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Long-term stability of intrabony defects treated with minimally invasive non-surgical therapy

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Abstract

Aim: The aim of this study was to assess the stability over time of periodontal intrabony defects treated with minimally invasive non-surgical therapy (MINST) and supportive periodontal therapy (SPT).

Methods: Clinical and radiographic analysis was carried out in 21 intrabony defects treated with MINST in 14 consecutive patients included in a prospective study and reassessed after 5 years of SPT. Baseline, 1- and 5-year radiographs were analysed, and bone levels were compared by multilevel linear regression adjusted by latent variable method.

Results: None of the 21 teeth with intrabony defects was lost at 5 years. Average probing pocket depth, clinical attachment level and radiographic intrabony vertical defect depth reductions were 3.6, 3.5 and 2.6 mm, respectively, 5 years after treatment ($p < 0.001$ compared with baseline). Further non-statistically significant reductions were seen in clinical and radiographic measures between 1 and 5 years. Deeper initial defects and narrower angles were predictive of a bigger reduction in defect depth ($p < 0.001$ and $p = 0.017$, respectively).

Conclusions: Clinical and radiographic improvements in intrabony defects after MINST seen at 1 year are stable up to 5 years, bringing evidence to support its long-term efficacy for the treatment of intrabony defects in non-smokers.

KEYWORDS
intrabony defects, minimally invasive, non-surgical therapy, periodontitis, radiographic bone gain

1 | BACKGROUND

Teeth with untreated periodontal intrabony defects are thought to carry a high risk of progression and tooth loss (Papapanou & Wennstrom, 1991). Several minimally invasive surgical techniques, with or without the use of biomaterials, have been suggested in the last decade for the treatment of intrabony defects (Aslan, Buduneli, & Cortellini, 2017; Checchi, Montevecchi, Checchi, & Laino, 2008; Cortellini & Tonetti, 2007, 2011; Trombelli, Farina, & Franceschetti, 2007). Evidence is now emerging for a role of non-surgical therapy in improving not only clinical (Ribeiro et al., 2011) but also radiographic bone level outcomes (Nibali, Pometti, Chen, & Tu, 2015; Nibali, Pometti, Tu, & Donos, 2011) in intrabony defects, therefore suggesting its possible use as sole therapy without need for surgery in many cases.

Among non-surgical treatment options, minimally invasive non-surgical periodontal therapy (MINST) has been introduced as a concept aiming to achieve extensive subgingival debridement with minimal tissue trauma and it has been linked with enhanced response in intrabony defects including larger reductions in probing pocket depth (PPD), clinical attachment level (CAL) and radiographic bone gain compared with standard non-surgical therapy (Nibali et al., 2015; Ribeiro et al., 2011). However, it has recently been highlighted that the long-term effectiveness of this minimally invasive technique remains to be assessed and long-term data (beyond 12 months) on stability of intrabony defects treated only non-surgically are not available in the literature (Trombelli, Simonelli, Minenna, Vecchiatini, & Farina, 2018). Hence, the aim of this study was to obtain a longer-term follow-up on intrabony defects treated with MINST, in order to establish whether long-term stability can be achieved only non-surgically.

2 | MATERIALS AND METHODS

This study describes a follow-up of cases previously included in a study on the effect of MINST in periodontal intrabony defects. The study reported 12-month clinical and radiographic results following MINST in 35 intrabony defects in 22 patients (Nibali et al., 2015). The current study includes follow-up data on patients with at least 5 years of follow-up (a total of 21 defects in 14 patients). All patients had been under care by the same operator (author LN) in three different private clinics in London and Hertfordshire (UK) after being referred by their general dental practitioners for periodontal assessment and treatment. This analysis is part of a larger prospective study on patient undergoing supportive periodontal therapy (SPT). London City & East NHS Research Committee gave a favourable opinion for the analysis to be carried out as service evaluation (reference 14 LO 0629). Inclusion criteria for patients to be included in the original report (Nibali et al., 2015) were as follows: (a) not pregnant; (b) non-smokers (or smokers who had given up at least 2 years before the baseline visit); (c) a diagnosis of chronic periodontitis (CP) (Lang, Bartold, & Cullinan, 1999) with at least one tooth with ≥5 mm PPD and clinical attachment loss (CAL) and evidence of radiographic bone loss; (d) presenting with at least one intrabony defect, with a radiographic component ≥3 mm (Eickholz et al., 2004) not in a furcation-involved area; (e) judged not to have periodontal–endodontic pathology requiring endodontic therapy; (f) treated non-surgically by one periodontist (author LN) without any adjuncts and reassessed clinically and radiographically at least 12 months after the completion of MINST. Consecutive patients included in the study above who had attended a follow-up appointment 5 years after treatment as part of the prospective study were included in the present analysis.

Clinical Relevance

Scientific rationale for the study: Evidence is starting to emerge about the favourable response of intrabony defect to non-surgical therapy, but long-term data are lacking.
Principal findings: Minimally invasive non-surgical therapy led to considerable clinical and radiographic improvement in intrabony defects up to 5 years after treatment.
Practical implications: The role of non-surgical therapy in the healing of intrabony defects should be emphasized.

2.1 | Clinical examination

Full-mouth clinical measurements of the distance from the free gingival margin (FGM) to the base of the sulcus (PPD, rounded up to the next millimetre) and of the distance from the cement–enamel junction (CEJ) to the FGM (recession, REC) were collected using a manual UNC-15 periodontal probe. The CAL was calculated as PPD + REC. Six sites were measured for each natural tooth, one each at the mesiobuccal, buccal, distobuccal, distolingual, lingual and mesiolingual sites encircling the tooth. A dichotomous full-mouth bleeding on probing score was recorded as the percentage of total bleeding surfaces upon probing. A full-mouth dichotomous plaque score was obtained as described previously (Nibali et al., 2011). Tooth mobility (Laster, Laudenbach, & Stoller, 1975) was also recorded. One single examiner (L. N.), who was also the therapist, previously been calibrated to >99% agreement of CAL within 2 mm in double measurements of 10 patients, carried out all the measurements (Nibali et al., 2015). All clinical measurements were re-taken at the re-evaluation (1 year after treatment) and then again at the "long-term follow-up" appointment 5 years after treatment, along with a new radiographic assessment of the intrabony defect sites, for clinical purposes.

2.2 | Radiographic examination

At first visit, routine long cone periapical radiographs with the parallel technique were obtained using Rinn holders from all intrabony

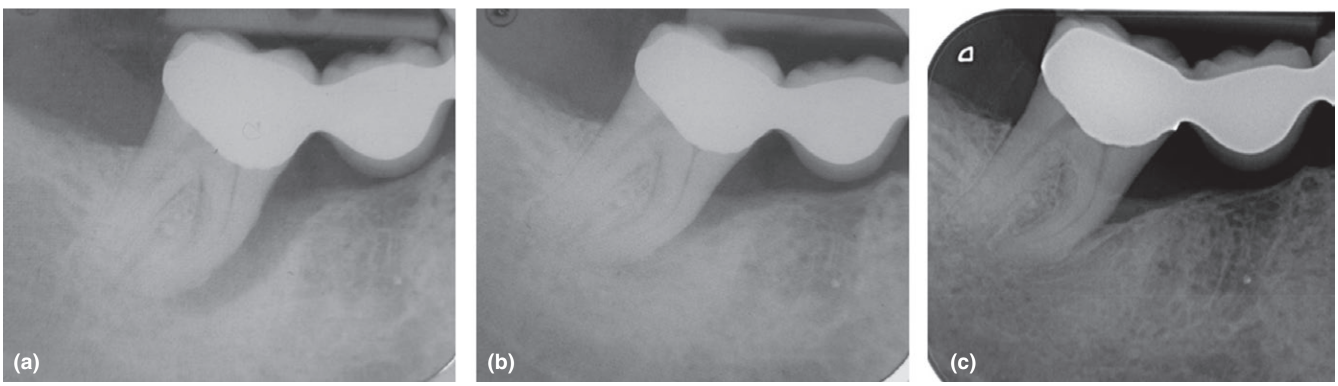

FIGURE 1 Baseline (a), 1-year re-evaluation (b) and 5-year follow-up (c) radiographic images of the mesial defect on lower right second molar (one of the cases included in the analysis)

defects for treatment planning purposes. Follow-up radiographs for further treatment planning had been obtained with the same technique on the same teeth after active periodontal therapy (1 and 5 years after the baseline examination). Horizontal and vertical bone loss of the intrabony defects were measured as previously described (Nibali et al. 2015), after identifying the following landmarks in periapical radiographs:

- CEJ on the tooth with the infrabony defect
- Most coronal part of the alveolar bone
- Most apical part of the alveolar bone crest, where the periodontal ligament space was judged to retain its normal width.

2.3 | Radiographic analysis

Some of the baseline and 1-year radiographs ($n = 9$) were not digital but were developed with an automatic film processor and then digitized using a standard scanner. All other radiographs including 5-year follow-ups were digital and were taken with setting at constant potential 7 mA 60 kV with 0.10-s exposure time. All radiographs were imported and analysed using a specific software (AutoCAD 2014; Autodesk, Inc., San Rafael, CA) as described before (Nibali et al., 2015). All radiographic analyses were performed by a previously trained single examiner (D. P.). A calibration exercise was again carried out for the 5-year radiographic assessments, including 10 duplicate measurements of bone levels and defect angles repeated and compared with those performed for baseline and 1-year analyses included the previous publication. The intraclass correlation coefficient was 0.99 for both defect depth and defect angle measurements, indicating a very good reproducibility in radiographic measurements.

2.4 | Periodontal treatment

The periodontal treatment of the patients included in this study has been described elsewhere (Nibali et al., 2015). Briefly, all patients received cause-related periodontal treatment by the same therapist (L.N.), including oral hygiene instructions and MINST under local anaesthesia using 3.4× magnification loupes and using prevalently piezo-electric devices with specific thin and delicate tips (Hu-Friedy after five plus 25K straight insert UI25KSF10S; Hu Friedy, Rotterdam, the Netherlands; Siroperio 1, 2, 3 and 7; Sirona, Salzburg, Austria; Woodpecker P3 tip; Guilin Woodpecker, Guilin, China), complemented by Gracey minicurettes including the range of "after five" and "micro mini five" curettes (Hu Friedy). All subjects were first reviewed approximately 3 months following the completion of cause-related therapy and then entered a maintenance therapy phase, including 3-month visits consisting of full-mouth periodontal measurements, oral hygiene instructions and maintenance supra- and subgingival debridement up to 12 months after baseline, when new clinical and radiographic measurements were taken (Nibali et al., 2015). After this appointment, patients were seen 3–6 months (according to patient needs) for SPT. This consisted of medical and dental history updates, clinical and (if necessary) radiographic examinations, oral hygiene re-instructions and motivation and supra- and subgingival debridement. During SPT, supra- and subgingival debridement was carried out with the same ultrasonic instruments as initial therapy. Specific oral hygiene re-instructions were given to patients when showing persisting PPD > 5, if these sites were associated with consistent presence of plaque deposits throughout SPT.

2.5 | Statistical analysis

Clinical data from all patients were entered in an Excel file. Continuous, normally distributed variables are reported as means ± standard deviations. Percentage intrabony defect depth reduction was calculated for each site as defect depth change (baseline—5 years) divided by baseline defect depth. Paired *t* tests were used to assess pairwise changes between baseline, 1- and 5-year follow-up for PPD, recessions, CAL, defect depth and defect angle measures. Multilevel linear regression analyses were used to evaluate the relation of baseline characteristics, clinical and radiographic variables to changes in intrabony defect depths and angles. We used the restricted maximum likelihood estimation method for the multilevel analyses. Since the before- and after-treatment radiographs were not taken in a standardized way, a latent variable factor analysis approach (Brown, 2006) was used to correct for the potential variations in radiographic images due to positioning (Tu, Donos, Pometti, & Nibali, 2010). All our statistical analysis was performed using statistical software package SAS, version 9.4. The statistical significance level was set to 5% throughout the analysis.

3 | RESULTS

3.1 | Baseline presentation

Demographic and clinical data of the 14 patients included in this report are presented in Table 1. The patients had an average of nearly 27 teeth present, with an average of 30 sites with PPDs > 4 m detected. Sixteen defects were located in the mandible (all in molars) and five in the maxilla (three in anteriors and two in premolars). Table 2 shows the characteristics of the 21 intrabony defects included in this study. The defects had a baseline average PPD of 7.0 mm, with an average 0.6 mm gingival recession and average CAL of 7.6 mm. Radiographical measurements showed that the average intrabony defect depth was 5.8 mm and the average defect angle was 32.2°. The average suprabony component of the defects was 1.9 mm, for a total bony defect (CEJ to bottom of the defect) of 7.7 mm (less than the 8.9 mm measured in the initial study sample with 1-year follow-up) (Nibali et al., 2015).

3.2 | Clinical outcomes

None of the 21 teeth with intrabony defects was lost at 5 years. Across the 21 intrabony defects, the average PPD reduction from baseline to 1-year re-evaluation was 3.0 mm (average buccal and lingual) ($p < 0.001$), with a further 0.6 mm reduction between 1 and 5 years (see Table 2) ($p < 0.001$ compared with baseline). The average CAL gain from baseline to re-evaluation was 3.0 mm ($p < 0.001$)

TABLE 1 Demographic and clinical parameters of consecutive patients treated with MINST who entered an SPT programme and were included in this study

	Patients	
	***n* = 14**	**%**
Age	50.1 ± 8.7	–
Gender		
Male	6	42.8
Female	8	57.2
Ethnicity		
Caucasian	12	85.7
Other	2	14.3
# Teeth present	26.6 ± 3.5	–
# PPD > 4 mm	30.5 ± 23.1	–
FMPS	–	26.4 ± 21.8
FMBS	–	27.2 ± 18.6

Note. FMBS: full-mouth bleeding on probing score; FMPS: full-mouth plaque score; MINST: minimally invasive non-surgical therapy; PPD: probing pocket depth; SPT: supportive periodontal therapy.

with further 0.5 mm gain at 5 years ($p < 0.001$ compared with baseline). The average gingival recession did not change at 1 year and increased by 0.1 mm at 5 years. No statistically significant differences in clinical outcomes were observed between 1- and 5-year follow-ups. Four out of 21 defects had persisting PPD > 5 mm with BOP at the 12-month follow-up appointment. Following SPT, two out of 21 defects presented persisting PPD > 5 mm at the last assessment, in one case with BOP. Table S1 shows frequency distribution of residual PPD at 1- and 5-year follow-ups and the percentage of PPD reduction. Five of the 21 affected teeth had mobility degree I recorded at baseline, while no mobility in any of the teeth was detected at the follow-up appointments.

3.3 | Radiographic outcomes

Following MINST, the average radiographic total defect depth changed from 7.7 mm at baseline to 5.9 mm at 1 year as well as at 5 years ($p < 0.001$ compared with baseline). The intrabony defect depth reduced from 5.8 mm at baseline, to 3.5 mm at year 1 and further to 3.2 mm at year 5 ($p < 0.001$ compared with baseline), resulting in a percentage intrabony defect depth reduction of 34.5% at 1 year and 46.8% at 5 years. The defect angle widened from 32.2° at baseline to 44.1° at 1-year re-evaluation and 44.2° at 5 years ($p < 0.001$ compared with baseline). Interestingly, the suprabony defect increased by 0.5 mm at 1 year and a further 0.3 mm in the following 5 years ($p < 0.025$ between baseline and 5 years). No statistically significant differences in radiographic parameters were observed between 1- and 5-year follow-ups. Figure 1 shows an example of radiographic outcomes at 1- and 5-year follow-ups of a case included in the analysis.

Table 3 shows the results of interaction models from the multilevel linear regression for baseline characteristics, clinical or radiographic variables and changes in intrabony defect depths and angles. Only baseline defect depth and baseline defect angle were associated with defect depth changes at 5 years. More specifically, deeper initial defects and smaller angles were predictive of a bigger reduction in defect depth ($p < 0.001$ and $p = 0.017$, respectively). Also, smaller baseline defect angles were associated with a bigger increase in defect angles at 5 years ($p = 0.034$).

4 | DISCUSSION

This is the first study, to our knowledge, to report long-term (5 years) clinical and radiographic data of intrabony defects treated with minimally invasive non-surgical periodontal

TABLE 2 Comparison between baseline, 1-year re-evaluation and 5-year follow-up after MINST in intrabony defects. *T* test values for differences between the two time-points are presented in the last columns

	Intrabony defects (*n* = 21)			*p* Values for comparisons (*t* test)		
Variable	**Baseline (mean ± *SD*)**	**1-year re-evaluation (mean ± *SD*)**	**5-year follow-up (mean ± *SD*)**	**Baseline versus 1 year**	**Baseline versus 5 years**	**1 year versus 5 years**
PPD (average buccal–lingual intrabony site) (mm)	7.0 ± 1.8	4.0 ± 1.5	3.4 ± 1.3	<0.001	<0.001	0.071
REC (average buccal–lingual intrabony site) (mm)	0.6 ± 0.7	0.6 ± 0.9	0.7 ± 0.9	0.711	0.436	0.691
CAL (average buccal–lingual intrabony site) (mm)	7.6 ± 1.9	4.6 ± 1.6	4.1 ± 1.4	<0.001	0.092	<0.001
Worst CAL (mm)	8.4 ± 2.1	5.1 ± 1.7	4.6 ± 1.6	<0.001	<0.001	0.125
CEJ to bone crest (mm)	1.9 ± 1.8	2.4 ± 1.6	2.7 ± 1.7	0.015	0.025	0.408
Infrabony defect depth (mm)	5.8 ± 2.6	3.5 ± 1.8	3.2 ± 1.8	<0.001	<0.001	0.400
Defect angle (°)	32.2 ± 10.5	44.1 ± 11.9	44.2 ± 14.5	<0.001	<0.001	0.974

Note. CAL: clinical attachment loss; CEJ: cement–enamel junction; MINST: minimally invasive non-surgical therapy; REC: recessions; PPD: probing pocket depth.

therapy (MINST). The use of minimally invasive procedures has recently been advocated for the treatment of periodontitis, in order to minimize patient discomfort and maximize the healing potential (Cortellini & Tonetti, 2007; Harrel, 1999; Trombelli et al., 2018). These techniques usually involve the use of magnification lenses or microscopes and slimline instruments which reduce the risk of tissue trauma compared with traditional instruments. Taking the principles of simplification and minimal invasiveness one step further, MINST has been proposed as a treatment option for intrabony defects and exhibited no differences in clinical outcomes compared with minimally invasive surgical therapy in group of 29 periodontitis patients (Ribeiro et al., 2011).

The present study supports the long-term efficacy of MINST, since none of the treated teeth were lost and stability in clinical periodontal parameters and radiographic bone level measurements was detected over 5 years of maintenance therapy. Therefore, as observed previously for results of surgical regenerative therapy (Cortellini, Buti, Pini Prato, & Tonetti, 2017), it appears that no relapse in clinical and radiographic healing is seen in treated intrabony defects of patients undergoing regular SPT. It is unknown whether the same stability could be seen in the absence of SPT.

We previously reported a PPD reduction of 3.1 mm, CAL gain of 2.8 mm and reduction of radiographic intrabony defect of 2.9 mm following MINST in a larger patient group (Nibali et al., 2015). In the subset of 14 patients who entered a prospective SPT study and are included in this report (including 21 intrabony defects), these clinical figures were similar at 1 year (3.0 mm for PPD and 2.9 mm CAL, respectively), while radiographic defect reduction was a bit smaller at 2.3 mm. The improvements observed at 1 year were kept stable throughout the following 4 years of maintenance care, with slight non-statistically significant further improvements at 5 years. In our original report (Nibali et al., 2015), we indicated that five out of 35 defects had persisting PPD > 5 mm with BOP at the 12-month follow-up appointment. This number corresponded to four out of the 21 defects of patients who then entered SPT and took part in the present study. Although these defects could have been considered good candidates for surgical therapy (Heitz-Mayfield & Lang, 2013; Serino, Rosling, Ramberg, Socransky, & Lindhe, 2001), for various reasons (strategic, financial, patient preference), they only underwent SPT instead. Following 5 years of SPT, only two out of 21 defects (in the same patient) presented persisting PPD > 5 mm at the last assessment (in one case with BOP) and might still be considered candidates for surgery. In addition to these, only one other 5 mm PPD with BOP was detected at the last reassessment. This shows further PPD reductions throughout SPT. It is still not clear if surgical regenerative procedures could lead to additional clinical and radiographic benefits in residual defects after MINST. It is also still unclear whether MINST could be effective for all types of intrabony defects, or whether some are more suitable for regenerative surgical therapy, whether with minimally invasive surgical procedures with or without biomaterials or not. This study confirmed that deeper defects and defects with narrower angles had more extensive defect resolutions at 5 years. However, the influence of defect width, number of walls and extension to buccal/lingual surfaces on healing following MINST still remains to be elucidated.

Data reported here suggest that significant bone remodelling takes place following MINST in intrabony defects, shown as radiographic reduction in intrabony defect depth, increase in suprabony defect component and widening of the defect angle. Histological evidence for new bone formation has been reported on extracted teeth 6 months following endoscope-assisted non-surgical therapy, associated with the absence of inflammatory signs and the presence of a long junctional epithelium (Wilson, Carnio, Schenk, & Myers, 2008). In the current patient sample, this bone fill and/or increase in bone mineralization likely occurred in the narrowest part of the defect, possibly more where supra-crestal periodontal fibres were still attached to the cementum (Nibali et al., 2011), with mechanisms probably not dissimilar from the healing following surgical regenerative therapy. This is further suggested by recent studies casting

TABLE 3 Results of univariate analysis from multilevel linear regression for association with reduction in radiographic defect depth and defect angle at 5 years

	Defect depth change			Defect angle change		
Outcome	Coefficients	95% confidence interval	*p*-Value	Coefficients	95% confidence interval	*p*-Value
Gender (Male)	−1.25	−3.18, 0.68	0.199	−3.50	−18.60, 11.60	0.641
Age	−0.09	−0.21, 0.03	0.123	0.14	−0.77, 1.04	0.762
Previous endodontic treatment	−1.26	−5.99, 3.48	0.594	20.84	−14.33,56.01	0.238
Premolar (versus anterior)	−1.05	−5.33, 3.23	0.622	−7.79	−38.48, 22.90	0.610
Molar (versus anterior)	−0.07	−3.02, 2.88	0.962	−2.63	−23.78, 18.52	0.802
Initial defect depth	−0.62	−0.89, −0.34	<0.001	0.94	−1.77, 3.65	0.486
Initial defect angle	0.10	0.02, 0.18	0.017	−0.67	−1.29, −0.05	0.034

doubts over the importance of bone grafting materials for space provision, osteoconductive or osteoinductive abilities in intrabony defects (Cortellini & Tonetti, 2011; Trombelli, Simonelli, Pramstraller, Wikesjo, & Farina, 2010). In other words, it could be speculated that healing mechanisms following MINST may to some extent mirror those following single-flap or minimally invasive surgical procedures (Trombelli et al., 2007). However, only studies directly comparing non-surgical and surgical procedures for the treatment of intrabony defects could clarify this.

The loss to follow-up of several patients included in the initial report is a limitation of this study along with the lack of standardization of the radiograph and the fact that the study therapist was also the examiner. However, results from all of those original patients who then went on to be included in a prospective SPT study were reported. Furthermore, the possible radiographic image distortion was corrected for with the validated method of latent variable analysis (Tu et al., 2010). The main strength of this study is its novelty, being the first study reporting clinical and radiographic outcomes of MINST with a 5-year follow-up. Overall, this study suggests that MINST is a valid long-term treatment option for improving the prognosis of teeth with intrabony defects. However, wide applicability to different operators and setting and learning curve for MINST still need to be clarified. Studies investigating healing mechanisms and clinical and radiographic outcomes in comparison with minimally invasive surgical therapy would now be beneficial in order to produce new guidelines for the treatment of intrabony defects.

CONFLICT OF INTERESTS

The authors declare no conflict of interests.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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