristics of the

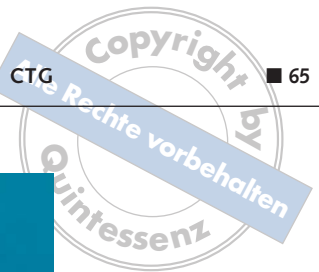


Fig 1 A 28-year-old woman presented with gingival recession of 5 mm in tooth #13.

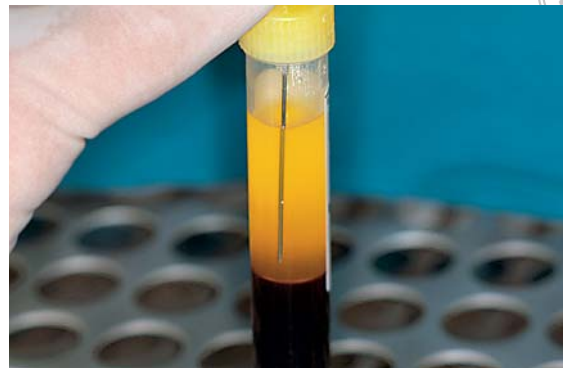


Fig 2 Separation of plasma (2400 rpm, 10 min).

study and gave their written consent to the procedures. The study was approved by the institutional committee for human investigations. The inclusion criteria were: 1) presence of either bilateral isolated or multiple defects with recession depths 2 mm when measured from the cemento-enamel junction (CEJ) on anterior teeth or premolars; 2) all defects were judged as Miller Class I or Class II (Fig 1); 3) the selected teeth were vital, free of restorations or had restorations removed, and with no bleeding upon probing.

One calibrated examiner blinded to the surgical treatment collected the data at baseline and 6 months post-operatively. All measurements were performed by the same operator. Randomisation for the test and control treatment was performed with a coin toss.

All 15 patients received both a CTG and a CTG plus PRP surgeries on bilateral defects. Matching surgical techniques were performed on both treated sites. After obtaining adequate anaesthesia, the exposed root surfaces in both groups were scaled and planed utilising hand and ultrasonic instruments. A fresh tetracycline solution (125 mg tetracycline/ml of saline) was prepared and applied to the root surfaces for each surgery. Before starting surgery, 50 ml of blood was drawn from each patient. The collection of autogenous platelet concentrate was performed using the Curasan PRP (double spin) system. The first spin (2400 rpm for 10 min) of blood provided separation of plasma (Fig 2). The second spin (3600 rpm for 15 min) of plasma separated PRP from platelet-poor plasma (PPP) (Fig 3). The initial, intrasulcular incision in the region of the recipient site was bevelled into the adjacent interdental papil-

lae at or slightly coronal to the CEJ of the tooth with an exposed root surface. A full-thickness flap was reflected beyond the mucogingival junction and at least 5 mm apical to the most apical margin of the bony dehiscence.

The flap was further released by sharp dissection. The mesio-distal length of the incision was extended to the nearest distal line angle of the most mesial and distal teeth involved. Mesial and distal vertical releasing incisions were made in each procedure (Fig 4). A measurement of the approximate width necessary for the graft was obtained with a periodontal probe. The CTG was harvested with a technique described by Bruno¹⁰ (Fig 5). Before the placement and fixation of the CTG in the experimental group (CTG+PRP), the CTG was completely soaked with platelet concentrate (Fig 6). After placement and stabilisation of the CTG (Fig 7) in the required position over the denuded root surface, a few drops of mixture of sterile purified bovine thrombin (Thrombostat®, Parke-Davis) and 10% CaCl₂ were added (Fig 8) to start the coagulation process. In the control group (CTG), the CTG tissue was not treated with activated platelet concentrate. The flap was then coronally positioned to completely cover the graft using a vertical mattress suture (Fig 9). A periodontal dressing was positioned over the treated regions. All patients were directed to use 0.12% chlorhexidine gluconate mouthrinse for 3 weeks. Patients were advised to follow routine periodontal mucogingival surgical post-operative instructions. Sutures were removed 2 weeks post-surgery. The periodontal clinical variables were evaluated in both groups. Prior to surgery, the following measurements were performed using a standard periodontal probe and were rounded to the nearest 0.5 mm:

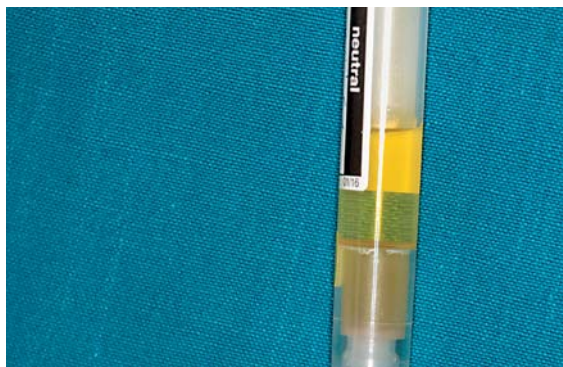


Fig 3 Separation of platelet-rich plasma from platelet-poor plasma (3600 rpm, 15 min).



Fig 4 A full thickness flap with mesial and distal releasing incisions was elevated.

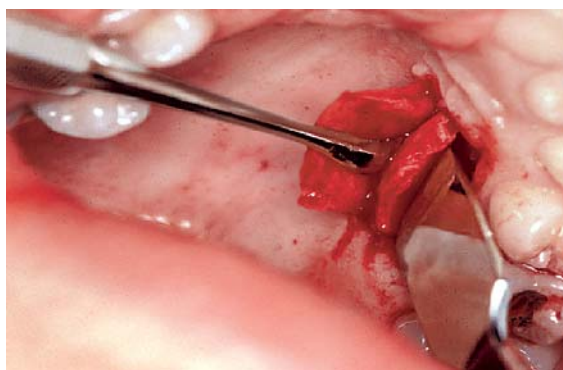


Fig 5 Harvesting of the CTG from the palate of the premolar region.

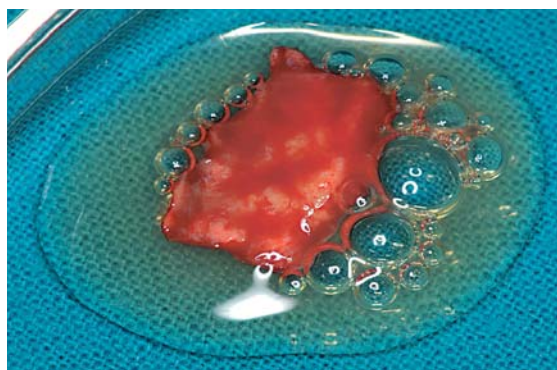


Fig 6 CTG conditioned with PRP.

- vertical gingival recession depth (VRD): distance from the CEJ to the free gingival margin (the middle point of the exposed root was considered)
- clinical attachment level (CAL): distance from the CEJ to the base of the gingival crevice
- clinical probing depth (PD): distance between free gingival margin and the base of the gingival crevice
- keratinised tissue width (KTW): distance from the free gingival margin to the mucogingival junction.

Clinical parameters were recorded at baseline and at the 6-month follow-up by the same examiner (Fig 10). Clinical evaluations of healing events were estimated with recordings of the healing index (HI)¹⁷. Recordings of HI were performed on the 1st, 2nd and 3rd week post-surgery. The HI scores healing on the basis of redness, presence of granulation tissue, bleeding

and suppuration and epithelialisation. A score of 1 to 5 is given, with 1 associated with very poor healing and 5 being excellent. Statistical analysis data are expressed as means \pm standard deviation (SD) of the parameters evaluated. Comparisons were made within each group between the baseline and 42-week evaluation. Student's paired t-test was used to compare pre- and post-surgery measurements. Inter-group comparisons were at baseline and 42 weeks. These comparisons were made using the unpaired t-test.

The subject's overall post-operative pain was also assessed for the first 7 days using a horizontal scale, with the left endpoint marking no pain (0), middle point marking pain (1), and the right endpoint marking severe pain (2). The Wilcoxon test was applied to compare the pain intensity in the post-operative period. A significance level of 0.05 was employed in all statistical comparisons.

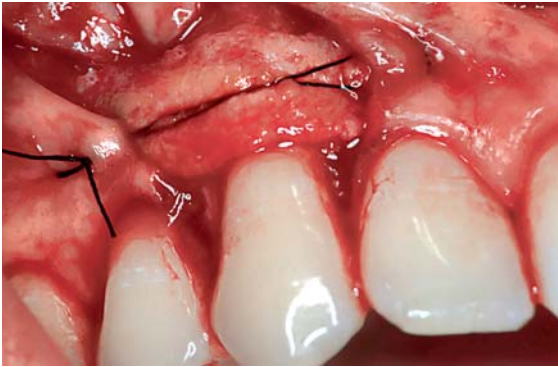


Fig 7 CTG placed and stabilised on the recipient site.

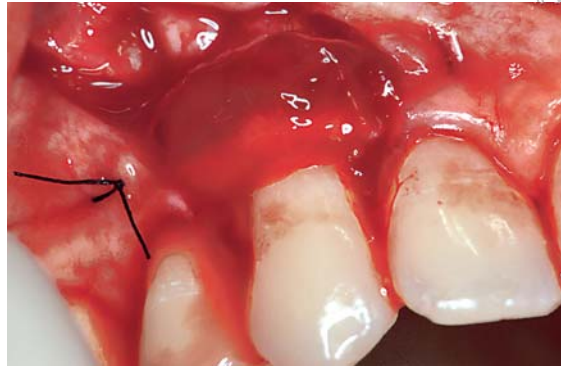


Fig 8 Additional application of activated PRP on the recipient site.



Fig 9 Coronally advanced flap sutured over connective tissue graft.



Fig 10 6 months post-operatively, full root coverage was obtained.

■ Results

During the evaluation period no side effects were reported.

Tables 1 to 3 illustrate the results of the evaluations at baseline and 6 months. VRD in the CTG+PRP group decreased from 3.61 ± 0.70 mm to 0.30 ± 0.45 mm, corresponding to a mean root coverage of $91.68\% \pm 10.65\%$. In the control (CTG) group, VRD decreased from 3.45 ± 0.84 to 0.38 ± 0.48 mm, corresponding to a mean root coverage of $88.96 \pm 15.46\%$ (Fig 11). Complete root coverage was achieved in the CTG+PRP group in 79.85% of the cases and in the control group in 74.56% of the cases. The differences in VRD between the groups were not statistically significant at baseline and at 6 months (Table 3).

KTW in the CTG+PRP group increased from 1.32 ± 0.66 mm to 3.20 ± 0.54 mm. In the control group, KTW increased from 1.41 ± 0.58 mm to 2.55 ± 0.45

mm. The gain in KTW (1.88 ± 0.71 mm for the CTG+PRP group and 1.14 ± 0.63 mm for the control group) was statistically significant for both groups. The gain in KTW was significantly higher for the CTG+PRP group in comparison with the control (CTG) group ($p < 0.05$) (Figs 12 and 13).

No significant changes were recorded in the two groups between baseline and 6 months for PD.

In the CTG+PRP group, CAL decreased from 4.35 ± 0.67 mm to 1.28 ± 0.40 mm, an attachment gain of 3.07 mm. In the control group, CAL decreased from 4.31 ± 0.61 mm to 1.35 ± 0.38 mm, an attachment gain of 2.96 mm. The differences between the two groups for CAL were not statistically significant.

Recordings of the HI (Table 4) showed higher values of HI obtained in the CTG+PRP group for the first 2 weeks after surgery in comparison with the control group. Results of the HI recorded in the CTG+PRP group after 1 and 2 weeks of surgery were

**Table 1** Clinical results of the CTG+PRP group.

Parameter	Baseline (mm)	6 month (mm)	p
VRD	3.61 ± 0.70	0.30 ± 0.45	< 0.01*
KTW	1.32 ± 0.66	3.20 ± 0.54	< 0.01*
CAL	4.35 ± 0.67	1.28 ± 0.40	< 0.01*
PD	0.74 ± 0.53	0.95 ± 0.41	> 0.05

* Statistically significant ($p < 0.05$)**Table 2** Clinical results of the CTG group.

Parameter	Baseline (mm)	6 month (mm)	p
VRD	3.45 ± 0.84	0.38 ± 0.48	< 0.01*
KTW	1.41 ± 0.58	2.55 ± 0.45	< 0.01*
CAL	4.31 ± 0.61	1.35 ± 0.38	< 0.01*
PD	0.86 ± 0.47	0.92 ± 0.48	> 0.05

* Statistically significant ($p < 0.05$)**Table 3** Mean changes of clinical recordings 6 months after surgery.

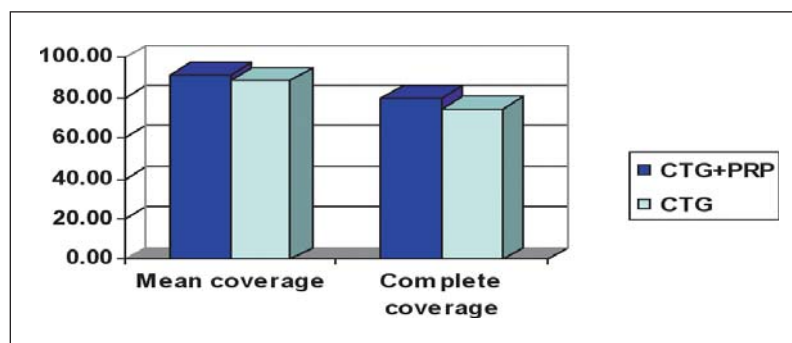
Parameter	CTG + PRP	CTG	p
VRD	3.31 ± 0.37	3.17 ± 0.30	> 0.05
KTW	1.88 ± 0.71	1.14 ± 0.63	< 0.05*
CAL	3.07 ± 0.39	2.96 ± 0.42	> 0.05
PD	0.21 ± 0.10	0.06 ± 0.09	> 0.05

* Statistically significant ($p < 0.05$)**Table 4** Healing Index by Landry et al¹⁷.

1 Very poor	<ul style="list-style-type: none"> tissue colour: ≥ 50% of gingiva red response to palpation: bleeding granulation tissue: present incision margin: not epithelialised, with loss of epithelium beyond incision margin suppuration present
2 Poor	<ul style="list-style-type: none"> tissue colour: ≥ 50% of gingiva red response to palpation: bleeding granulation tissue: present incision margin: not epithelialised, with connective tissue exposed
3 Good	<ul style="list-style-type: none"> tissue colour: ≥ 25% and < 50% of gingiva red response to palpation: no bleeding granulation tissue: none incision margin: no connective tissue exposed
4 Very good	<ul style="list-style-type: none"> tissue colour: < 25% of gingiva red response to palpation: no bleeding granulation tissue: none incision margin: no connective tissue exposed
5 Excellent	<ul style="list-style-type: none"> tissue colour: all tissues pink response to palpation: no bleeding granulation tissue: none incision margin: no connective tissue exposed

Table 5 Pain intensity in the first 7 days after surgery.

Day	Pain intensity		p
	CTG+PRP	CTG	
1	1.06 ± 0.67	1.48 ± 0.74	< 0.05*
2	0.92 ± 0.43	1.40 ± 0.61	< 0.05*
3	0.81 ± 0.41	1.37 ± 0.55	< 0.05*
4	0.67 ± 0.35	1.25 ± 0.40	< 0.05*
5	0.43 ± 0.22	1.07 ± 0.33	< 0.05*
6	0.25 ± 0.10	0.65 ± 0.31	< 0.05
7	0.15 ± 0.05	0.26 ± 0.27	< 0.05

* Statistically significant ($p < 0.05$)**Fig 11** Percentage of the mean and complete coverage of the treated gingival recessions.

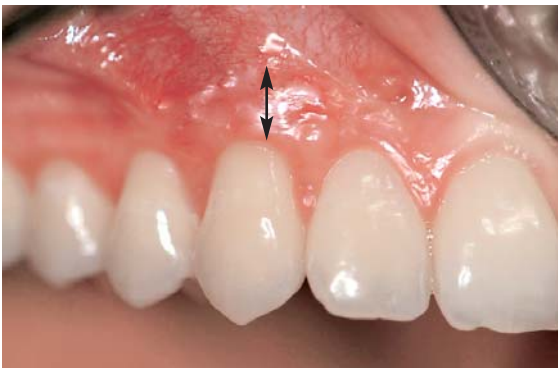


Fig 12 Post-operative (6 months) view of the outcome of gingival recession treatment with CTG and PRP. Note the significant increase of keratinised tissue width.



Fig 13 Post-operative (6 months) view of the outcome of gingival recession treatment with CTG. Note the appreciably smaller gain of keratinised tissue in comparison with gingival recession treated with CTG+PRP.

3.11 ± 0.32 and 4.20 ± 0.27 respectively. HI values obtained in the control group for the 1st and 2nd week post-surgery were 2.25 ± 0.54 and 3.05 ± 0.38. HI values recorded in the CTG+PRP group after 1 and 2 weeks of surgery were significantly improved compared with data recorded in CTG group ($p < 0.05$). Recordings of the HI obtained in the CTG+PRP group and the CTG group 3 weeks after surgery showed a high level of equivalence, 4.51 ± 0.21 and 4.29 ± 0.36 ($p > 0.05$) (Fig 14).

Regarding the post-operative period, 3 patients in the CTG+PRP group experienced severe pain compared with 7 patients recorded in the CTG group. All 15 patients indicated a greater discomfort in the CTG group. The pain intensity was statistically different between the groups for the first 5 days, favouring the CTG+PRP group (Table 5).

Discussion

Obtaining predictable and aesthetic root coverage is the goal of all root coverage procedures. The outcomes of this study reveal that both techniques, either CTG or CTG soaked with platelet concentrate (PRP) covered by a coronally positioned flap, are effective in the treatment of gingival recession defects with significant root coverage (91% and 88% respectively) and clinical attachment gain 6 months post-operatively. One hundred per cent root coverage was obtained in 77.54% of the cases for the CTG+PRP group and in 73.12% of the cases for the control (CTG) group. The literature reports wide variation for the clinical parameter of root coverage. Mean root coverage for the CTG in combination with coronally advanced flap ranges from 70%¹⁸ to 98%¹⁹⁻²².

The present study demonstrated that there were no statistically significant differences in PD or CAL recorded between the two groups. CAL showed significant attachment gain for both groups. For the CTG+PRP group the mean gain was 3.07 mm, and for the control group, it was 2.96 mm. KTW was statisti-

Fig 14 Healing index results.

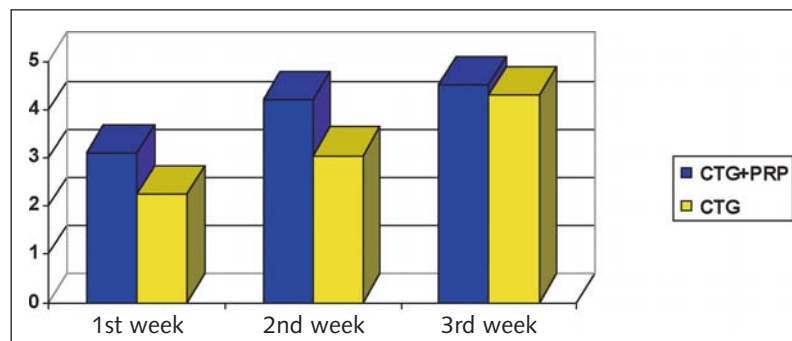




Fig 15 Pre-operative view of the gingival recession, tooth #23.

cally increased for both groups, averaging 1.88 mm and 1.14 mm in the CTG+PRP and the control group respectively. These outcomes are in agreement with literature reports for the treatment of gingival recession with CTG and coronally advanced flap^{23–25}.

The most interesting result recorded in the present study was a statistically significantly higher gain of KTW obtained in the CTG+PRP group in comparison with the CTG group (Figs 13, 14 and 15). Increased KTW in the CTG group may be related to the ability of the connective tissue of the palatal graft to induce keratinisation of the epithelium²⁶. Significantly higher gain of KTW obtained in the group treated with CTG in combination with PRP may be explained as a result of a tissue manifestation of the proliferation of gingival or periodontal fibroblasts as a result of the influence of the growth factors from PRP. While there was a statistical difference in gains of keratinised tissue, the final width in both groups was acceptable. It is unlikely that the final width of keratinised tissue of 3.20 ± 0.54 mm found in the CTG+PRP group would give a better outcome than the 2.55 ± 0.45 mm found in the CTG group.

Results of the HI indicated improvements of early wound healing (1st and 2nd week post-surgery) in the group treated with PRP, compared with the group treated without this fraction of plasma. This outcome may be related to the extremely elevated density of fibrin fibres (100 times more than normal) detected in the region treated with PRP. The high density of fibrin fibres provides additional stability for the wound. PRP acts like a tissue glue. The improvements of HI achieved in the PRP group could be explained as action of PDGF, VEGF (vascular endothelial growth factor) and TGF, the main growth factors from PRP. These growth factors might

enhance soft tissue healing by increasing the angiogenesis and matrix biosynthesis during wound healing²⁷. The effect on HI achieved in the experimental group is directly correlated with decreased patient discomfort for the first 5 days. The data obtained during evaluation of HI were in high correlation with results presented by Cheung and Griffin²⁸.

Results of this study indicate that the use of CTG is a highly effective method for root coverage. Clinical advantages of additional application of PRP are related with a significant increase in keratinised tissue, advanced tissue healing for the period of the first 2 weeks post-surgery and a major decrease of patient discomfort during the early wound healing period. Positive tendency of PRP utilisation should be better evaluated in studies involving larger numbers of subjects. No histological evaluation was performed in the present study; therefore the effect of PRP on overall regeneration capacity remains to be determined.

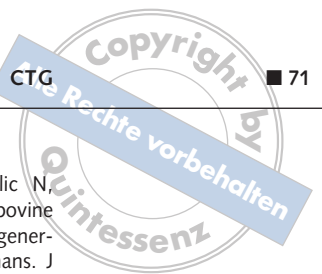
■ Conclusions

According to the results obtained in this clinical trial, it could be concluded that the positive clinical impact of additional application of PRP following treatment of gingival recession with CTG is based on:

- improved early healing process
- decreased patient discomfort
- noticeable increase in keratinised tissue in the treated region.

■ Clinical relevance

Obtaining predictable root coverage supported with significant levels of tissue regeneration has become an essential element of periodontal plastic surgery. It is conceivable that concentrated growth factors within PRP up-regulate cellular activity and subsequently promote periodontal regeneration *in vivo*. The aim of the present study was to evaluate and validate the clinical impact of activated PRP in the treatment of gingival recession with CTG as the basic procedure. The intention was to increase the regenerative potential of the periodontal tissues following the root coverage procedure and to enhance the wound healing process.



Principal findings

Deficient, visible, statistically significant differences of root coverage outcomes between the two groups (CTG alone versus CTG+PRP) were found, particularly the increase in keratinised tissue in CTG+PRP group.

Practical implications

PRP does not clearly improve the clinical results obtained with a CTG in gingival recession therapy, but it enhances the wound healing process and decreases patient discomfort.

References

- Kawase T, Okuda K, Wolff LF, Yoshie H. Platelet-rich plasma-derived fibrin clot formation stimulates collagen synthesis in periodontal ligament and osteoblastic cells in vitro. *J Periodontol* 2003;74:858–864.
- Bernimoulin JP, Lusher B, Muhelmann HR. Coronally repositioned periodontal flap: clinical evaluation after 1 year. *J Clin Periodontol* 1975;2:1–13.
- Guinard EA, Caffesse RG. Treatment of localized gingival recessions. Part I: Lateral sliding flap. *J Periodontol* 1978;49:351–356.
- Miller PD. Root coverage using a free soft tissue autograft following citric acid application. Part I: Technique. *Int J Periodontics Restorative Dent* 1982;2:65–70.
- Raetzke PB. Covering localized areas of root exposure employing the 'envelope' technique. *J Periodontol* 1985;56:397–402.
- Langer B, Langer L. Subepithelial connective tissue graft technique for root coverage. *J Periodontol* 1985;56:715–720.
- Nelson S. The subpedicle connective tissue graft: a bilaminar reconstructive procedure for the coverage of denuded root surfaces. *J Periodontol* 1987;58:95–102.
- Harris RJ. The connective tissue with partial thickness double pedicle graft: the results of 100 consecutively treated defects. *J Periodontol* 1994;65:448–461.
- Allen A. Use of the supraperiosteal envelope in soft tissue grafting for root coverage. II. Clinical results. *Int J Periodontics Restorative Dent* 1994;14:302–315.
- Bruno J. Connective tissue graft technique assuring wide root coverage. *Int J Periodontics Restorative Dent* 1994; 14:127–137.
- Marx RE. Platelet-rich plasma: a source of multiple autologous growth factors for bone grafts. In: Lynch SE, Genco RJ, Marx RE (eds). *Tissue Engineering. Applications in Maxillofacial Surgery and Periodontics*. Chicago: Quintessence 1999:71–82.
- Landesberg R, Roy M, Glickman RS. Quantification of growth factor levels using a simplified method of platelet-rich plasma gel preparation. *J Oral Maxillofac Surg* 2000;58:297–300.
- Camargo PM, Lekovic V, Weinlaender M, Vasilic N, Madzarevic M, Kenney EB. Platelet-rich plasma and bovine porous bone mineral combined with guided tissue regeneration in the treatment of intrabony defects in humans. *J Periodont Res* 2002;37:300–306.
- Okuda K, Kawase T, Momose M, Murata M, Saito Y, Suzuki H et al. Platelet-rich plasma contains high levels of platelet-derived growth factor and transforming growth factor- α and modulates the proliferation of periodontally related cells in vitro. *J Periodontol* 2003;74:849–857.
- Momose M, Murata M, Kato Y, Yamazaki K, Yoshie H. Vascular endothelial growth factor and transforming growth factor are released from human cultured sheets. *J Periodontol* 2002;73:748–753.
- Weibrich G, Kleis WKG, Hafner G. Growth factor levels in the platelet-rich plasma produced by two different methods: Curasan-type PRP kit versus PCCS PRP system. *Int J Oral Maxillofac Implants* 2002;17:184–190.
- Landry RG, Turnbull RS, Howley T. Effectiveness of benzylamine HCl in the treatment of periodontal post-surgical patients. *Res Clinic Forums* 1988;10:105–118.
- Bouchard P, Nilveus R. Clinical evaluation of tetracycline HCl conditioning in the treatment of gingival recession: a comparative study. *J Periodontol* 1997;68:262–269.
- Wennström JL, Zuchelli G. Increased gingival dimensions. A significant factor for successful outcome of root coverage procedures. *J Clin Periodontol* 1996;23:770–777.
- Clauser C, Nieri M, Franceschi D, Pagliaro U, Pini-Prato G. Evidence-based mucogingival therapy. Part 2: Ordinary and individual patient data meta-analyses of surgical treatment of recession using complete root coverage as the outcome variable. *J Periodontol* 2003;74:741–756.
- Jahnke PV, Sandifer JB, Gher ME, Gray JL, Richardson AC. Thick free gingival and connective tissue autografts for root coverage. *J Periodontol* 1993;64:315–322.
- Wang HL, Bunyaratavej P, Labadie M, Shyr Y, MacNeil RL. Comparison of 2 clinical techniques for treatment of gingival recession. *J Periodontol* 2001;72:1301–1311.
- Trombelli L, Scabbia A, Tatakis DN, Calura G. Sub-pedicle connective tissue graft versus guided tissue regeneration with bioabsorbable membrane in the treatment of gingival recession defects. *J Periodontol* 1998;69:1271–1277.
- Wang HL, Bunyaratavej P, Labadie M, Shyr Y, MacNeil RL. Comparison of 2 clinical techniques for treatment of gingival recession. *J Periodontol* 2001;72:1301–1311.
- Rocuzzo M, Bunino M, Needleman I, Sanz M. Periodontal plastic surgery for treatment of localized gingival recessions: a systematic review. *J Clin Periodontol* 2002;29(Suppl 3): 178–194.
- Pini Prato G, Cortellini P. Guided tissue regeneration versus mucogingival surgery in the treatment of human buccal gingival recession. *J Periodontol* 1992;63:919–928.
- Huang I, Neiva EF, Soehren S, Giannobile V. The effect of PRP on the coronally advanced flap root coverage procedure: a pilot human trial. *J Periodontol* 2005;76:1768–1777.
- Cheung WS, Griffin TJ. A comparative study of root coverage with connective tissue and platelet concentrate grafts: 8-month results. *J Periodontol* 2004;75:1678–1687.