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# Crestal bone resorption after the application of two periodontal surgical techniques. A randomized, controlled clinical trial

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***Abstract***

**Aim:** To radiographically assess, by means of digital subtraction radiography, crestal bone loss following two periodontal surgical techniques, over a period of 6 months.

**Material and methods:** A total of 30 chronic periodontitis patients participated in this randomized controlled clinical trial and were separated into two groups. Modified Widman flap was applied in the control group and apically positioned flap, without intervention to the bone, in the experimental group. Clinical measurements (plaque index, gingival bleeding index, probing pocket depth and clinical attachment level) were recorded at baseline, 6 weeks, 3 and 6 months after surgery. Digital radiographs were taken at baseline, 1, 3, 6 weeks, 3 and 6 months after surgical treatment and subtracted digitally in pairs.

**Results:** Both groups showed statistically significant improvement of clinical parameters. Statistically significant differences between the two groups were observed only in probing pocket depth (PPD) at 6 weeks interval, where the test group showed more reduction (smallest statistically significant differences observed, SSSDO = 0.64). Both groups showed the same rate of crestal bone resorption.

**Conclusions:** Bone resorption of the alveolar crest is a phenomenon that is observed as a consequence of periodontal surgical treatment without significant differences between the two techniques. Furthermore, both surgical techniques lead to satisfactory clinical results, indicating that bone removal during periodontal surgical treatment is not always necessary.

Key words: periodontitis; periodontal surgical treatment; digital subtraction radiography; bone resorption

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**Conflict of interest and source of funding statement**

The authors declare that they do not have any conflict of interests.
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The primary goal of periodontal therapy is to arrest the inflammatory disease process. Treatment involves mechanical removal of the subgingival biofilm and the establishment of a local environment compatible with periodontal health [American Academy of Periodontology (AAP) 1998]. Chronic periodontal disease can be successfully treated by non-surgical or surgical mechanical therapy provided adequate plaque control is maintained during the supportive phase of treatment

(American Academy of Periodontology 2001). Modified Widman flap (MWF) and apically positioned flap (APF), with or without intervention to the bone, are the surgical techniques mostly used in everyday clinical practice.

Histological findings in humans have revealed that a consequence of periodontal surgical treatment is the loss of crestal bone. Kohler and Ramfjord found an average loss of 0.23 mm (Kohler & Ramfjord 1960), whereas Donnenfeld et al. observed a mean loss of 0.63 mm (Donnenfeld et al. 1964). All studies indicated that crestal bone loss after surgical treatment depends on the bone trauma and on the periodontal biotype, with the thin one exhibiting greater crestal resorption (Donnenfeld et al. 1964, Wilderman 1964, Tavtigian 1970).

Intraoral radiographs provide an acceptable, non-invasive, diagnostic test for the assessment and follow-up of periodontal bone status. By measuring distances between anatomical landmarks, the extent of bone loss and, by comparison of such measurements over time, changes in bone level may be assessed (Hausmann 2000, Mol 2004). Digital subtraction analysis represents another volume-based tool for detecting even minor bone changes (Ortman et al. 1985).

The aim of this prospective, randomized, controlled, clinical trial was the radiographic assessment of crestal bone loss, by means of digital subtraction analysis, after the application of MWF and APF, without intervention to the bone, over a 6-month period.

## Material and Methods

### Study design

A total of 33 severe chronic periodontitis (Armitage, 1999) patients (15 women and 17 men, aged 35–70), referred for therapy to the postgraduate clinic of the Department of Preventive Dentistry, Periodontology and Implant Biology, Dental School, Aristotle University of Thessaloniki, Greece, from April 2008, until December 2009, were selected after a screening examination of 45 patients. The study was performed in accordance with the Helsinki Declaration of 1975, as revised in 2008, and was pproved by the Ethics Commission of the Dental School, Aristotle University of Thessaloniki (protocol number 114, 10/04/2008). All patients read and signed informed consent forms prior to their enrolment in the study. The study design and patient flow are depicted in Fig. 1.

All patients completed Phase I periodontal therapy, consisting of scaling and root planing. At baseline, and at every recall session, patients were continuously given training, were motivated to implement oral hygiene procedures and supragingival debridement was performed. After a healing period of 6–8 weeks, clinical evaluation was repeated and patients presenting at least three residual periodontal pockets of posterior teeth, measuring $\geq 6$ mm in one quadrant, with radiographic evidence of bone loss were selected to participate in the study. In addition to demonstrating adequate oral hygiene levels (plaque and bleeding score $\leq 20\%$), patients enrolled in the study met the following inclusion criteria: (1) no systemic diseases or drugs potentially influencing the outcome of therapy, (2) no smokers, (3) no intake of systemic antibiotics during the preceding 6 months, (4) no pregnancy, (5) tooth mobility $\leq$ I grade, (6) tooth recession $\leq$ class I (Miller 1985).

### Minimum sample size

The determination of sample size was performed on a patient-based analysis. If a difference in bone resorption between the two groups of $1 \pm 0.9$ mm SD (Persson et al. 2000) within each group is to be detected at significance level $\alpha = 0.05$ with a power of $\gamma = 0.80$, the minimum number of patients per group would be 14. Hence, the inclusion of at least 28 patients in the study would yield the adequate statistical power for group comparisons. Hence, the primary outcome variable was bone resorption in mm as calculated from digital subtraction images and the secondary variables were PPD, CAL, PLI and GBI. The power analysis was accomplished by the GPower v.3 software (Faul et al. 2007). This difference between the two groups was considered clinically significant according to previous histological studies (Kohler & Ramfjord 1960, Donnenfeld et al. 1964). In total, 32 patients have been included in the study, to foresee any dropouts and were randomly assigned to the control group receiving MWF (Ramfjord & Nissle 1974), or to the test group receiving APF (Friedman & Levine 1964), without intervention to the bone.

### Surgical procedure

Reverse bevel flaps with a scalloped gingival incision were given using the Bard Parker knife with blade number 12 and 11, respectively, on both the buccal and lingual sides in the operated sites. The gingival incision was parallel to the long axis of the teeth, about 1 mm from the tooth surface, including the interproximal surfaces and extending to the alveolar bone. Vertical releasing incisions were not made. A full thickness mucoperiosteal flap was then reflected using the periosteal elevator. Care was taken not to elevate the flap beyond the mucogingival junction in the control group. At the test group the flap was elevated beyond the mucogingival junction. After reflection of the flap and exposure of theosseous defect, a thorough surgical debridement of soft and hard tissue was performed without bone removal. The mucoperiosteal flaps were then repositioned and secured in place using 4–0 silk sutures. Interrupted direct loop sutures were placed to obtain primary closure of the interdental space, in the control group, while continuous sling sutures were used in the test group, so as to place the flap more apically.

All patients were prescribed with Nimesulide 100 mg tablets twice daily for 3 days and chlorexidin digluconate 0.12% rinsing for 2 weeks. After 1 week, sutures were removed.

### Randomization

Randomization was performed using a computer-generated assignment procedure (http://www.randomization.com). This process was completed by one investigator who did not participate in the surgical treatment or data collection (D. S.). Then another investigator (L. T.) gave a

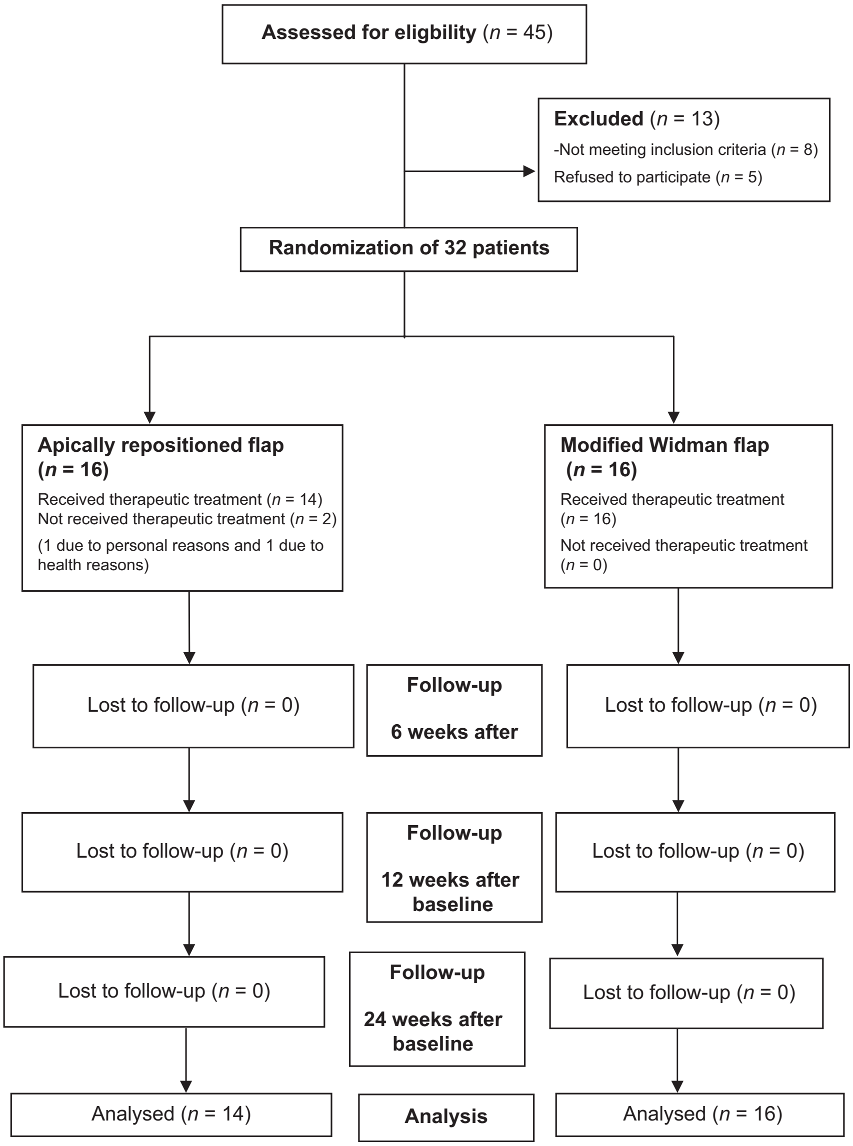


*Fig. 1.* Flowchart of the patients throughout the study.

sealed envelope to the clinicians immediately after they had performed the clinical measurements, with the details of the surgical treatment. The randomization code was not broken until all data had been collected.

### Clinical parameters

The following clinical parameters were assessed on the day of the surgery (baseline), after 6 weeks, 3 and 6 months, using the same type of periodontal probe (PCP-UNC 15; Hu-Friedy, Chicago, IL, USA): probing pocket depth (PPD), clinical attachment level (CAL), plaque index (PLI, O'Leary et al. 1972) and gingival bleeding index (GBI, Carter & Barnes 1974). The measurements were made at six sites per tooth. All clinical measurements were made by the clinicians performing the surgery (T. K., S. G.). Initially, a total of five patients were selected for calibration. Every clinician measured PPD and CAL of the five patients twice, with at least 1 h between the examinations. The examination was judged to be reproducible, if the percentage of agreement within ±1 mm between repeated measurements was at least 90%. So, intra-class correlation for the one clinician (T. K.) was 92% for PPD and 91% for CAL, and for the other (S. G.) was 93% and 92%. Inter-class correlation between the two clinicians was 91%. To ensure blindness of the procedure, at every recall session the clinician recorded the clinical measurements of those patients that had not received surgical treatment by him.

### Radiographic procedure

Standardized periapical digital radiographs (RadioVisioGraphy; Trophy Radiology S.A., Paris, France) were obtained using the long-cone paralleling technique (Eggen 1969). The radiographs were taken employing an Oralix AC Densomat X-ray unit (Gendex Dental System, Milano, Italy), operating at 65 kV and 7.5 mA. The exposure time was the same for all the radiographs. To standardize the exposure geometry, a customized bite-block of an elastic impression material was placed on the film holder, stored in sealed plastic containers at room temperature and reused during every recall radiographic appointment (Albandar 1989, Janssen et al. 1989, Shrout et al. 1993, Eickholz et al. 1994). The digital radiographs were taken before the surgical treatment on the day of the surgery (baseline), 1, 3, 6 weeks and 3 and 6 months after surgery.

Each radiographic image was digitally subtracted from the baseline radiograph using the software Eikona Subtraction Radiography for Windows (AIIA Laboratory, Department of Informatics, Aristotle University of Thessaloniki). This software utilizes algorithms for registration and subtraction of digital images. The resulting digital subtractive image was a greyscale image, with white regions where there was crestal bone apposition, or with black regions where there was crestal bone resorption. The digital subtraction images that were acquired from the subtraction of the baseline image were: (1) D1, 1 week from the baseline, (2) D2, 3 weeks from baseline, (3) D3, 6 weeks from baseline, (4) D4, 3 months from baseline, (5) D5, 6 months from baseline. In addition, the image of the third week was subtracted from that of the 6 months (D6), because according to histological studies, from the third postoperative week there is a crestal bone apposition (Caffesse et al. 1968). Subsequently, one examiner (G. M.), who did not participate in the clinical and surgical procedures, made linear measurements of the white and black regions of all the digital subtraction images, close to the tooth surface, recording two measurements in each interproximal space. These measurements were made by clicking two points on the radiographic image with the mouse. The distance between these points was calculated by the software. Initially, a total of five patients were selected for examiner calibration. The examiner measured the digital subtraction images of the five patients twice, with at least 1 h between the examinations. The examination was judged to be reproducible if the percentage of agreement within ±1 mm between repeated measurements was at least 90%. Intra-class correlation was found to be 90%.

### Statistical analysis

The available data, only from patients that had completed the study, were summarized using statistical descriptive indices of central tendency and dispersion (means, medians and standard deviations). Data for bone resorption, PPD, CAL, GBI and PLI were analysed in the methodological frame of the Mixed Linear Models to take into account the hierarchical structure of the data (West et al. 2007). Specifically, the model involved two fixed effects factors, one factor between patients, the group, and one factor within patients with repeated measures, the time, and two random effects factors: patients within groups and sites nested in patients within groups. Mean values of the parameters were tested with the Least Significant Difference criterion at $p < 0.05$. Due to the fact that the design was unbalanced each comparison of means was based on a separate standard error and not on a common one. In general, different standard errors for the mean differences were estimated by the corresponding Analyses of Variance. For this reason and to facilitate the interpretation of the results of the absolute value of the smallest statistically significant differences observed (SSSDO) were reported in tabulated results (Kadoglidou et al. 2011). The significance level of all statistical hypothesis testing procedures was preset at $p < 0.05$. All the statistical analyses were performed using the SPSS ver. 15.0 statistical package (SPSS Inc, Chicago, IL, USA).

## Results

Figure 1 illustrates the study flowchart. The final composition of the study population was 30 patients, 16 comprising the control group and 14 the test one. Two patients from the test group did not receive any treatment, one due to personal reasons and the other due to health problems. Patients' characteristics at baseline were not clinically significantly different between the two groups, as can be seen in Table 1. Post-operative healing was uneventful in all cases.

### Clinical results

The means of PLI and GBI at the surgical sites in both groups were $\leq 20\%$ during the whole study. The values of PPD at the surgical sites are displayed in Table 2. In the control group baseline PPD was 5.65 ± 0.23 mm and was decreased to 3.69 ± 0.24 mm at 6 months interval, which was statistically significant (SSSDO = 1.86). At every time interval the decrease in PPD was statistically significant from baseline (SSSDO = 1.86). The same tendency was also observed in the patients who received APF. Probing pocket depth was 5.39 ± 0.21 mm at baseline and was statistically significantly decreased at 6 months (3.23 ± 0.21 mm, SSSDO = 0.64). Statistically significant difference was observed between the control and test group only in 6 weeks, where APF group showed greater reduction (SSSDO = 0.64).

The values of CAL at the surgical sites are shown in Table 2. In the control group baseline CAL was 7.15 ± 0.36 mm and was decreased

*Table 1.* Demographic characteristics of the patient sample

| | APF | MWF |
|---|---|---|
| *N* | 14 | 16 |
| Age (mean ± SD years) | 50.3 ± 13.2 | 51.7 ± 14.6 |
| Gender (male/female) | 6/8 | 7/9 |
| Initial PPD (mean ± SD mm) | 3.57 ± 1.37 | 3.62 ± 1.58 |
| Initial CAL (mean ± SD mm) | 5.21 ± 1.84 | 5.42 ± 1.79 |
| Full mouth PLI (mean ± SD %) | 14.46 ± 1.27 | 16.77 ± 1.45 |
| Full mouth GBI (mean ± SD %) | 12.74 ± 1.23 | 14.21 ± 1.05 |

APF, Apically Positioned Flap; CAL, clinical attachment level; GBI, gingival bleeding index; MWF, Modified Widman Flap; PLI, plaque index; PPD, probing pocket depth.

*Table 2.* Mean probing pocket depth (PPD) and clinical attachment level (CAL) scores (mean ± SE) at various examination intervals

| | Baseline | 6 weeks | 3 months | 6 months |
|---|---|---|---|---|
| PPD | | | | |
| APF | 5.39 ± 0.21 mm | **3.16 ± 0.21** mm* | 3.26 ± 0.21 mm* | 3.23 ± 0.21 mm* |
| MWF | 5.65 ± 0.23 mm | **3.79 ± 0.23** mm* | 3.73 ± 0.23 mm* | 3.69 ± 0.23 mm* |
| CAL | | | | |
| APF | 6.57 ± 0.33 mm | 5.79 ± 0.33 mm* | 6.00 ± 0.33 mm* | 5.71 ± 0.33 mm* |
| MWF | 7.15 ± 0.36 mm | 6.72 ± 0.36 mm | 6.37 ± 0.36 mm* | 6.48 ± 0.37 mm* |

*Statistically significant difference from baseline (absolute SSSDO = 1.86 for PPD and absolute SSSDO = 0.56 for CAL).
Statistically significant differences among groups are indicated by bold lettering (absolute SSSDO = 0.64 for PPD).

to 6.48 ± 0.37 mm at 6 months interval, which was statistically significant (SSSDO = 0.56). At every time interval the decrease in CAL was statistically significant from baseline (SSSDO = 0.56). The same tendency was also observed at the patients who received APF. CAL was 6.57 ± 0.33 mm at baseline and was statistically significant decreased at 6 months (5.71 ± 0.33 mm, SSSDO = 0.56). No statistically significant differences were observed between the control and test group.

### Radiographic results

The total number of teeth analysed radiographically was 62. The final radiographic analysis included 58 teeth. Four teeth were excluded (two belonging to the control and two to the test group) because the subtraction of the images could not be performed, due to geometrical distortion of these images.

The minimal difference that could be detected by this methodology is one pixel (picture element). The actual size of a pixel of a digital image is depended on its resolution. In this study the resolution of digital subtractive images was 300 pixels/cm, so the minimal difference that could be detected was 0.0033 cm (Orstavic et al. 1990, Reddy 1992).

The healing process of the alveolar bone was the same for the two surgical procedures and can be seen in Table 3. Bone resorption was observed from the first week after surgery and it lasted until the third week. From the third postsurgical week, and throughout the sixth postsurgical month, there was bone apposition that never reached the pre-surgical level of bone. The linear measurements of the black and white regions (bone resorption or apposition) of the digital subtraction images (Figs. 2–4) showed that, in the control group, bone absorption was 2.80 ± 0.37 mm during the first post-surgical week, 3.01 ± 0.37 mm during the third week and reached to 0.80 ± 0.39 mm at 6 months. In the test group, bone resorption was 2.68 ± 0.34 mm at the first week, 2.90 ± 0.34 mm at the third week and finally, 1.49 ± 0.36 mm at 6 months. In addition, patients who received MWF showed bone apposition of 2.64 ± 0.38 mm from the third postsurgical week throughout the sixth month. The same measurement for the APF showed bone apposition of 1.61 ± 0.36 mm. This difference was not statistically significant between the two groups (SSSDO = 1.08). Statistically significant differences between the two groups were only observed in bone resorption at the third postsurgical month, where MWF group showed 1.0 mm less resorption than APF group (SSSDO = 1.08).

### Discussion

The results of this study showed that periodontal surgical treatment is an effective method of therapy that arrests the disease progression, as shown by the clinical outcomes. Although the 6 months of observation is not a very long period from which to extract safe conclusions, the strict study design with the randomization, the blindness of the investigators and the frequent recall system of the patients, indicate that surgical treatment can successfully inhibit the disease progression. In addition, the study showed that MWF and APF, without intervention to the bone produce very similar clinical results.

Probing pocket depth of all the patients were statistically significant reduced from the baseline measurements. In addition, there was a statistically significant gain in CAL of all the patients. Statistically significant differences between the two groups were found only in PPD at 6 weeks; attributable to greater gingival recession of the patients that had undergone APF, due to the more apical position of the flap. These results in the present study are in agreement with those of the classical studies over greater time periods (Pihlstrom et al. 1983, Lindhe et al. 1984, Olsen et al. 1985, Westfelt et al. 1985, Isidor & Karring 1986, Ramfjord et al. 1987, Kaldahl et al. 1996, Becker et al. 1988, 2001). Pihlstrom et al. (1983) in their study, found a reduction of 2.18 mm in PPD and a gain of 0.91 mm in CAL at 6 months after periodontal surgical treatment. A more recent study produced the same results. Patients

*Table 3.* Mean bone resorption/apposition in mm (mean ± SE) during healing process

| | 1 week | 3 weeks | 6 weeks | 3 months | 6 months | Bone apposition (3w–6 m) |
|---|---|---|---|---|---|---|
| APF (*n* = 14) | −2.68 ± 0.34 | −2.90 ± 0.34 | −2.15 ± 0.34 | **−2.06 ± 0.34** | −1.49 ± 0.36 | 1.61 ± 0.36 |
| MWF (*n* = 16) | −2.80 ± 0.37 | −3.08 ± 0.37 | −1.72 ± 0.37 | **−0.98 ± 0.37** | −0.80 ± 0.39 | 2.64 ± 0.38 |

Statistically significant differences in radiographic linear measurements among groups are indicated by bold lettering (absolute SSSDO = 1.08).

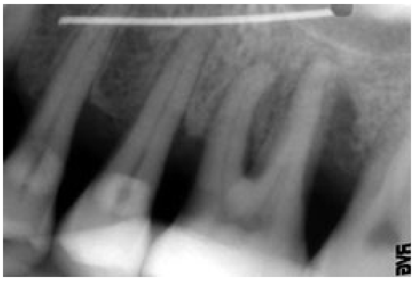

*Fig. 2.* Digital radiography image at baseline.

*Fig. 3.* Digital radiography image at 6 months.

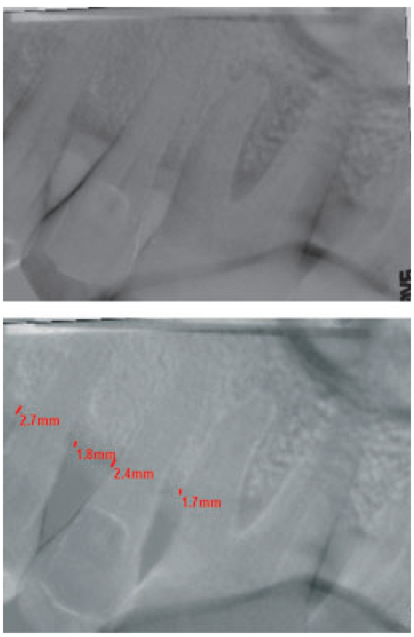


*Fig. 4.* Digital subtraction radiography image resulting from the subtraction of the sixth month image from the baseline one and linear measurements of the black areas (bone resorption) of this digital subtraction radiography image.

who received MWF had a 2 mm reduction of PPD and a gain of 0.73 mm in CAL, whereas patients of APF with bone removal had a 2.6 mm reduction of PPD and a gain of 0.77 mm in CAL (Becker et al. 2001).

The final bone resorption after MWF was 0.80 ± 0.39 mm and 1.49 ± 0.36 mm after APF, at 6 months. This difference was not statistically significant. Bone apposition from the third postsurgical week throughout the 6 months, was 2.64 ± 0.38 mm for the control group and 1.61 ± 0.36 mm in the test one; not a statistically significant difference. Statistically significant differences between the two groups were found only at 3 months, where patients in APF group had 1.0 mm more crestal bone loss. This is probably due to the fact that healing of bone after the application of APF demands more time, as indicated by the not statistically significant difference between the two groups at 6 months.

To the best of our knowledge, few clinical trials study crestal bone resorption after periodontal surgical treatment. Nevertheless, there are some studies of guided tissue regeneration (GTR) that refer to this phenomenon as a secondary parameter. Persson et al., through linear measurements in digital images, found that crestal bone loss after APF is 1.7 and 1.5 mm after GTR (Persson et al. 2000). These findings are almost identical to those of the present trial. However, Eickholz et al. found less bone resorption of 0.4 mm after surgical therapy (Eickholz et al. 1997). A more recent study evaluated bone resorption at 0.18 mm after GTR and 0.32 mm after MWF (Joly et al. 2002). The majority of the other clinical trials using digital subtraction radiography just answer the question of whether or not bone resorption occurs, qualitatively, without producing numerical data (Brägger et al. 1988, Schmidt et al. 1988). At this point, it is worth noting that a number of quantitative measurements can be made, such as linear, area, perimeter and density to detect bone loss in digital imaging (Brägger et al. 1992, Iversen et al. 1996, Parashis & Tsiklakis 2000, Christgau et al. 2006). In the present clinical trial a programme of digital radiography was used to execute linear measurements in the subtraction images. Tonetti et al. and Toback et al. stated that linear measurements in radiographs underestimate bone apposition by almost 1 mm after GTR (Tonetti et al. 1993, Toback et al. 1999). Nevertheless, the findings of the present study are almost the same of the above studies and closer to the histological ones that were made in the 1970s.

All the histological findings in humans have revealed that crestal bone loss is a consequence of periodontal surgical treatment. Kohler and Ramfjord found an average loss of 0.23 mm after MWF (Kohler & Ramfjord 1960), whereas Froum et al. showed a bone loss that reached 0.8 mm (Froum et al. 1982). In addition, Donnenfeld et al. observed a mean loss of 0.63 mm in patients who received APF which reached 1.2 mm to some patients (Donnenfeld et al. 1964). Similar results were reported by Tavtigian with a mean bone loss of 0.47 mm of the facial radicular alveolar crest, after full thickness flap procedures in six patients. Post-operative changes varied from a loss of 2.3 mm to a bone gain of 0.5 mm. This loss of bone after APF was statistically significant (Tavtigian 1970). Crestal bone loss is greater when osteoplasty and ostectomy procedures are performed during surgery (Moghaddas & Stahl 1980). The results of the above histological trials, which present the most reliable method of studying the bone healing, almost coincide with the radiographic ones of the present trial. In conclusion, the findings of this study suggest that crestal bone resorption is a phenomenon that happens as a consequence of periodontal surgical treatment, with similar effect for patients receiving either a MWF, or an APF. In addition, both surgical techniques lead to satisfactory clinical results, indicating that bone removal during periodontal surgical treatment is not always necessary.

## References

Albandar, J. M. (1989) Validity and reliability of alveolar bone level measurements made on dry skulls. *Journal of Clinical Periodontology* **23**, 512–516.

American Academy of Periodontology. (2001) Treatment of plaque-induced gingivitis, chronic periodontitis and other clinical conditions. *Journal of Periodontology* **72**, 1790–1800.

American Academy of Periodontology (AAP). (1998) Guidelines for periodontal therapy. *Journal of Periodontology* **69**, 405–408.

Armitage, G. C. (1999). Development of a classification system for periodontal diseases and conditions. *Annals of Periodontology* **4**(1), 1–6.

Becker, W., Becker, B. E., Caffesse, R., Kerry, G., Ochsenbein, C., Morrison, E. & Prichard, J. (1988) A longitudinal study comparing scaling, osseous surgery and modified Widman flap procedures: results after 1 year. *Journal of Periodontology* **59**, 351–365.

Becker, W., Becker, B. E., Caffesse, R., Kerry, G., Ochsenbein, C., Morrison, E. & Prichard, J. (2001) A longitudinal study comparing scaling, osseous surgery and modified Widman flap procedures: results after 5 years. *Journal of Periodontology* **72**, 1675–1684.

Brägger, U., Hammerle, C. H., Mombelli, A., Burgin, W. & Lang, N. P. (1992) Remodelling of periodontal tissues adjacent to sites treated according to the principles of guided tissue regeneration (GTR). *Journal of Clinical Periodontology* **19**(9 Pt 1), 615–624.

Brägger, U., Pasquali, L., Rylander, H., Carnes, D. & Kornman, K. S. (1988) Computer-assisted densitometric image analysis in periodontal radiography. A methodological study. *Journal of Clinical Periodontology* **15**, 27–37.

Caffesse, R. G., Ramfjord, S. P. & Nasjleti, C. E. (1968) Reverse bevel periodontal flaps in monkeys. *Journal of Periodontology* **39**, 219–235.

Carter, H. G. & Barnes, G. P. (1974) The Gingival Bleeding Index. *Journal of Periodontology* **45**, 801–805.

Christgau, M., Moder, D., Wagner, J., Gläßl, M., Hiller, K.-A., Wnzel, A. & Schmalz, G. (2006) Influence of autologous platelet concentrate on healing in intrabony defects following guided tissue regeneration therapy: a randomized prospective clinical split-mouth study. *Journal of Clinical Periodontology* **33**, 908–921.

Donnenfeld, O. W., Marks, R. M. & Glickman, I. (1964) The apically repositioned flap – a clinical study. *Journal of Periodontology* **35**, 381–387.

Eggen, S. (1969) Standardiserad intraoral røntgenteknikk. *Sveriges Tandlakarforbunds Tidning* **61**, 867–872.

Eickholz, P., Dorfer, C. & Staehle, H. J. (1994) Reproduzierbarkeit standartisierter Bibflugelaufnahmen bei Patienten mit fortgeschrittener Parodontitis. *Deutsche Zahnarztliche Zeitung* **49**, 398–402.

Eickholz, P., Kim, T.-S. & Holle, F. (1997) Guided tissue regeneration with non-resorhable and biodegradable barriers: 6 months results. *Journal of Clinical Periodontology* **24**, 92–101.

Faul, F., Erdfelder, E., Lang, A.-G. & Buchner, A. (2007) G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, **39**, 175–191.

Friedman, N. & Levine, H. L. (1964) Mucogingival surgery: current status. *Journal of Periodontology* **35**, 5–17.

Froum, S. J., Coran, M., Thaller, B., Kurshner, L., Scopp, I. W. & Stahl, S. S. (1982) Periodontal healing following open debridement flap procedures. I. Clinical assessment of soft tissue and osseous repair. *Journal of Periodontology* **53**, 8–14.

Hausmann, E. (2000) Radiographic and digital imaging in periodontal practice. *Journal of Periodontology* **71**, 497–503.

Isidor, F. & Karring, T. (1986) Long -term effect of surgical and non-surgical periodontal treatment. A 5-year clinical study. *Journal of Periodontal Research* **21**, 462–472.

Iversen, B., Albandar, J. M., Oydna, J. & Gjermo, P. (1996) Bone density changes after 1 year in periodontal lesions treated surgically with or without ePTFE membrane placement. *Journal of Clinical Periodontology* **23**, 512–516.

Janssen, P. T., Van Palenstein Helderman, W. H. & Van Aken, J. (1989) The effect of in-vivo-occurring errors in the reproducibility of radiographs on the use of the subtraction technique. *Journal of Clinical Periodontology* **16**, 53–58.

Joly, J. C., Palioto, D. B., Martorelli de Lima, A. F., Mota, L. F. & Caffesse, R. (2002) Clinical and radiographic evaluation of periodontal intrabony defects treated with guided tissue regeneration. A pilot study. *Journal of Periodontology* **73**, 353–359.

Kadoglidou, K., Lagopodi, A., Karamanoli, K., Vokou, D., Bardas, G. A., Menexes, G. & Constantinidou, H.-I. A. (2011) Inhibitory and stimulatory effects of essential oils and individual monoterpenoids on growth and sporulation of four soil-borne fungal isolates of aspergillus terreus, fusarium oxysporum, penicillium expansum, and verticillium dahliae. *European Journal of Plant Pathology*, **130**, 297–309.

Kaldahl, W. B., Kalkwarf, K. L., Patil, K. D., Molvar, M. P. & Dyer, J. K. (1996) Long-term evaluation of periodontal therapy: I. Response to 4 therapeutic modalities. *Journal of Periodontology* **67**, 93–102.

Kohler, C. A. & Ramfjord, S. P. (1960) Healing of gingival mucoperiosteal flaps. *Oral Surgery Oral Medicine Oral Pathology Oral Radiology Endodontics* **13**, 89–103.

Lindhe, J., Westfelt, E., Nyman, S., Socransky, S. S. & Haffajee, A. D. (1984) Long-term effect of surgical/non-surgical treatment of periodontal disease. *Journal of Clinical Periodontology* **11**, 448–458.

Miller, P. D. (1985) A classification of marginal tissue recession. *International Journal of Periodontics and Restorative Dentistry* **5**, 8–13.

Moghaddas, H. & Stahl, S. S. (1980) Alveolar bone remodelling following osseous surgery. A clinical study. *Journal of Periodontology* **51**, 376–381.

Mol, A. (2004) Imaging methods in periodontology. *Periodontology 2000* **34**, 34–48.

O'Leary, T. J., Drake, R. B. & Naylor, J. E. (1972) The plaque control record. *Journal of Periodontology* **43**, 38.

Olsen, C. T., Ammons, W. F. & van Belle, G. (1985) A longitudinal study comparing apically repositioned flaps with and without osseous surgery. *International Journal of Periodontics and Restorative Dentistry* **4**, 11–33.

Orstavic, D., Farrants, G., Wahl, T. & Kerekes, K. (1990) Image analysis of endodontic radiographs: digital subtraction and quantitative densitometry. *Endodontic and Dental Traumatology* **6**, 6–11.

Ortman, L. F., Dunford, R., McHenry, K. & Hausmann, E. (1985) Subtraction radiography and computer - assisted densitometric analyses of standardized radiographs. A comparison study with 125I absorptiometry. *Journal of Periodontal Research* **20**, 644–651.

Parashis, A. & Tsiklakis, K. (2000) Clinical and radiographic findings following application of enamel matrix derivative in the treatment of intrabony defects. *Journal of Clinical Periodontology* **27**, 705–713.

Persson, G. R., Falk, H. & Laurell, L. (2000) A retrospective radiographic outcome assessment study of intra-bony defects by osseous surgery or by bone graft procedures. *Journal of Clinical Periodontology* **27**, 104–108.

Pihlstrom, B. L., Mc Hugh, R., Oliphant, T. H. & Ortiz-Campos, C. (1983) Comparison of surgical and nonsurgical treatment of periodontal disease. A review of current studies and additional results after 6 1/2 years. *Journal of Clinical Periodontology* **10**, 524–541.

Ramfjord, S. P., Caffesse, R. G., Morrison, E. C., Hill, R. W., Kerry, G. J., Appleberry, E. A., Nissle, R. R. & Stults, D. L. (1987) 4 modalities of periodontal treatment compared over 5 years. *Journal of Clinical Periodontology* **14**, 445–452.

Ramfjord, S. P. & Nissle, R. R. (1974) The modified Widman flap procedure. *Journal of Periodontology* **45**, 601–607.

Reddy, M. S. (1992) Radiographic methods in the evaluation of periodontal therapy. *Journal of Periodontology* **63**(Suppl. 12), 1078–1084.

Schmidt, E. F., Webber, R. L., Ruttimann, U. E. & Loesche, W. J. (1988) Efect of periodontal therapy on alveolar bone as measured by subtraction radiography. *Journal of Periodontology* **59**, 633–638.

Shrout, M. K., Hildelbolt, C. F. & Vannier, M. W. (1993) Alignment errors in bitewing radiographs using uncoupled positioning devices. *Dentomaxillofacial Radiology* **22**, 33–37.

Tavtigian, R. (1970) The height of the facial radicular alveolar crest following apically positioned flap operations. *Journal of Periodontology* **41**, 412–419.

Toback, G. A., Brunsvold, M. A., Nummikoski, P. V., Masters, L. B., Melloning, J. T. & Cochran, D. L. (1999) The accuracy of radiographic methods in assessing the outcome of periodontal regenerative therapy. *Journal of Periodontology* **70**, 1479–1489.

Tonetti, M., Pini Prato, G. P., Williams, R. & Cortellini, P. (1993) Periodontal regeneration of human intrabony defects. III. Diagnostic strategies to detect bone gain. *Journal of Periodontology* **64**, 269–277.

West, B., Welch, K. & Galecki, A. (2007) *Linear Mixed Models: A Practical Guide Using Statistical Software*. New York: Chapman and Hall/CRC.

Westfelt, E., Bragd, L., Socransky, S. S., Haffajee, A. D., Nyman, S. & Lindhe, J. (1985) Improved periodontal conditions following therapy. *Journal of Clinical Periodontology* **12**, 283–293.

Wilderman, M. N. (1964) Exposure of bone in periodontal surgery. *Dental Clinics of North America* **8**, 23–25.

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**Clinical Relevance**

*Scientific rationale for the study*: Although, histological findings from animal and human studies have provided evidence that crestal bone loss is a consequence of periodontal surgical treatment, it is not yet determined whether apically positioned flap without intervention to the bone, leads to greater bone resorption, compared to modified Widman flap.

*Principal findings*: The findings of this study indicate that periodontal surgery involving either modified Widman flap, or apically positioned flap with no bone removal lead to similar crestal bone resorption.

*Practical implications*: Both surgical techniques lead to satisfactory clinical results, indicating that bone removal during periodontal surgical treatment is not always necessary. In addition, there is lack of significant differences in bone resorption between the two surgical procedures.