Author/s:
Naicker, M;Ngo, LH;Rosenberg, AJ;Darby, IB

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The effectiveness of using the perioscope as an adjunct to non-surgical periodontal therapy: clinical and radiographic results

Meloshini Naicker PhD,*† Luan H. Ngo PhD,*, Adam J. Rosenberg MS†, Ivan B. Darby PhD *

Corresponding Author

ADDRESS FOR CORRESPONDENCE

Prof Ivan B. Darby, Melbourne Dental School, The University of Melbourne, 720 Swanston Street, Carlton, VIC 3053, Australia. ORCID ID: 0000-0002-6457-5327. Email: idarby@unimelb.edu.au

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RUNNING TITLE

Perioscopy & non-surgical debridement

SUMMARY

The adjunctive use of the perioscope provided additional benefit to the outcomes of non-surgical therapy particularly at deeper probing depths.

KEYWORDS

Periodontitis, non-surgical periodontal therapy, radiology, perioscope

ABSTRACT

Background: It is well known that following root surface debridement (RSD) residual deposits remain. Periodontal endoscopy has provided a method of directly visualizing root surfaces during periodontal debridement in an intact pocket without the need for surgical incision. The aim of this study was to determine if periodontal debridement utilizing endoscopic visualization was more effective in improving clinical and radiographic parameters as compared to root surface debridement (RSD).

Methods:

Thirty-eight subjects were randomised into RSD with perioscope (n=19) or RSD only (n=19) groups. A full mouth evaluation included probing pocket depths (PPD), clinical attachment levels (CAL), bleeding upon probing (BOP) and plaque scores (PI) recorded at baseline, three and twelve months and compared between groups. Radiographs were taken at sites with deepest pockets at baseline and 12-months and the change in radiographic bone levels (RBL) compared. An independent samples T-test was used to assess statistical significance.

Results:

Both groups had significant improvements in clinical outcomes. The test (T) group had a significantly lower percentage of PPDs 7-9 mm at three (0.72±1.2 %) and twelve months (0.5±1.0 %) as compared to the control (C) group (2.25±2.9 %; 1.84±2.3 %). At twelve months, the test group recorded a significantly lower mean PPD (T: 2.70+0.2 mm; C: 2.98±0.4 mm), BOP% (T: 4.3±3.2%; C: 11.95±7.1%), PI% (T: 25.61±3.9%; C: 30.11±6.3%) and less change in gingival recession (T: -0.13±0.2 mm; C: -0.50±0.6 mm) ($p<0.05$). More radiographic bone gain was observed in the test group (0.69±0.3 mm) as compared to the control group (0.49±0.2 mm). This was also observed around multi-rooted teeth (T: 0.83±0.45 mm; C: 0.46±0.36 mm).

Conclusion:

The adjunctive use of the perioscope provided a slight benefit to the outcomes of non-surgical therapy particularly at deeper probing depths.

INTRODUCTION

Non-surgical periodontal therapy for the initial management of periodontal disease has been the gold standard for years with many studies reporting positive outcomes following use of this treatment modality. [1-4] However, not all sites respond successfully. Contributing factors include visibility, accessibility and anatomical factors.[5-8] In addition, complete removal of calculus and bacteria is not possible following instrumentation[9-12] and that instrumentation becomes less effective as the pocket depth increases.[11-13] Residual calculus deposits reduce the efficacy of non-surgical management. Therefore, adjuncts to therapy have been developed.

Periodontal endoscopy was developed in the late 1990s and features miniaturized digital video technology allowing the operator to directly visualise the subgingival environment during debridement in an intact pocket without the need for surgical incision. The endoscope consists of glass fibres (less than 1 mm in diameter) embedded in a plastic disposable sheath inserted subgingivally. The image from the tip is shown on a monitor, magnified 24-48 times allowing the clinician to better assess the subgingival area, especially remnants of subgingival calculus and biofilm.[14] (Supplementary Figure 1) The effects of direct visualization technology in reducing clinical and inflammatory parameters has been demonstrated in a small number of retrospective[15], prospective studies[16] and randomised controlled trials (RCTs).[17-20]. Improvements in clinical outcomes following endoscopic debridement were reported, but some studies[16, 21, 22] had no control groups for comparison. RCTs have compared the perioscope with conventional debridement with varying results and short follow-ups ranging from 6 weeks to three months.[17-20] Blue *et al.,* (2013) found that BOP and gingival index (GI) significantly reduced at perioscope sites. No statistically significant differences were observed between the groups with PPDs and CALs.[17] Hou (2016) reported reductions in PPDs and BOP in both root surface debridement (RSD-only) and RSD-with perioscope groups with no significant differences between groups. [18] Similarly, Avradopoulos *et al.,* (2004) did not report statistically significant differences in PPD reduction between perioscope sites and control sites. [19] Liao *et al.,* (2016) found the use of the perioscope was effective in reducing deep pockets ≥6 mm in anterior teeth.[20]

The use of radiographs to track osseous changes following endoscopic debridement is limited to only one study. Kwan *et al.*, (2009) included radiographic examination, but radiographs were not standardised making it difficult to compare osseous changes. [20]

† Zest Dental Solutions, Carlsbad, California, USA

§ Curettes and Scalers Hu Friedy, Chicago, IL, USA

|| Cavitron Dentsply Sirona, Charlotte, North Carolina

¶ PCPUNC15, Hu Friedy, Chicago, IL, USA

Based on results of these previous studies, there is a need to further investigate the effectiveness of the endoscope in reducing clinical, inflammatory and radiographic parameters using an RCT over a longer time period. This study was designed to compare endoscope- assisted RSD with conventional RSD in reducing clinical and inflammatory parameters in a 12-month period and to record changes in radiographic bone levels using standardised radiographs to assess if endoscope-assisted RSD showed more evidence of radiographic bone gain after the 12-month period as compared to conventional debridement.

MATERIALS AND METHODS

Human ethics approval was obtained from the University of Melbourne HEAG (Medicine and Dentistry Human Ethics Sub-Committee number 1543782). All subjects gave informed consent. The study followed the CONSORT guidelines (Figure 1).

Sample size calculation

With an independent samples design, to detect a standardized effect size of one millimetre in pocket depth, with a statistical significance level of 0.05 and power of 0.80, the target sample size in each group was 17. Nineteen subjects in each group were targeted to be recruited to allow for dropouts.

Inclusion and Exclusion Criteria

This project commenced before the "2017 periodontal classification" [23] was released, hence the 1999 periodontal classification[24] was used. Subjects diagnosed with moderate to severe chronic periodontal disease, had at least 20 natural teeth, with more than ten sites with pocket depths greater than 4 mm were included.

The exclusion criteria included medical conditions that required antibiotic coverage for routine dental treatment, antibiotic usage in the last three months for medical reasons, whose medical conditions contraindicated use of treatment methods proposed, autoimmune

† Zest Dental Solutions, Carlsbad, California, USA

§ Curettes and Scalers Hu Friedy, Chicago, IL, USA

|| Cavitron Dentsply Sirona, Charlotte, North Carolina

¶ PCPUNC15, Hu Friedy, Chicago, IL, USA

diseases and on long term use of corticosteroids, pregnancy and lactation, periodontal disease affecting third molars and presence of dental implants.

Study Design and Protocol

Participants were selected from patients attending the Perio Centre (East Malvern, Victoria). Initial screening was done by the Periodontist (AR). If a participant met all the study requirements, they were randomly placed into test and control groups. This continued throughout the study and was not modified at any point. All data collection was by one clinician (MN).

Participants in the test group were treated with RSD-with perioscope[†] whilst those in the control group were treated using RSD-alone. To ensure consistency of treatment provided, the treatment time allocated for both RSD-with perioscope and RSD-alone were 1.5 hours for each quadrant under local anaesthetic. All hand and powered instruments used for both groups were the same. [§||] In the test group the perioscope was inserted into pockets to detect deposits during initial debridement. Patients were recalled every 3-months for supportive periodontal maintenance (SPT) and received oral hygiene instructions which was reinforced throughout the study period (Supplementary Figure 2).

Clinical measurements

All measurements were recorded using a manual rigid periodontal probe.[¶] Clinical measurement including probing pocket depths (PPDs) and clinical attachment levels (CALs) and bleeding on probing (BOP) were measured at six sites per tooth. Gingival recession was measured to the nearest millimetre from the CEJ to the gingival margin. The Ainamo & Bay index was used to assess BOP. If bleeding occurred within 30 seconds after periodontal probing, a positive finding was recorded [25]. The Plaque Index (PI) was assessed by the presence or absence of plaque on the mesial, distal, facial and lingual surfaces using the O'Leary, Drake and Naylor Index.[26] Clinical records taken at each point of treatment were

† Zest Dental Solutions, Carlsbad, California, USA

§ Curettes and Scalers Hu Friedy, Chicago, IL, USA

|| Cavitron Dentsply Sirona, Charlotte, North Carolina

¶ PCPUNC15, Hu Friedy, Chicago, IL, USA

checked by an experienced periodontist (AR) to ensure consistency and accuracy of clinical records. There was no disagreement of more than 1 mm observed.

† Zest Dental Solutions, Carlsbad, California, USA

§ Curettes and Scalers Hu Friedy, Chicago, IL, USA

|| Cavitron Dentsply Sirona, Charlotte, North Carolina

¶ PCPUNC15, Hu Friedy, Chicago, IL, USA

Measurements were recorded at baseline, three and twelve months except for BOP and PI which were recorded at each SPT visit. Mean PPD, CAL, recession, BOP%, PI% were calculated for each group at each time point. PPD and CAL were categorised as 1-3 mm, 4-6 mm, 7-9 mm and 10± mm and percentage of sites in each category calculated and compared.

Radiographic Analyses

Radiographs using film-holding devices[||] were taken at sites with deepest pockets and those displaying angular/vertical bone loss. Silicone rubber impression material was used to create a positioning stent for each area radiographed to provide a standardised radiograph. Digital radiographic sensors were placed parallel to the area of interest with the locating ring placed at a fixed distance from the sensor. The stents were used at the 12-month re-evaluation appointment.

Image Analysis software[#] was used to measure radiographic bone levels (RBL). In order to standardise measurements taken, the dimensions of radiographic sensors were included by measuring the actual size of the size 1 (23 mm) and 2 (40 mm) sensors. These dimensions were set as the default calibration in the software. The distance from the CEJ to the bone crest was measured for each area visible on the radiograph (Figure 2). Radiographic measurements were repeated for sites to ensure accuracy. To formally assess agreement between radiographic measurements, the Bland- Altman method was used, and that majority of measurements differed by less than 0.03 mm, is an excellent agreement.

The mean change in RBL was calculated by subtracting the RBL at 12 months from the RBL pre-RSD for all teeth and single and multi-rooted teeth.

Statistical Analyses of Data

Clinical and radiographical data were analysed using statistical software programmes. **.[††]

The independent samples T-test was used to test for statistically significant differences between means for the two groups for all clinical and radiographic parameters. Descriptive statistics including the mean, standard deviation and standard error of mean were reported. Confidence intervals were also determined. $P<0.05$ was considered as statistically significant. The range of values of RBL in 0.5 mm increments were calculated and frequency and range were represented graphically.

RESULTS

Fifty-seven patients were assessed for eligibility of which thirty-eight patients (24 females and 14 males) with a mean age of 52 ± 11.05 years (range 28 – 75 years) were included in this study (Table 1). All patient data was included in the analysis.

All thirty-eight participants completed the study. There were no statistically significant differences between groups with regards to age, gender, smoking status and medical history.

Clinical

Both groups showed significant improvements in all clinical parameters after therapy ($p<0.05$) (Table 2). At three months, no statistically significant differences could be found between groups with mean PPD, categories of PPDs mean CAL and categories of CAL, BOP and PI. However, for PPDs 7-9 mm the test group had a significantly lower percentage as compared to the control group at three and twelve months ($p<0.05$). At twelve months, the mean PPD was found to be significantly lower in the test group (2.70 ± 0.2 mm) as compared to the control group (2.98 ± 0.4 mm) ($p<0.05$). BOP% was significantly lower in the test group at baseline, 6, 9 and 12 months ($p<0.05$). PI percentage was also reported to be significantly lower in the test group as compared to the control group at baseline, nine and twelve months ($p<0.05$).

The test group had less change in gingival recession (-0.13±0.2 mm) as compared to the control group (-0.5±0.6 mm) from baseline to twelve months ($p<0.05$).

Radiographic

The mean change in RBL was higher in the test group (0.69±0.3 mm) as compared to the control group (0.49±0.2 mm) ($p<0.05$) (Table 3). This is indicative of more radiographic bone gain in the test group. There were no differences reported between groups with regards to mean change in RBL for single-rooted teeth ($p>0.05$). However, for multi-rooted teeth more radiographic bone gain was observed in the test group (0.83±0.5 mm) compared to the control group (0.46±0.4 mm) ($p<0.05$). The test group had a higher frequency of RBL gain between 0.5 mm and 1.0 mm and 1.0 mm to 1.5 mm as compared to the control group. For multi-rooted teeth, the frequency of RBL between 0.5 mm and 1.0 mm; 1.00 mm to 1.5 mm and 1.5 mm to 2.00 mm was higher in the test group. (Figure 3).

DISCUSSION

This study compared RSD-only and RSD-with perioscope in initial phase management of periodontitis. Both treatment modalities were effective in improving clinical, inflammatory and radiographic outcomes with some more significant improvements observed with use of the perioscope.

Clinical Parameters

There were no statistically significant differences between groups with mean PPD three-months post-therapy. Studies by Blue *et al.*,(2013), Hou (2016) and Avradopoulos *et al.*, (2004) also reported no statistically significant differences between perioscope and non-perioscope sites.[17-19] At 12-months our results were better for RSD-with perioscope, with a significantly lower mean PPD as compared to the RSD-only group. A further 0.28 mm reduction in mean PPD from three to twelve months was observed in this group whereas the control group recorded a 0.07 mm reduction. It can be said that healing and maturation of pockets continued for both groups, with the test group better at twelve months. Past studies have supported that healing and maturation of the periodontium may continue over 9-12 months with improvements in PPDs and CALs.[4, 27-29] Although the RSD-with perioscope group showed more improvements with PPD's 1-3 mm, 4-6 mm and 10+ mm; statistical significance was not reached. However, the benefits of utilizing the perioscope was observed for PPDs 7-9 mm with a significantly greater reduction post-RSD and at twelve months as compared to conventional debridement. The difference is small and may not be of clinical relevance. Stambaugh and Myers (2003) reported a 5.25 mm reduction in PPD for PPDs greater than 6 mm with use of the perioscope[21], whereas Kwan and Workman (2009) found that for PPDs 7-9 mm, 55% of molars reduced to <5 mm at one year (n=284); 57% of premolars to <5 mm (n=30) and 89% of anterior teeth reduced to <5 mm (n=57).[14, 16] Similarly, Liao *et al.,* (2016) using a split -mouth design study found the perioscope to be effective especially for medium to long term management of anterior teeth with pockets >6 mm.[20] The systematic review by Heitz-Mayfield *et al.,* (2002) concluded that deeper pockets can be difficult to debride using conventional RSD and surgical procedures may result in greater gain in pocket depth reduction and clinical attachment levels.[30] Our study supports a slightly better outcome at PPDs 7-9 mm using the perioscope. One can speculate that direct visualization of the root surface can result in successful debridement of deeper pockets and may reduce the need for surgical periodontal treatment. However, larger studies are required to confirm this.

Both treatment groups had gains in CAL post-RSD and at 12-months with RSD-with perioscope group recording more attachment gain especially in sites with CAL 7-9 mm and 10+ mm with results bordering on significance. Again, more controlled trials with larger sample sizes are needed to analyse the effect of RSD-with perioscope on CALs when compared to conventional treatment.

The RSD-with perioscope group recorded a significantly higher mean gingival recession (0.90$\pm$0.4 mm) as compared to the RSD-only group (0.46$\pm$0.7 mm) at baseline, yet the mean change in recession from baseline to 12-months, was significantly lower (-0.13$\pm$0.2 mm) as compared to the RSD-only group (-0.5$\pm$0.6 mm). The assumption could be that the ability to directly visualise may be less invasive and result in less trauma to the gingival tissues. This could be a suggested method of debridement especially in aesthetic zones and in patients with thin tissue phenotype where gingival recession should be kept to its minimal.

BOP% reduced more than 70% in both groups post-RSD. Significantly lower BOP% in RSD-with perioscope group at six, nine and twelve months were recorded. Studies comparing perioscope and non-perioscope sites showed significant improvements in gingival inflammation and BOP post-therapy in perioscope sites[17], whereas some studies reported that although more reduction in BOP at perioscope sites were observed, statistical significance was not reached. [18, 20] It needs to be noted that the RSD-with perioscope had a statistically significantly lower BOP at the baseline and this may have affected the outcome and statistical significance.

Clinical studies have suggested that presence of BOP after non-surgical periodontal therapy can be indicative of residual deposits present in pockets.[31, 32] A direct relationship was established between BOP and subgingival deposits when using endoscopic visualization to view pockets with BOP. [32] Wilson *et al.,* (2008) found a statistically significant relationship between subgingival calculus covered with biofilm and inflammation of the pocket wall using periodontal endoscopy. In more than 60% of cases, inflammation and increased redness of the pocket epithelium was associated with deposits of subgingival calculus covered with biofilm.[33] The ability to directly visualise the root surface during debridement, could have resulted in less residual calculus and biofilm and so less BOP for the current study. However, using the perioscope to check sites with BOP post-RSD and during SPT did not form part of the study protocol. One also has to consider that the test group had better oral hygiene than the control group at three and six-months and the statistically significant lower PI% at baseline, nine and twelve-months. This lower PI% may have attributed to the lower BOP% in this group as meticulous plaque control can reduce inflammation especially around the marginal gingiva. However, the role of SPT in maintaining and stabilizing the periodontium also needs consideration.[34, 35]

Radiographic Parameters

This study evaluated osseous changes using standardised radiographs following use of the perioscope. The findings show that RSD-with perioscope resulted in a higher mean change in RBL (0.69±0.3 mm) and higher frequency of RBL of gain between 0.5 mm to 1.0 mm and 1.0 mm to 1.5 mm as compared to RSD-only (0.49±0.2 mm). These results are suggestive of greater radiographic bone gain with use of the perioscope including multi-rooted teeth. However, the differences between groups are small and may not be of clinical relevance..

The mean RBL in this study was higher for both groups than that reported by Machtei *et al.*, (0.16±0.2 mm) although measurement errors were more likely in their study as radiographs were not standardised.[36] More recent retrospective studies by Nibali *et al.,* (2011, 2015) followed similar study protocols as our study where infrabony defects were assessed following non-surgical periodontal therapy using clinical and radiographic measurements and patients placed on three-monthly SPT and re-evaluated at 12 and 18 months. Their study found that there was approximately a 0.69 mm gain in the average vertical defect angle at re-evaluation ($p<0.001$)[37]; similar to our results obtained in the RSD-with perioscope group. Nibali *et al.,* (2015) assessed intrabony and infrabony defects following minimally invasive non-surgical periodontal therapy (MINST) which included extensive subgingival debridement using magnification lenses, microscopes and small instruments to minimize tissue trauma. Their findings also reported a 0.7 mm gain in the infrabony defect.[37] The concept of utilizing the periscope is in line with MINST and similar gains in RBL were observed. The systematic review by Nibali *et al.,* in 2015 supported non-surgical techniques for managing periodontal disease and found that radiographic improvements in intrabony defects following non-surgical therapy are the same range as observed in studies on periodontal regeneration (median 3.3 mm in radiographic intrabony defect gains).[38] Klein *et al.*, (2001) assessed mean radiographic changes from the CEJ to the alveolar crest at six and 24-months following guided tissue regeneration in 24 patients with advanced periodontitis. The change in RBL reported at six months (0.37±1.52 mm) and at 24 months (0.29±1.54 mm)[39] was lower than in studies by Nibali *et al.*, (2011 2015) and the present study suggesting that minimally invasive methods of managing periodontal disease may be equally as effective. One can speculate that more bone fill occurred when using the perioscope as the direct visualization technique aids in more effective removal of subgingival calculus and biofilm which in turn has a positive impact on the healing. Continued SPT can also result in stable alveolar bone height as demonstrated by Killeen *et al.*[40] For the current study, all patients were recalled every three-months for SPT during the research period which could have contributed to stability of RBLs.

There were a number of limitations in this current study. The mean differences between groups with PPD's 7-9mm and radiographic bone gain was small. More clinical trials are required to test the efficacy of direct visualization. Exact replication of radiographs taken at twelve-months were not possible due to some patient's intolerance to positioning stents, damage to putty and movement of radiographic sensors during exposure, which resulted in twenty-three radiographs being excluded. Accurate replication can be affected by tooth wear and movement [41]. Superimposition of images can also mask osseous changes.[42] However, linear measurements have been validated in studies [43] and using a simple modification of the Rinn holder has been found to provide a significant degree of standardization and allows for comparison of serial radiographs and to gather information from these images.[44] Our study included positioning stents and Rinn holders placed at fixed distances and were able to provide a clear depiction of changes in RBLs for the study population.

Even though, statistical tests revealed only minimal differences between the measurements, measurement errors can occur with overestimation and underestimation of distances.[45-47] Future studies should explore use of new software programs utilizing digital subtraction radiography [48], Computer-Assisted Densitometric Image Analysis System (CADIA) [49] and CBCT technology. [50]

One clinician was responsible for all clinical data collection and treatment which leads to bias. However, perioscopy is a new concept in Australia and the clinician involved in the treatment was the only person trained to use the equipment, hence only one clinician was used throughout the study. Blinding of the clinician was not possible in a private practice setting. More than one clinician would have been necessary if blinding was to occur and due to training and manpower issues, this was not possible.

CONCLUSION

Both treatment groups reported positive clinical and radiographic outcomes. The use of the perioscope resulted in a slight, statistically significant benefit in 7-9mm pockets. However, the clinical benefit is unclear. An option to treat periodontal disease in a less invasive way may be advantageous compared to a surgical approach and with more research and improvements in visualization techniques for non-surgical management of periodontal disease, this method could provide an alternative to surgery. Larger, prospective and controlled studies are recommended to test the efficacy of this technology.

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Figures and Tables Legends

Figure 1 Consort Flow Diagram

Consort flow diagram including enrolment, intervention, allocation, follow-up and data analysis of participants in the RCT.

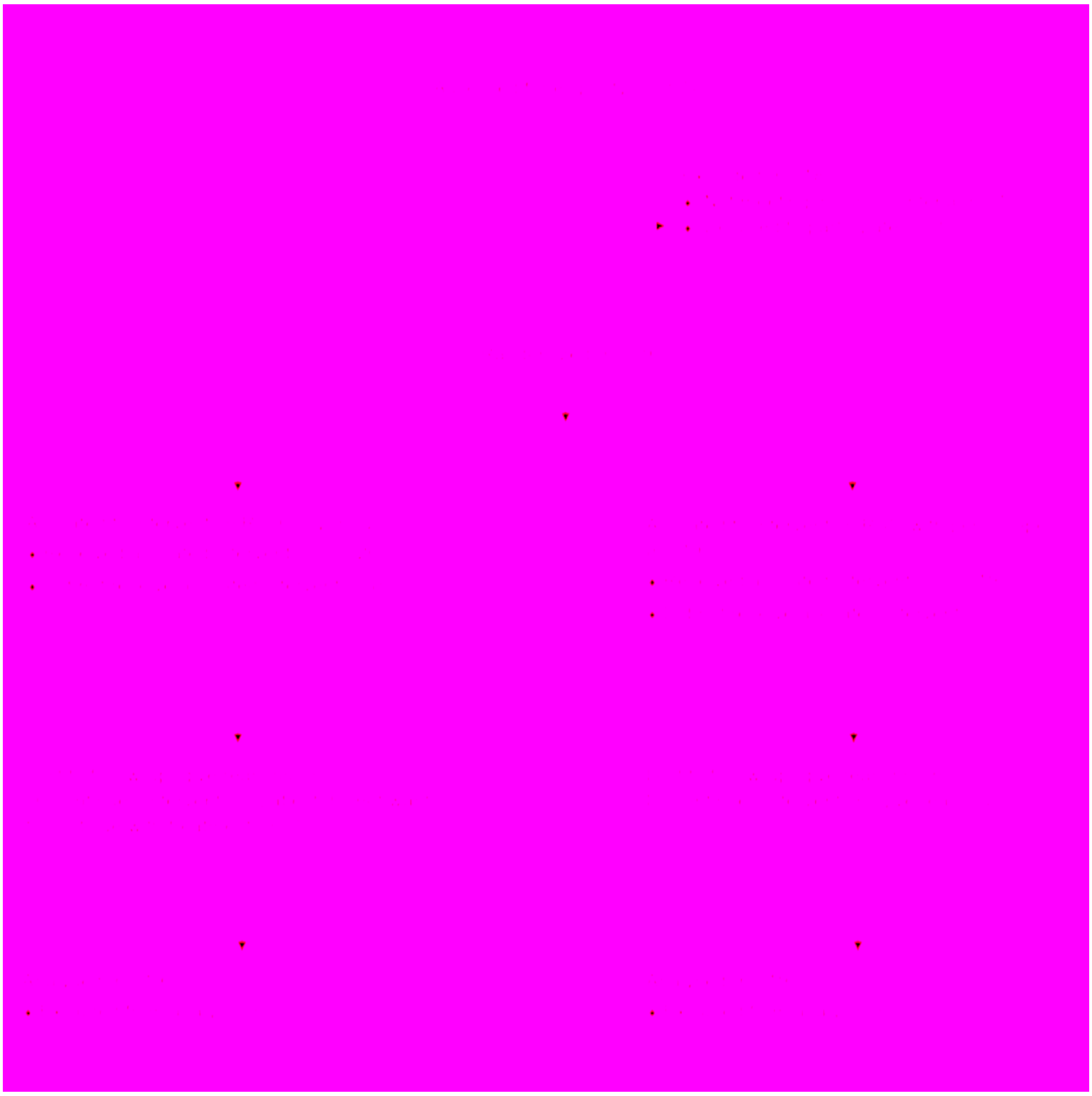


Figure 2 Radiographic film with analysis using Digimizer Image Analysis software

This software system allows manual measurements to be taken and measures distances and lengths of segments. In order to standardise measurements taken, the dimensions of the radiographic sensors were measured and included. The dimensions of the sensor were obtained by measuring the actual size of the radiographic sensor (size 1 and 2 sensors). Size 2 sensors were 40 mm and Size 1 sensors 23 mm. These dimensions were set as the default calibration in the software as represented by the horizontal line across the radiographic film. The distance from the CEJ to the bone crest was measured for each area visible on the radiograph. This represented the radiographic bone level (RBL).

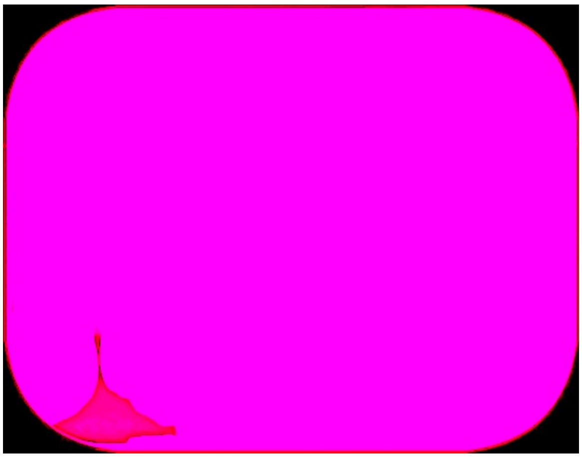


Figure 3 Histogram showing range and frequency for change in RBL for PPDs 5-11 mm for control and test groups at twelve months for all teeth and multi-rooted teeth

Histogram showing frequency distributions of change in radiographic bone levels for PPDs 5-11 mm at intervals between 0.0 mm - 0.5 mm; 0.5 mm - 1.0 mm; 1.0 mm - 1.5 mm; 1.5mm - 2.0 mm for all teeth and multi-rooted teeth.

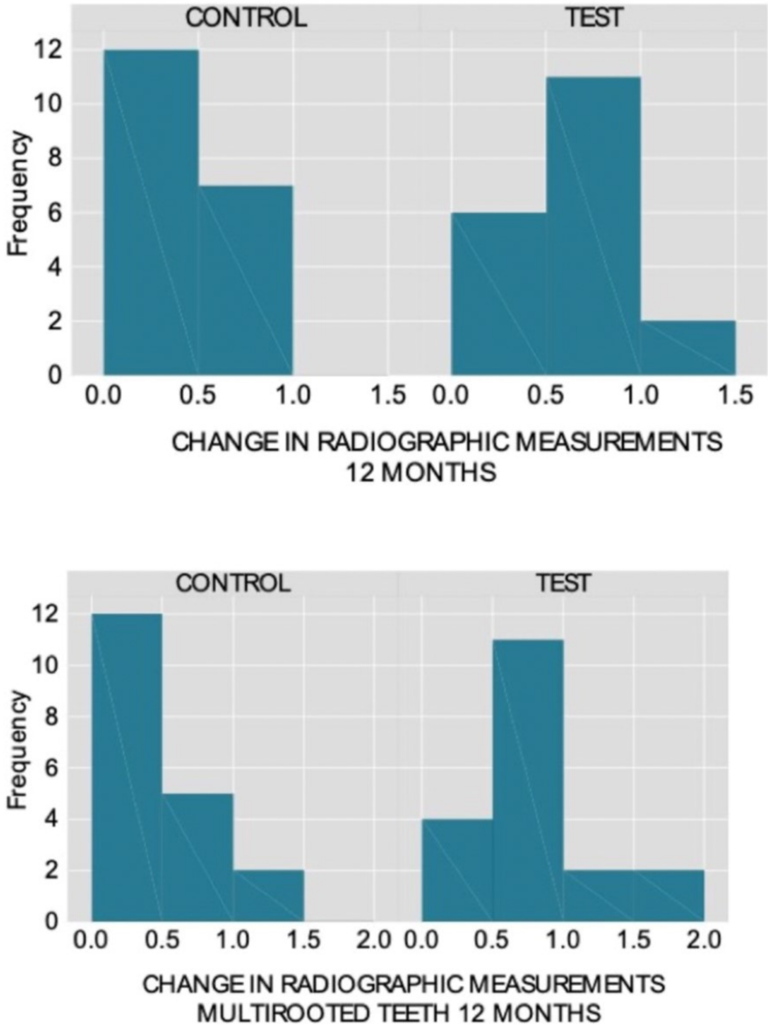


Table 1 Demographics of study population

	Control (n=19)	Test (n=19)	Overall
Male	6 (31.6%)	8 (42.1%)	14 (36.8%)
Female	13 (68.4%)	11 (57.9%)	24 (63.2%)
Mean Age (SD) and Range in years	51.37(±13.04) 28-47 years	53.63(±8.28) 38-68 years	52.50 (±11.05) 28-75 years
Average time between SPT appointments in days	90.49(±4.5)	91.08(±2.2)	p=0.6
Non-smokers	16(84.2%)	16(84.2%)	32(84.2%)
Past Smokers	2(10.2%)	1(5.3%)	3(7.9%)
Smokers	1(5.3%)	2(10.2%)	3(7.9%)

Number (N) and Percentage (%) of Males and Females; mean age, standard deviation (SD) and range in years for test (T) and control (C) groups; average time in days between supportive periodontal maintenance appointment; number (N) and % of smokers, non-smokers and past smokers.

Table 2 Summary of statistics for mean PPD, PPD of categories 1-4 mm, 5-7 mm, 8-10 mm and 10+ mm, mean PAL, PAL for categories 1-3 mm, 4-6 mm, 7-9 mm, 10+ mm and mean recession at baseline, three and twelve months, change in mean recession from baseline to twelve months, BOP%, PI% at baseline, three, six, nine and twelve months for control and test groups

	Control (n=19) RSD - only		**Test (n=19) RSD- with perioscope**		**Independent sample t-test summary statistics**	
Variable	**Mean, standard deviation**	**Standard error of mean**	**Mean, standard deviation**	**Standard error of mean**	**95% CI**	**p-value**
Mean PPD (mm)						
Baseline	4.63 ±0.8	0.19	4.24 ±0.6	0.13	-0.8;0.9	0.1
Three months	3.05 ±0.5	0.12	2.89 ±0.3	0.06	-0.1;0.4	0.2
Twelve months	2.98 ±0.4	0.10	2.70 ±0.2	0.05	0.0;0.5	**0.02**
PPD 1-3 mm %						
Baseline	30.14 ±17.9	4.11	39.21 ±17.7	4.07	-20.8;2.7	0.1
Three months	79.28 ±14.8	3.40	82.88 ±7.5	1.71	-11.3;4.2	0.4
Twelve months	81.59 ±13.0	2.98	86.66 ±6.3	1.44	-11.8;1.8	0.1
PPD 4-6 mm %						
Baseline	57.22 ±14.0	3.22	54.06 ±16.0	3.68	-6.7;13.1	0.5
Three Months	18.23 ±12.5	2.88	16.42 ±7.1	1.62	-4.9;8.6	0.6
Twelve Months	16.32 ±11.4	2.61	12.84 ±5.9	1.34	-2.5;9.5	0.2
PPD 7-9 mm %						
Baseline	11.56 ±12.6	2.88	6.32 ±4.6	1.05	-1.0;11.6	0.1
Three months	2.25 ±2.9	0.66	0.70 ±1.2	0.27	0.1;3.0	**0.04**
Twelve months	1.84 ±2.3	0.54	0.50 ±1.0	0.23	0.2;2.6	**0.03**
PPD 10+ mm %						
Baseline	1.07 ±1.8	0.41	0.41 ±1.0	0.24	-0.3;1.6	0.2
Three months	0.23 ±0.8	0.18	0.00 ±0.0	0.00	-0.1;0.6	0.2
Twelve months	0.23 ±0.8	0.17	0.00 ±0.0	0.00	-0.1;0.6	0.2
Mean PAL (mm)						
Baseline	5.09 ±0.8	0.19	5.13 ±0.6	0.15	-0.5;0.4	0.9
Three months	3.96 ±0.7	0.72	3.93 ±0.5	0.48	-0.4;0.4	0.9
Twelve months	3.94 ±0.7	0.16	3.73 ±0.5	0.11	-0.2;0.6	0.3
PAL 1-3 mm %						
Baseline	19.05 ±14.9	3.42	16.99 ±11.2	2.56	-6.6;10.8	0.6
Three months	47.26 ±17.2	3.96	44.52 ±16.8	3.85	-8.5;13.9	0.6
Twelve months	47.78 ±17.8	4.09	48.81 ±16.3	3.74	-12.3;10.2	0.9
PAL 4-6 mm %						

Baseline	60.53 ±12.8	2.93	63.83 ±10.3	2.37	-10.9;4.3	0.4
Three months	44.82 ±12.2	2.81	50.08 ±15.4	3.53	-14.4;3.9	0.3
Twelve months	44.33 ±12.9	2.95	47.42 ±15.2	3.49	-12.4;6.2	0.5
PAL 7-9 mm %						
Baseline	18.20 ±12.3	2.83	16.78 ±8.9	2.04	-5.6;8.5	0.7
Three months	7.05 ±8.3	1.91	5.13 ±4.1	0.94	-2.4;6.3	0.4
Twelve months	6.96 ±7.4	1.70	3.53 ±3.2	0.73	-0.3;7.2	007
PAL 10+ mm %						
Baseline	2.21 ±3.2	0.72	2.40 ±2.8	0.63	-2.1;1.8	0.9
Three months	0.86 ±1.4	0.31	0.26 ±0.4	0.09	-0.1;1.3	0.08
Twelve months	0.94 ±1.5	0.34	0.23 ±0.3	0.07	-0.0;1.4	0.05
Mean recession (mm)						
Baseline	0.46 ±0.7	0.15	0.90 ±0.4	0.10	-0.8; -0.1	**0.03**
Three months	0.91 ±0.4	0.10	1.0 ±0.4	0.09	-0.4;0.1	0.3
Twelve months	0.96 ±0.4	0.10	1.03 ±0.4	0.09	-0.3;0.2	0.5
Change in mean recession from baseline to twelve months						
	-0.50 ±0.6	0.12	-0.13 ±0.2	0.04	-0.6; -0.1	**0.01**
BOP %						
Baseline	60.16 ±19.6	4.50	48.37 ±16.8	3.86	-0.2;23.8	0.05
Three months	17.32 ±12.1	2.78	11.37 ±4.7	1.07	-0.1;12.1	0.06
Six months	12.47 ±7.7	1.76	6.31 ±3.8	0.88	2.2;10.2	**0.00**
Nine months	12.53 ±8.5	1.94	4.68 ±3.0	0.70	3.6;12.1	**0.00**
Twelve months	11.95 ±7.1	1.63	4.63 ±3.2	0.74	3.6;11	**0.00**
PI %						
Baseline	65.89 ± 14.7	3.36	56.86 ±11.3	2.59	0.4;17.6	**0.04**
Three months	31.66 ±5.5	1.26	30.85 ±5.5	1.26	-2.8;4.4	0.7
Six months	30.27 ±6.2	1.43	28.24 ±5.1	1.18	-1.7;5.8	0.3
Nine months	32.08 ±8.9	2.03	26.77 ±5.2	1.19	0.5;10.1	**0.03**
Twelve months	30.11 ±6.3	1.44	25.61 ±3.9	0.90	1.0;8.0	**0.01**

Mean, standard deviation, standard error of mean and independent sample t-test summary of statistics including 95 % confidence intervals (CI), p-values with significant results p<0.05 in red and bold for probing pocket depth (PPD), PPD categories, clinical attachment levels and categories and mean recession at baseline, three and twelve months, for bleeding on probing (BOP)% and plaque index (PI)% at baseline, three, six, nine and twelve months for test (T) and control (C) groups.

Table 3 Statistical analyses of mean change (mm) in radiographic bone levels (PPDs 5-11 mm) for all teeth and single and multi-rooted teeth at baseline (pre-RSD) and at twelve months between control and test groups

Control (n=19) RSD - only					Test (n=19) RSD- with perioscope					Independent sample t-test summary statistics	
Mean, std deviation	**Std error of mean**	**Min**	**Max**	**Range**	**Mean, std deviation**	**Std error of mean**	**Min**	**Max**	**Range**	**95% CI**	**p-value**
0.49 ±0.2	0.05	0.06	0.97	0.92	0.69 ±0.3	0.08	0.10	1.48	1.38	-0.4; -0.0	**0.03**
Single rooted teeth											
0.49 ±0.32	0.1	0.03	1.43	1.40	0.52 ±0.28	0.1	0.08	1.13	1.05	-0.2; 0.2	0.8
Multi-rooted teeth											
0.46 ±0.36	0.1	0.01	1.11	1.10	0.83 ±0.45	0.1	0.18	1.93	1.75	-0.6; -0.1	**0.00**

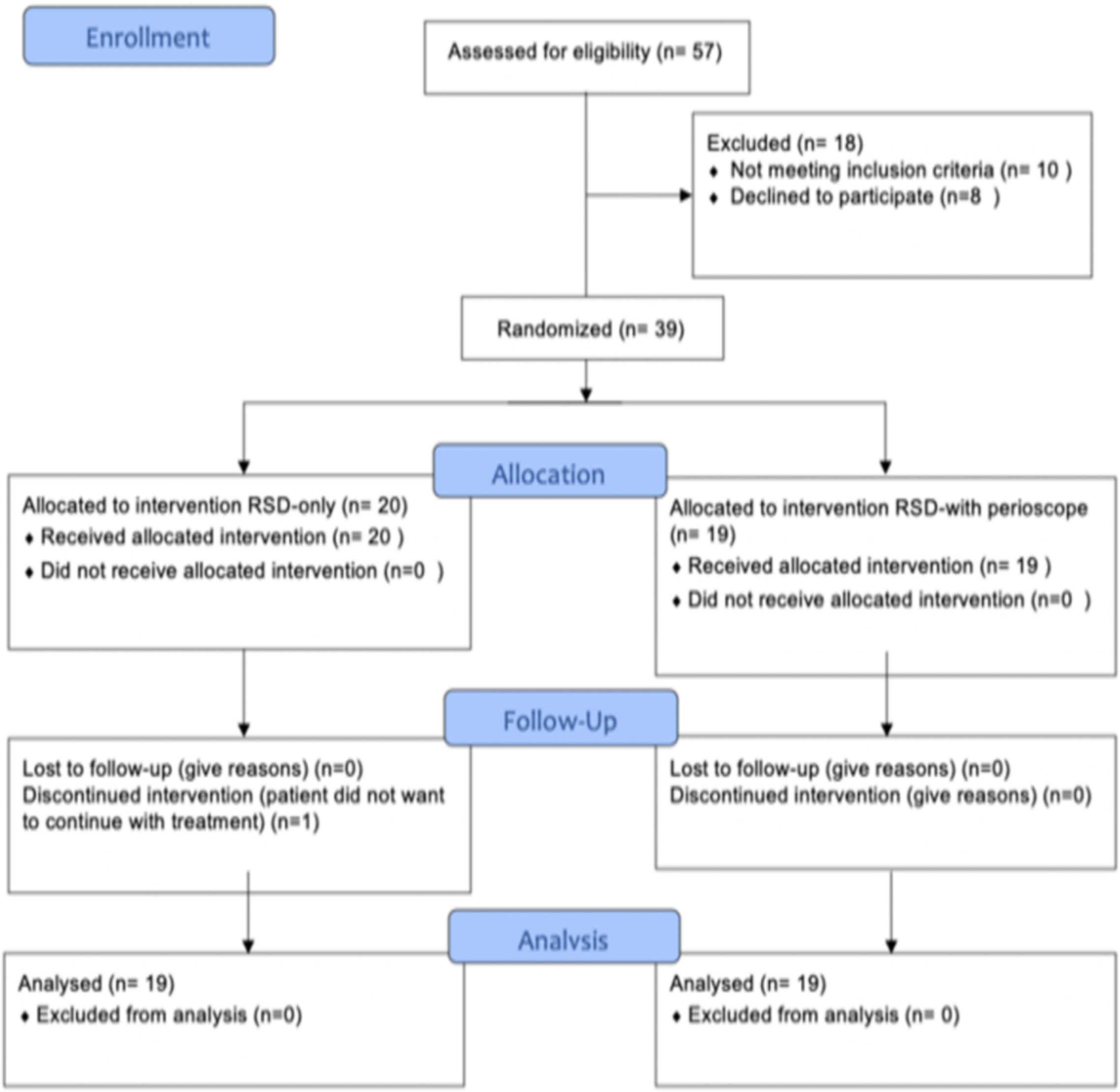
Mean change in millimeters (mm) in radiographic bone levels (PPDs 5-11 mm) from baseline to twelve months for test (T) and control (C) groups, standard deviation, standard error of mean, minimum , maximum and range in mm for RBL, and independent sample t-test summary of statistics including 95 % confidence intervals (CI), p-values with significant results p<0.05 in red and bold for mean change in RBL from baseline to twelve months for all teeth, single rooted teeth and multi-rooted teeth for test (T) and control (C) groups.

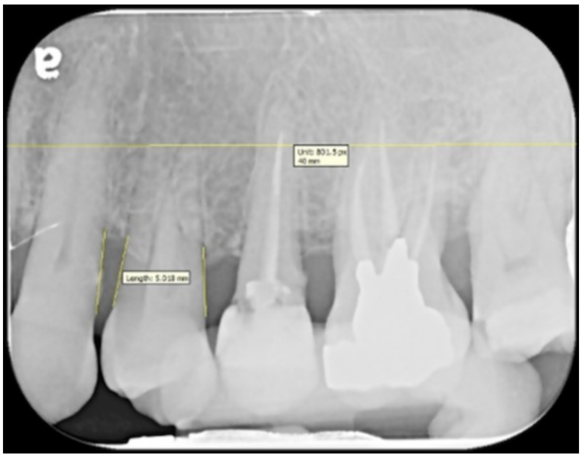
Supplementary Figure 1 Images before and after SRD with perioscope

Images of the shield, soft tissue, subgingival area and root surface before and after use of periscope

Supplementary Figure 2 Study Outline

Study outline including time in weeks between inclusion of participants in test and control groups and start of treatment. Time in weeks (12 weeks) between completion of first phase of treatment (RSD with or without the perioscope) and follow up supportive maintenance appointments. Treatment and data collection included at each visit.

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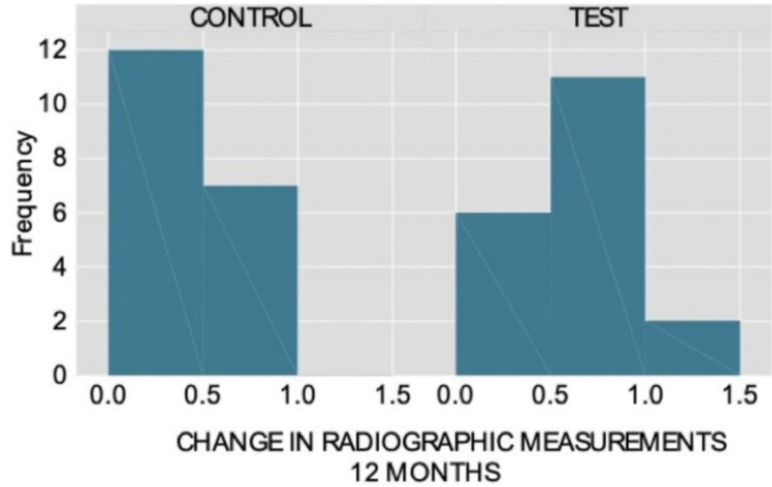
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10
8
6
4
2
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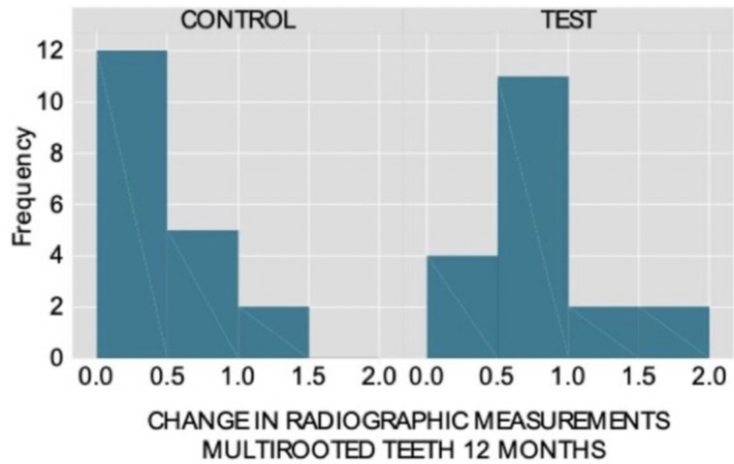
CHANGE IN RADIOGRAPHIC MEASUREMENTS
12 MONTHS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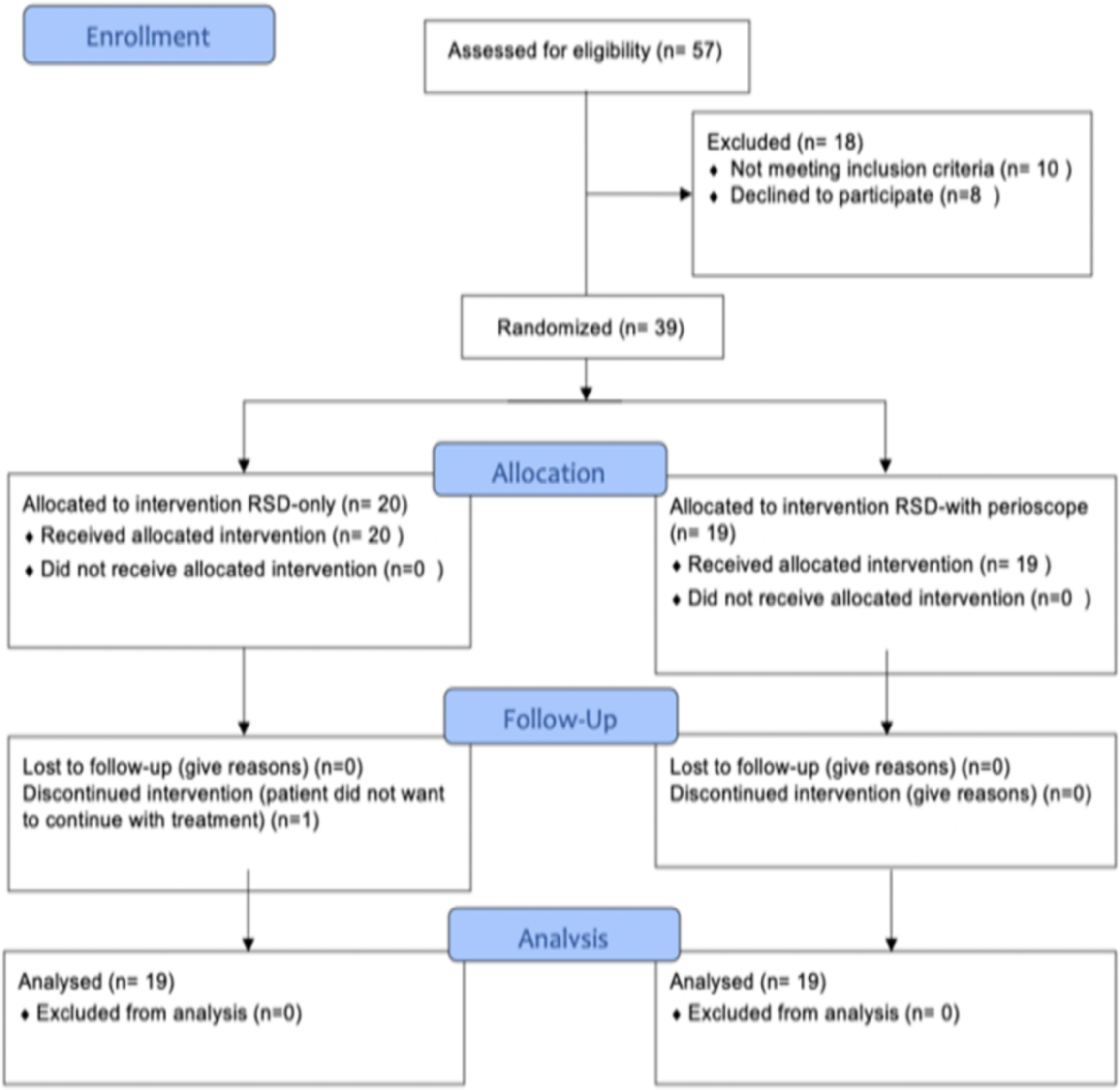
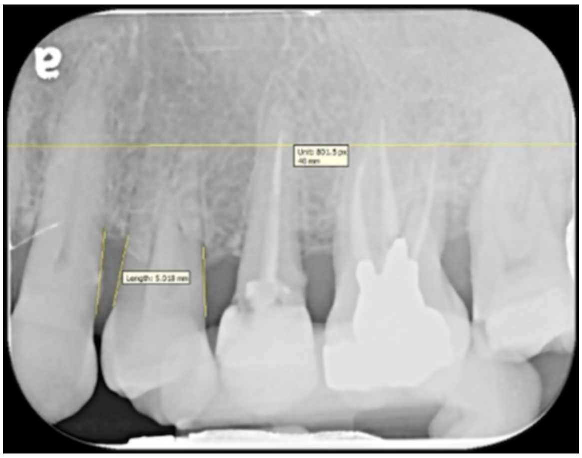
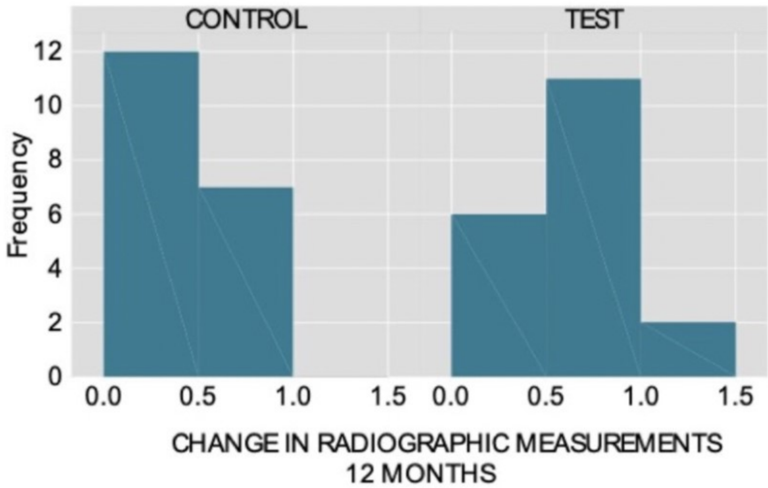
CHANGE IN RADIOGRAPHIC MEASUREMENTS
MULTIROOTED TEETH 12 MONTHS


Enrollment
Assessed for eligibility (n= 57)
Excluded (n= 18)
• Not meeting inclusion criteria (n= 10)
• Declined to participate (n=8)
Randomized (n= 39)
Allocation
Allocated to intervention RSD-only (n= 20)
• Received allocated intervention (n= 20)
• Did not receive allocated intervention (n=0)
Allocated to intervention RSD-with perioscope (n= 19)
• Received allocated intervention (n= 19)
• Did not receive allocated intervention (n=0)
Follow-Up
Lost to follow-up (give reasons) (n=0)
Discontinued intervention (patient did not want to continue with treatment) (n=1)
Lost to follow-up (give reasons) (n=0)
Discontinued intervention (give reasons) (n=0)
Analysis
Analysed (n= 19)
• Excluded from analysis (n=0)
Analysed (n= 19)
• Excluded from analysis (n= 0)

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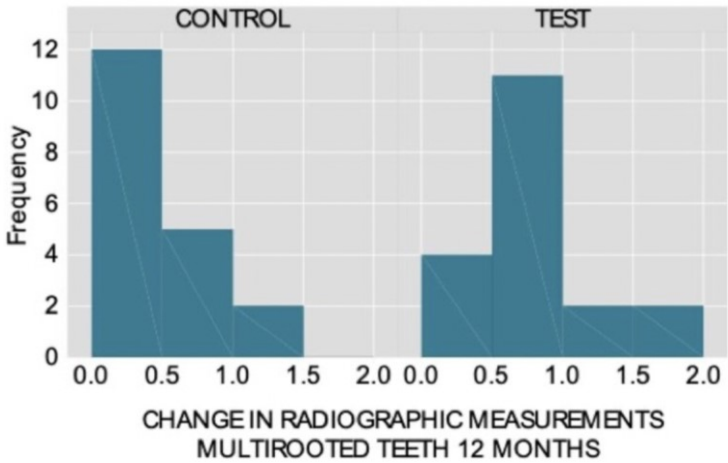
TEST
Frequency
CHANGE IN RADIOGRAPHIC MEASUREMENTS
12 MONTHS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Frequency
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MULTIROOTED TEETH 12 MONTHS