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Residual Periodontal Ligament in Extracted Teeth – Is It Associated With Indication for Extraction?

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ABSTRACT

Background: Periodontal disease is a major cause of tooth loss. Few studies have evaluated the residual area of the periodontal ligament in extracted teeth and, to the best of our knowledge, none from Latin America have done so regarding indications for extraction. The aim of this study was to evaluate the residual periodontal ligament (RPL) with respect to indication for extraction in a sample of teeth from a Brazilian Public Health Service district.

Materials and methods: All teeth extracted within the Public Health Service district of Santa Maria, Brazil, over a 5-month period were requested for analysis. A total of 414 teeth eligible for measurement were stained and evaluated for RPL using a stereo microscope. Participating Public Health Service dentists completed a questionnaire detailing demographic variables and indication for each extracted tooth. The percentage of RPL was determined for each tooth. Comparisons of RPL between teeth extracted on periodontal versus other indications were made using the Mann-Whitney test.

Results: RPL averaged 34.8% for teeth extracted on periodontal indications versus 79.5% for other teeth ($P \leq 0.001$). When considering teeth with an RPL $\geq 30\%$ as possible to maintain, 189 (76%) of the teeth extracted on periodontal indications could have been maintained. When RPL cut-off limits of $\geq 40\%$ or $\geq 50\%$ are applied, 93 (37%) and 43 (17%) teeth, respectively, could have been maintained.

Conclusion: This study suggests that strictly based on RPL, a large number of teeth extracted on periodontal indications conceivably could be maintained.

Introduction

Tooth loss and the resulting functional, social, psychological and financial distress become the ultimate outcome of dental diseases and challenge both the patient and dental profession.[1] Tooth loss can often be avoided through preventive and therapeutic measures, with choices made by the dentist often deciding whether to maintain or extract a tooth.[2] Major indications for tooth extraction include dental caries, periodontal disease, fractures, failing endodontic treatment, orthodontic and prosthetic treatment, third molar complications, and requests by the patient,[3] with cost and associated treatment alternatives closely related to the decision making. In regard to this, dental health care programs which aim to control etiologic factors through thorough self-performed oral hygiene measures reinforced at periodic follow-ups, rather than routine symptomatic treatment, enable patients to maintain their teeth while dramatically reducing, if not eliminating, caries, periodontal disease, and future tooth loss altogether.[4,5]

However, although tooth loss is significantly declining in many countries, still a significant number of teeth are lost, with edentulism encompassing a large percentage of elderly subjects.[6,7] An epidemiologic survey conducted in Brazil in 2010 showed a mean of 25.3 teeth lost in 65–74 year-olds, and 57% of this population was rendered edentulous.[8] Research

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conducted in Europe suggests that the mean number of teeth in aging populations is usually lower than 20, dramatically decreasing with age.[9]

As much as periodontal disease is considered a major cause of tooth loss, there appears to be a discrepancy between the high numbers of teeth extracted on periodontal indications and the relatively low prevalence of severe periodontal disease.[10] Previous studies have evaluated the attachment level in teeth extracted on periodontal indications and reported that many extracted teeth are already at a stage of moderate periodontal disease.[11,12] Some criteria have been proposed to establish periodontal prognosis.[13–15] For example, Becker et al.[14] established as hopeless the prognosis for teeth with more than 75% of the supporting bone lost. Although there are several options to replace missing teeth, maintenance of the natural dentition when possible remains the preferred alternative. Thus, the decision matrix leading to tooth extraction due to periodontal disease, and how these decisions can be modified to maintain teeth, appear important to research. Only a few studies have evaluated the residual area of periodontal ligament in extracted teeth, and to the best of our knowledge no studies from Latin America have evaluated this parameter with regard to indications for tooth extraction.

The aim of this study was to evaluate the residual periodontal ligament (RPL) with respect to the indication for extraction in a sample of extracted teeth collected from a Brazilian Public Health Service district. The conceptual hypothesis was that many teeth extracted on periodontal indications could be maintained.

Material and methods

Experimental design and sample

This cross-sectional study, approved by the Ethical Committee for Research, Federal University of Santa Maria (CAEE n° 15250913.3.0000.5346), was conducted with the objective of collecting all permanent teeth extracted on any indication from the Public Health Service, Santa Maria, Brazil, over a 5-month interval (August–December 2013). According to the clinical judgment made by each dentist, the teeth extracted on periodontal indications had insufficient periodontal clinical attachment to warrant periodontal treatment.

Fifteen out of 17 Public Health Service dental clinics (with 19 dentists) from the directory of the Health Secretary of Santa Maria volunteered to participate in the study. One clinic refused to participate; a second clinic was temporarily closed during the study period. A meeting was conducted prior to initiating the study to clarify any questions from the participating dentists.

Upon extraction, teeth were immersed in a 10% aqueous ethanol solution[12] in separate color-coded receptacles according to indication, red for periodontal disease and white for all other indications. The receptacles were additionally identified using adhesive labels detailing the respective indications. The dentists completed a brief questionnaire detailing patient gender and age, and the extraction indication for each tooth. When multiple teeth were extracted from any patient, indications for all of the extractions were delineated using a single questionnaire. Teeth and questionnaires were collected weekly from the clinics. At the end of study, it was possible to compare the number of collected teeth with the total number of extracted teeth from Public Health Service records made available by the Health Secretary, Santa Maria.

Tooth preparation

Collected teeth were stained using an established method.[11] Briefly, the teeth were immersed in a 5% hematoxylin solution for 5 minutes, washed in running water for 10 minutes and air-dried using a dental three-way syringe. Then, calculus and other deposits were removed through scaling with manual instruments to enable identification of the cemento-enamel junction. Transitions between root surfaces were delineated using a pencil to define the mesial, distal, buccal and palatal/lingual surfaces. Images of each root surface were then captured and saved for analysis (Figure 1).
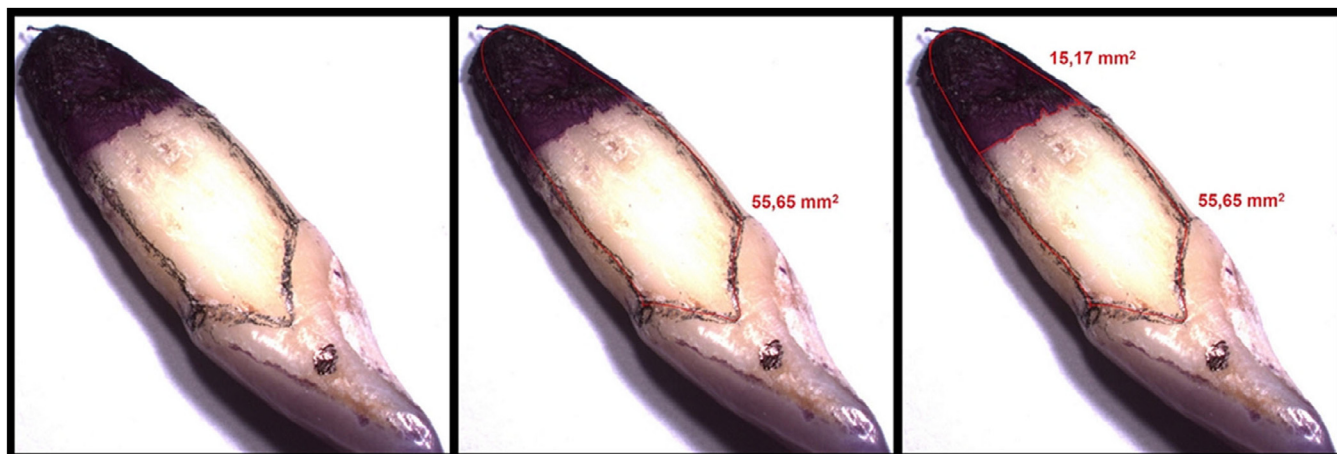

Fig. 1 – Delineation of the transition angles on root surfaces and measurements of total root and residual periodontal ligament area (7.5× magnification).

Training and calibration

Two examiners, CCS and JM, both with experience in identifying landmarks critical to the present study (cemento-enamel junction, transitions between root surfaces and delineation of the stained periodontal ligament) conducted the microscopic evaluation. Intra- and inter-examiner reproducibility was evaluated through duplicate examinations of 10 teeth 1 hour apart. The intra-examiner correlation coefficient was 0.99 for both examiners; the inter-examiner correlation coefficient was 0.98.

Microscopic evaluation

The root surfaces were evaluated using a stereo microscope (Zeiss SteREO Discovery.V20, Carl Zeiss, Göttingen, Germany) equipped with a digital camera system (Axio Cam ICc3, Carl Zeiss, Göttingen, Germany). Images of each surface were captured at $7.5 \times$ magnification and were evaluated using digital image processing software (Axio Vision 4.8, Carl Zeiss, Göttingen, Germany). Using the "outline spline" tool it was possible to delineate the RPL and root area, from the cemento-enamel junction to the apex of each root surface (Figure 1).

Statistical analysis

Summary statistics (means ± SD) and frequency distributions were computed for the demographic parameters of age and gender, and for extraction indication and tooth type. The total periodontal ligament area was calculated by summation of the area over four root surfaces. Summation of the RPL from the four root surfaces determined the total RPL for each tooth. These measurements were used to calculate the fraction of RPL for each tooth. Normalised distributions were evaluated using the Shapiro-Wilk test. Differences between age groups were evaluated using an independent *t*-test. Differences between genders were examined using chi-square tests. Comparisons between RPLs were evaluated using the Mann-Whitney test. For all analyses, the tooth was the unit. The significance level was set at 5%. Data were analysed using SPSS (SPSS Windows, version 21.0, SPSS, Chicago, IL, USA).

Results

A total of 725 teeth were collected of which 311 could not be evaluated, leaving 414 teeth to be stained and evaluated microscopically; of these 259 teeth were extracted due to periodontal and 155 teeth on other indications (Figure 2). There
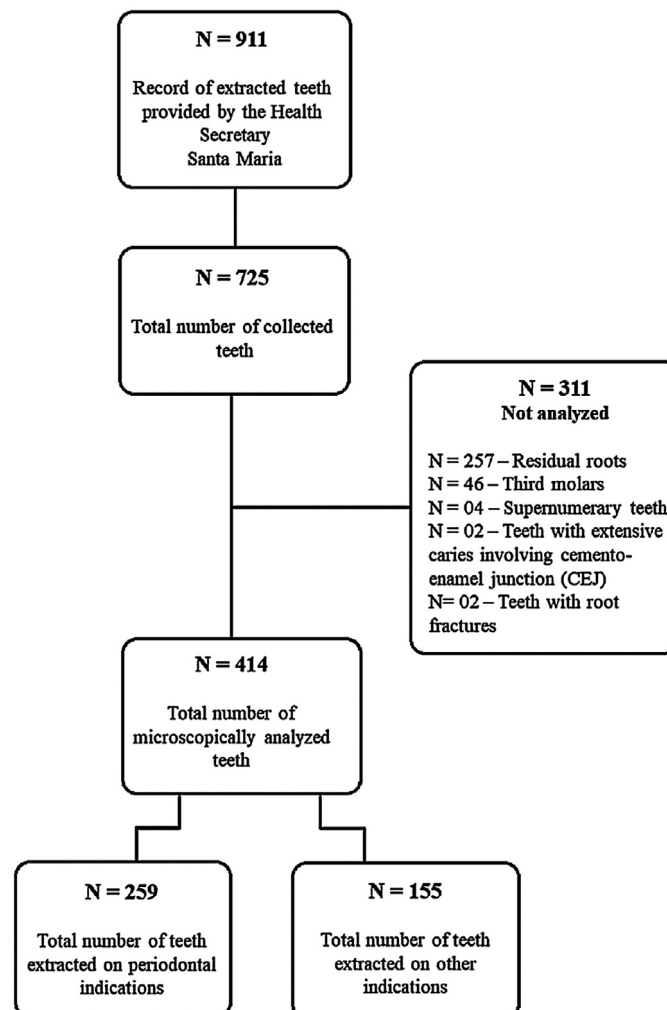

Fig. 2 – Flowchart of analysed teeth.

Table 1 – Demographic parameters and extraction indications collected in the questionnaires (n = 651)

	Periodontal	Other	P
Age ($\overline{x} \pm SD$)*	56.0 ± 11.3	37.0 ± 16.4	0.00
Gender n (%)[†]			
Male	130 (52.2)	143 (35.6)	0.00
Female	119 (47.8)	259 (64.4)	
Extraction indication n (%)			
Periodontal disease	249 (38.2)		
Residual root	139 (21.4)		
Unrestorable caries	76 (11.7)		
Third molars	71 (10.9)		
Endodontic treatment needs	65 (10.0)		
Other	51 (7.8)		

* Independent t-test; $P < 0.05$.
[†] Chi-square test; $P < 0.05$.

was a 20.4% loss of teeth compared with the record of extracted teeth provided by the Health Secretary, Santa Maria. This loss may be ascribed at least in part to the refusal of three dentists to participate in the study. Ten percent of the questionnaires were returned incomplete.

Patients subject to extractions on periodontal indications exhibited a mean age of 56 years (52% men). Corresponding observations for patients receiving extraction on other indications were 37 years (36% men; Table 1). Residual roots, third molars, teeth with extensive caries involving the cemento-enamel junction, root fractures, bone tissue–adjacent root surfaces and extensive root caries were not evaluated.

Periodontal disease alone was the major indication for extraction, followed by residual roots and unrestorable caries (Table 1). The mean RPL for teeth extracted on periodontal indications was 34.9%, versus 79.6% for teeth extracted on any other indication ($P \leq 0.01$), with premolars and molars exhibiting a greater RPL than incisors/canines (Table 2). A higher percentage of incisors/canines and premolars were extracted on periodontal indications, whereas mandibular molars were extracted due to other indications (Table 2). Table 3 details the mean RPL by dental surface.

When considering teeth with an RPL ≥ 30% as possible to maintain, 189 (76%) teeth extracted on periodontal indications could have been maintained. When RPL cut-off limits of ≥40% or ≥50% are applied, 93 (37%) and 43 (17%) teeth, respectively, could have been maintained (Figure 3).

Table 3 – Mean (± SD) fraction of residual periodontal ligament area (RPL; %) for each dental surface by periodontal and other indications

	Periodontal	Other
Buccal	39.04 (21.71)	78.63 (19.09)
Lingual/Palatal	31.30 (18.75)	78.17 (21.25)
Mesial	33.36 (19.15)	81.80 (19.81)
Distal	36.99 (19.15)	79.01 (20.86)

DISCUSSION

The aim of the present study was to evaluate the RPL with respect to the extraction indication in a sample of extracted teeth from a Brazilian Public Health Service district. The conceptual hypothesis was that many teeth extracted on periodontal indications could be maintained. It was observed that teeth extracted on periodontal indications exhibited a mean RPL of 34.9%, constituting 249 (38.2%) of all extracted teeth. When evaluating with various RPL cut-off limits, it was found that a considerable number of periodontally compromised teeth could have been maintained, using cut-off limits set at ≥30% (189 teeth), ≥40% (93 teeth), and ≥50% (43 teeth).

It is a contemporary dilemma whether to maintain or extract and substitute compromised teeth using various prosthetic approaches. Dentists frequently face these decisions, with the decision matrix including socioeconomic conditions, possibilities to provide needed/desired treatment, cost, presence of risk factors, alternative treatments, prognosis, and patient expectations. The ultimate objective must always be the reestablishment of healthy dentition with the potential to provide comfort and function throughout life. In this study, the RPL was smaller in teeth extracted on periodontal indications (34.9%) compared with that of teeth extracted on all other indications (79.6%), with premolar and molar teeth extracted on periodontal indications exhibiting somewhat larger RPL estimates than anterior teeth. There is controversy regarding the limitations of periodontal treatment and whether to maintain teeth with severe attachment loss. Some prognostic algorithms suggest that teeth with severe attachment loss usually exhibit a more favourable prognosis than initially estimated.[13] When criteria proposed for categorising a questionable or hopeless prognosis are applied to the RPL measured in the present study, it was found that many teeth could have been preserved. In regard to this, Lindhe and Nyman[16,17] demonstrated the longevity of teeth exhibiting advanced periodontal disease over 14 years under

Table 2 – Mean (± SD) fraction of residual periodontal ligament area (RPL; %) by periodontal and other indications

	Periodontal (n = 259)			Other (n = 155)		
	RPL	Maxillary	Mandibular	RPL	Maxillary	Mandibular
Incisor/Canine	31.3 ± 14.6	67 (48.2%)	50 (41.7%)	60.7 ± 19.1	14 (19.7%)	3 (3.6%)
Premolar	37.5 ± 16.7	24 (17.3%)	31 (25.8%)	73.7 ± 20.2	12 (16.9%)	12 (14.3%)
Molar	37.9 ± 15.4	48 (34.5%)	39 (32.5%)	83.6 ± 15.6	45 (63.4%)	69 (82.1%)
Total	34.9 ± 15.7*	139 (100%)[†]	120 (100%)	79.6 ± 18.3*	71 (100%)[†]	84 (100%)[†]

SD, Standard Deviation.

* Mann-Whitney test; $P < 0.05$.
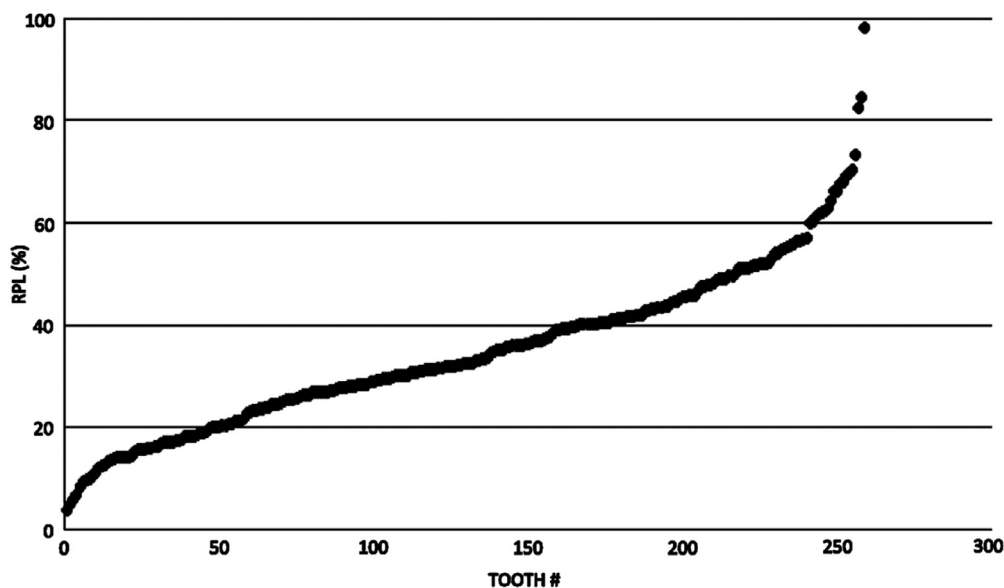[†] Chi-square test; $P < 0.05$.

Fig. 3 – Frequency distribution, less to more residual periodontal ligament (RPL) in teeth extracted on periodontal indications.

maintenance of high plaque control standards, with teeth often serving as anchors for advanced fixed prosthetic reconstructions.

In the present study, subjects that had teeth extracted on periodontal indications were significantly older than subjects having teeth extracted on any other indication. Periodontal disease has in most cases slow progression and severe loss of attachment may most commonly be encountered in older subjects. Several studies suggest that periodontal disease is the principal cause for tooth loss in 45-year-olds and older subjects.[18,19] However, others report caries and its consequences as the principal reason for tooth loss followed by periodontal disease.[20] When aggregating caries and its consequences (residual root, endodontic treatment needs) in the same group for extracted teeth in the present study, they represent the principal indication for extraction (43.1%). Similarly, evaluating a cohort deprived of regular dental care over 24 years, van der Velden et al.,[21] observed that caries was the major reason for tooth loss. A significant percentage in the current sample exhibited severe periodontitis and with aging more teeth should be expected to be lost due to periodontal disease as suggested by Hull et al.,[22] who found caries to be the major reason for extraction prior to 50 years of age and periodontal disease for subjects 50 years of age or older.

Our observations corroborate other studies evaluating the attachment level in extracted teeth.[11,12] Klock and Haugejorden[11] in a Norwegian sample found that teeth were extracted in the early stage of periodontal disease. Splieth et al.[12] in an East German sample similarly found that teeth without caries or exposed pulp tissues exhibited less residual periodontal ligament than teeth with these defects. However, the level of residual periodontal ligament was still substantial, ranging from 50%–70%. Both studies suggest that teeth usually are extracted in an early phase of periodontal disease and that better knowledge may help to form decisions directed at

maintaining teeth. Costs associated with treatments to replace missing teeth are usually high and may in turn generate future costs associated with repair and replacement. Thus, periodontal treatment and maintenance in health and function appear substantially more cost-effective.[23] Notably, when tooth replacements are made using dental implants, costs for maintenance appear still higher than routine periodontal maintenance.[24]

Jafarian and Etebarian[25] evaluated indications for extraction of permanent teeth, with 51% lost due to caries and 14% due to periodontal disease. They observed a higher percentage of extractions due to caries for mandibular followed by maxillary molars, and a higher percentage of extractions due to periodontal disease for mandibular incisors, similar to the observations made in the present study, as we found that mandibular molars followed by maxillary molars were more frequently extracted on non-periodontal indications (data not shown). However, teeth extracted on periodontal indications were more equally distributed among incisors/canines, premolars and molars in the present study.

RPL estimates for multi-rooted teeth were accomplished by delineating the surface area for each root as for single-rooted teeth. However, it was not possible to capture images of the internal aspects corresponding to the furcation dome in multi-rooted teeth. Thus, teeth with furcation involvement extracted on periodontal indications could have displayed lower RPL estimates. While this represents one limitation of this study, as estimates were captured according to the total area evaluated, only limited information was probably lost.

The present study recognises that assessments other than the RPL informed the clinical decisions leading to the extractions of teeth in the sample. Nevertheless, the clinicians independently identified the indications that prompted individual extractions through the questionnaires. The assessment of the RPL was then correlated with the actual indication with a

focus on teeth extracted due to periodontal disease and their potential longevity. It is noteworthy that the rate of teeth collected over the study period was high, representative of an urban Brazilian public health community.

In conclusion, based strictly on RPL estimates, the present study suggests that a large number of teeth extracted on periodontal indications conceivably could have been maintained.

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