CLINICAL RESEARCH

Outcome of Root Canal Treatment of Teeth with Asymptomatic Apical Periodontitis Treated with Foraminal Enlargement and 2% Chlorhexidine Gel: A Retrospective Cohort Study

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SIGNIFICANCE

This retrospective cohort trial evaluated the success rate of teeth diagnosed with pulp necrosis and asymptomatic apical periodontitis treated with the foraminal enlargement instrumentation technique in association with 2% chlorhexidine gel. This approach reached a similar outcome to the conventionally established approach.

ABSTRACT

Introduction: This retrospective cohort study aimed to estimate the success rate (SR) of primary root canal treatment on teeth with a diagnosis of pulp necrosis (PN) and asymptomatic apical periodontitis (AAP) when using 2% chlorhexidine gel as an auxiliary chemical substance and foraminal enlargement instrumentation technique. **Methods:** This study evaluated 178 patients with 206 teeth submitted to primary root canal treatment performed by graduate residents in endodontics. The inclusion criteria were patients who underwent treatment over a period of 1–7 years on teeth with a diagnosis of PN and AAP. The SR was evaluated clinically and radiographically and categorized considering strict (complete resolution of the periradicular lesion) or loose (reduction in the size of the existing periradicular lesion) criteria. Cases of clinical and/or radiographic absence of repair were classified as a failure. Two calibrated examiners independently assessed treatment outcomes using ImageJ software (National Institutes of Health, Bethesda, MD). **Results:** The SRs were 81.1% (95% confidence interval, 75.7%–86.4%) and 87.4% (95% confidence interval, 82.8%–91.9%) when considering the strict or loose criteria, respectively. Females had a higher SR when strict criteria were applied. Also, the SR was significantly reduced when there was an increase in the patient's age. **Conclusions:** Teeth with a diagnosis of PN and AAP and treated with 2% chlorhexidine gel and foraminal enlargement achieved substantial SR. Sex and age were prognostic factors that played a significant role in the SR. Future randomized controlled trials should further investigate the effects of foraminal enlargement and 2% chlorhexidine gel as an auxiliary chemical substance. *(J Endod 2023;49:972–979.)*

KEY WORDS

Chlorhexidine; endodontics; foraminal enlargement; retrospective study; treatment outcome

Primary endodontic treatment is considered the gold standard treatment option for the maintenance of inflamed and/or infected dental elements because it removes the cause (eg, biofilm and inflamed pulp tissue) and establishes adequate conditions for repairing or maintaining periradicular health. In this way, it is able to avoid, reduce, or completely repair periradicular lesions of endodontic origin[1]. It is estimated that about 52% of the world's adult population has at least 1 tooth with apical periodontitis, and about 39% of these teeth have already been previously endodontically treated[2].

In order to increase the predictability of the treatment's success, it is of major importance to properly clean and shape the apical third of the root canal system because this area can host high taxa of the bacterial microbiome[3]. From this perspective, achieving and maintaining apical patency are well-known for playing key roles in increasing the endodontic treatment success outcome[4]. Another measure that has been studied to enhance apical cleaning is foraminal enlargement, an instrumentation technique

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that consists of widening the apical foramen using an endodontic file larger than the anatomic constriction at the foramen level or beyond[5-7]. This approach has been investigated in past studies, with a few pieces of evidence reporting that it could reduce the bacterial load in the apical region and thus may increase the success rate (SR) of root canal treatment[8-10]; the available clinical evidence report an SR of up to 96% using this approach[11,12]. Moreover, increasing the diameter of the apical instrumentation favors the auxiliary chemical substance (ACS) to penetrate deeper into the root canal system[13], thus promoting improvements in decontamination and the reduction of endotoxin levels[8] without an increase in the extrusion of debris through the apical foramen[14].

Furthermore, to enhance the safety of this procedure, using an ACS well tolerated by the soft tissues is highly recommended; thus, 2% chlorhexidine should be preferred[15]. Studies evaluating the properties of chlorhexidine have demonstrated broad-spectrum antimicrobial activity[16], substantivity that gives this substance the potential to continue acting after several days and weeks[17], and other clinically relevant aspects such as lubricating properties and rheological action[15]. Although sodium hypochlorite is the most commonly used ACS, 2% chlorhexidine gel can be considered a viable option, as demonstrated by previous high-impact studies[18,19]. However, the current literature is still scarce on clinical evidence regarding the use of 2% chlorhexidine gel to perform foraminal enlargement of teeth with asymptomatic apical periodontitis (AAP) and the SR of this intervention[20]. Thus, the objective of this retrospective cohort study was to evaluate the SR of the primary endodontic treatments performed using 2% chlorhexidine gel and the foraminal enlargement instrumentation technique on teeth diagnosed with AAP. The null hypothesis tested in this retrospective trial was that the use of 2% chlorhexidine gel as an ACS and performing foraminal enlargement have similar SR to the clinical protocol recommended by the American Association of Endodontics[21].

MATERIAL AND METHODS

The study protocol was approved by the local Ethics Committee in Research with Human Beings of the Piracicaba Dental School, State University of Campinas (CAAE 59171822.2.0000.5418), and the participants signed an informed consent form before the study started. This study was reported in accordance with the Preferred Reporting Items for Observational Studies in Endodontics 2023 guidelines[22]. The sample size was calculated *a priori* using the Epi Info 7.2 software (Centers for Disease Control and Prevention, Atlanta, GA) with a 95% confidence level and 5% alpha; this calculation was based on previous studies with a similar outcome[23,24], which led to a minimum of 196 teeth for the findings to be statistically significant. From a pool of 4201 patients treated at the graduate endodontic clinic from January 2015 to December 2020, a total of 474 patients who were diagnosed with AAP were included in this study. The inclusion criteria were healthy patients with no chronic systemic conditions who underwent primary endodontic treatment of teeth with necrotic pulp and AAP (minimum size $\geq 2.0 \times 2.0$ mm) with follow-up at 1–7 years after treatment. Teeth with incomplete root development; internal and/or external root resorption; a history of dental trauma; root fractures, which had procedural accidents; and endodontic complications in the transoperative period were excluded. Moreover, teeth in close proximity to important anatomic structures, such as the inferior alveolar nerve, mental nerve, and maxillary sinus, or that had severe apical curvatures that may pose a risk for paresthesia, file fracture, and other transoperative accidents were excluded from this trial because of the nature of the intervention (ie, instrumentation beyond the apical foramen). A total of 206 teeth from 178 patients met all the study criteria and were evaluated for the investigated outcome (for a return rate of 43.5%).

Endodontic treatments were performed following the treatment protocol of the graduate endodontics clinic. Pulp and periradicular tests and digital periapical radiographic examinations were performed to confirm the pulpal and periradicular diagnosis. All endodontic procedures were performed by dentists certified by the Brazilian Federal Council of Dentists and enrolled in the endodontics graduate program under the supervision of the endodontics faculty. The ACS used was 2% chlorhexidine gel (Drogal Farmácias, Piracicaba, São Paulo, Brazil), active syringe irrigation with saline solution, and 17% EDTA (Biodinâmica, São Paulo, Brazil) as a final irrigation solution. The instrumentation technique was crown-down preparation with foraminal enlargement. The full working length (FWL) was determined through electronic apex locators (RomiApex A15; Romidan, Kiryat Ono, Israel), and both manual K-files (VDW GmbH, Munich, Germany) associated with mechanized rotary and/or reciprocating files (Easy-Bassi; Belo Horizonte, Minas Gerais, Brazil) were used to prepare the entire length of the root canals respecting their original anatomy. To perform a proper foraminal enlargement, the FWL was determined to be 1 mm beyond the apical foramen, and then after foraminal patency was achieved, all files were chosen based on each root canal anatomy, and they were used at this FWL (ie, +1 mm). The prepared teeth were filled using calibrated gutta-percha (Tanari; Manacapuru, Amazonas, Brazil) following the single-cone technique and Endomethasone N sealer (Septodont, Saint-Maur-des-Fossés, France). Afterward, coronal sealing was performed with a resin-based composite (Filtek Z250 XT; 3M, Saint Paul, MN). In cases in which it was not possible to complete the treatment in a single visit, a calcium hydroxide (Biodinâmica) paste mixed with 2% chlorhexidine was inserted using lentulo burs (Dentsply Sirona, Charlotte, NC) coupled with a low-speed handpiece and temporary sealing with resin-based composite.

Data retrieved from dental records included patient age, sex, tooth treated, area of the periradicular radiolucency, number of visits, filling limit, root canal sealer extrusion, follow-up time, quality and type of final rehabilitation, and preoperative and postoperative radiographs. In addition, regarding the follow-up visit (performed after 1–7 years), signs and symptoms such as the presence or absence of pain, sensitivity to percussion/palpation, swelling, sinusitis, and a follow-up periradicular radiograph were collected.

Clinical and Radiographic Evaluation

The outcomes of endodontic treatments were evaluated from the analysis of signs and symptoms present at the follow-up visit and radiographic evaluation performed individually by 2 calibrated endodontic specialists (T.A.S. and L.B.G.) who achieved an interobserver kappa of 0.8565, which is considered a "good" agreement and "almost perfect" consistency[25]. If any disagreement was observed, a third reviewer (C.C.R.F.) was consulted to achieve consensus and make a final decision. Subsequently, they were classified based on the criteria described later and used in studies with a similar outcome[26-28]. Moreover, the evaluated teeth were always classified according to the worst result to avoid bias[29,30].

Complete Repair

Functional, asymptomatic tooth and complete restoration of the periodontal ligament space in the perirradicular zone.

TABLE 1 - Results of Analysis of Associations of Success Outcome (Considering Loose Criteria) in Primary Endodontic Treatments Performed on Teeth Diagnosed with Asymptomatic Apical Periodontitis ($N = 206$)

			Success		
		General	Yes*	No	
Variable	Category	Frequency (%)	Frequency (%)		*P* value
General	—	206 (100.0)	180 (87.4)	26 (12.6)	—
Age range	≤25 years	10 (4.9)	10 (100.0)	0 (0.0)	.1123†
	>25 and ≤50 years	93 (45.1)	85 (91.4)	8 (8.6)	
	>50 years	103 (50.0)	85 (82.5)	18 (17.5)	
Sex	Female	125 (60.7)	112 (89.6)	13 (10.4)	.2330‡
	Male	81 (39.3)	68 (84.0)	13 (16.0)	
Tooth group	Canine	9 (4.4)	8 (88.9)	1 (11.1)	.2766‡
	Incisive	56 (27.2)	47 (83.9)	9 (16.1)	
	Molar	95 (46.1)	81 (85.3)	14 (14.7)	
	Premolar	46 (22.3)	44 (95.6)	2 (4.4)	
Number of visits	Single visit	166 (80.6)	144 (86.8)	22 (13.2)	.5781‡
	Multiple visits	40 (19.4)	36 (90.0)	4 (10.0)	
Quality of coronal seal on follow-up	Absent	11 (5.3)	8 (72.7)	3 (27.2)	.0988†
	Unsatisfactory	25 (12.1)	20 (80.0)	5 (20.0)	
	Satisfactory	170 (82.5)	152 (89.4)	18 (10.6)	
Type of coronal sealing	Absent	11 (5.3)	8 (72.7)	3 (27.3)	.1067†
	Crown	19 (9.2)	15 (79.0)	4 (21.0)	
	Direct restoration	176 (85.4)	157 (89.2)	19 (10.8)	
Filling limit	Ideal	190 (92.2)	167 (87.9)	23 (12.1)	.2890†
	Overextension	7 (3.4)	5 (71.4)	2 (28.6)	
	Underfilling	9 (4.4)	8 (88.9)	1 (11.1)	
Root canal sealer extrusion	Absent	53 (25.7)	44 (83.0)	9 (17.0)	.3361‡
	Present	153 (74.3)	136 (88.9)	17 (11.1)	
Follow-up period	≤4 years	145 (70.4)	123 (84.8)	22 (15.2)	.0914†
	>4 years	61 (29.6)	57 (93.4)	4 (6.6)	
Radiolucency area	<20 mm^2	132 (64.1)	116 (87.9)	16 (12.1)	.7728‡
	≥20 mm^2	74 (35.9)	64 (86.5)	10 (13.5)	

*Complete or incomplete repair.
†Fisher exact test.
‡Chi-square test.

Incomplete Repair

Functional, asymptomatic tooth and decreased lesion area compared to preoperative radiographic exam.

Absence of Repair

Nonfunctional tooth, symptomatic or not, with persistent periradicular pathology or increased radiolucent area compared to preoperative radiographic exam.

SR was estimated considering cases of complete repair (strict criteria) and considering cases of complete and incomplete repair (loose criteria). The area of the periradicular radiolucency present on the initial radiographic examination was recorded using the mean values (mm^2) of 3 consecutive measurements using ImageJ software (National Institutes of Health, Bethesda, MD). The values were recorded and summed in cases of multirooted teeth with more than 1 root with periradicular radiolucency, and then they were classified as <20 mm^2 or ≥20 mm^2.

Statistical Analysis

The SR was estimated with a 95% confidence interval (CI). Association analyses between treatment success and categoric variables were performed using chi-square and Fisher exact tests. If statistically significant differences were observed, multivariate analysis was performed to further investigate the effect of covariates.

Moreover, comparisons between success and failures regarding quantitative variables were performed using the Student *t* test. All analyses were performed using R software version 4.1.3 (R Foundation for Statistical Computing, Vienna, Austria) with a significance level of 5%.

RESULTS

When considering the loose criteria (complete or incomplete repair), the SR in endodontic treatments performed on teeth with primary infection and a diagnosis of APP was 87.4% (95% CI, 82.8%–91.9%). When considering stricter criteria for success (complete repair), the prevalence of success was 81.1% (95% CI, 75.7%–86.4%).

Table 1 shows the clinical data considering the loose criteria. The mean age of the patients was 50 years, with a mean periradicular radiolucency size of 21.2 mm^2 and a mean follow-up period of 36.8 (±20.1) months. There was no significant difference between SR related to the evaluated parameters. Moreover, most of the treated patients were females (60.7%), and the treatment was performed in a single visit (80.6%), with the quality of the coronal seal in the follow-up considered satisfactory (82.5%). Most patients received direct restoration with resin-based composite (85.4%). Furthermore, the apical filling limit was considered ideal (92.2%). Root canal sealer extrusion is also observed in most cases (74.3%). There was no significant difference between the quality of the coronal seal at follow-up and the SR. However, when quantitatively comparing the teeth with

TABLE 2 - Results of Analysis of Associations of Success Outcome (Considering Strict Criteria) in Primary Endodontic Treatments Performed on Teeth Diagnosed with Asymptomatic Apical Periodontitis ($N = 206$)

			Success		
		General	Yes*	No	
Variable	Category	Frequency (%)	Frequency (%)		*P* value
General	—	206 (100.0)	167 (81.1)	39 (18.9)	—
Age range	≤25 years	10 (4.9)	10 (100.0)	0 (0.0)	.2520†
	>25 and ≤50 years	93 (45.1)	76 (81.7)	17 (18.3)	
	>50 years	103 (50.0)	81 (78.6)	22 (21.4)	
Sex	Female	125 (60.7)	107 (85.6)	18 (14.4)	.0392†
	Male	81 (39.3)	60 (74.1)	21 (25.9)	
Tooth group	Canine	9 (4.4)	7 (77.8)	2 (22.2)	.2456‡
	Incisive	56 (27.2)	43 (76.8)	13 (23.2)	
	Molar	95 (46.1)	75 (78.9)	20 (21.1)	
	Premolar	46 (22.3)	42 (91.3)	4 (8.7)	
Number of visits	Single visit	166 (80.6)	135 (81.3)	31 (18.7)	.8477†
	Multiple visits	40 (19.4)	32 (80.0)	8 (20.0)	
Quality of coronal seal on follow-up	Absent	11 (5.3)	7 (63.6)	4 (36.4)	.1778‡
	Unsatisfactory	25 (12.1)	19 (76.0)	6 (24.0)	
	Satisfactory	170 (82.5)	141 (82.9)	29 (17.1)	
Type of coronal sealing	Absent	11 (5.3)	7 (63.6)	4 (36.4)	.2554‡
	Crown	19 (9.2)	15 (78.9)	4 (21.1)	
	Direct restoration	176 (85.4)	145 (82.4)	31 (17.6)	
Filling limit	Ideal	190 (92.2)	154 (81.1)	36 (18.9)	.7628‡
	Overextension	7 (3.4)	5 (71.4)	2 (28.6)	
	Underfilling	9 (4.4)	8 (88.9)	1 (11.1)	
Root canal sealer extrusion	Absent	53 (25.7)	43 (81.1)	10 (18.9)	.9890†
	Present	153 (74.3)	124 (81.0)	29 (19.0)	
Follow-up period	≤4 years	145 (70.4)	113 (77.9)	32 (22.1)	.0764†
	>4 years	61 (29.6)	54 (88.5)	7 (11.5)	
Radiolucency area	<20 mm^2	132 (64.1)	108 (81.8)	24 (18.2)	.7136†
	≥20 mm^2	74 (35.9)	59 (79.7)	15 (20.3)	

*Complete repair.
†Chi-square test.
‡Fisher exact test.

absent and unsatisfactory coronal sealing, the SR ranged from 72.7%–80%, and the SR significantly increased to 89.4% among those with satisfactory sealing.

Table 2 shows the clinical data considering only the strict criteria. The findings are similar to those in Table 1. However, when the strictest criteria were considered, there was a significant difference between SR and patient sex ($P \leq .05$). The percentage of success was statistically higher among women (85.6%) than men (74.1%).

Table 3 shows that there was no significant difference between the SR according to the loose criteria regarding periradicular radiolucency size and follow-up time ($P > .05$). However, the patient's age played a significant role in the SR ($P \leq .05$).

TABLE 3 - Patient Age Range, Radiolucency Area, and Follow-up Period of the Patients Considering the Loose Criteria

		Success		
	General	Yes*	No	
Variable	Mean (standard deviation)			*P* value
Patient age (y)	50.0 (14.4)	48.9 (14.3)	57.9 (12.8)	.0024
Radiolucency area (mm^2)	21.2 (17.4)	21.2 (17.5)	21.1 (16.6)	.9901
Follow-up period (mo)	36.8 (20.1)	37.4 (20.7)	33.2 (15.2)	.3232

*Complete or incomplete repair.

DISCUSSION

The apical third of the root canal is considered a critical zone because it can harbor a large number of microorganisms responsible for perpetuating periradicular inflammation[3]. For many decades, apical constriction and cementodentinal junction were considered the apical limit of root canal treatment. However, later it was observed that irregularities in shape and location might be a clinical limitation during the establishment of precise working lengths[31-33]. Although it is not possible to attest that the achievement of foraminal patency is crucial to establish the success of root canal treatment[34,35], it provides an improvement in the penetration of the irrigant in the apical third of the root and better cleaning, shaping, and subsequent filling of the root canals[35], in addition to providing a higher survival rate than in cases in which foraminal patency was not performed[4].

Even though foraminal enlargement can be performed at a 0.0 reading of the electronic apex locator, in the present study, we opted to establish the working limit at 1 mm beyond the apical foramen so that an appropriate foraminal enlargement could be performed while maintaining the foraminal patency. Greater removal of the number of viable bacteria and endotoxins of the apical third when the apical foramen is enlarged is 1 of the desired outcomes when performing this technique[8], thus promoting more favorable conditions for periradicular healing[36,37]. It is also worth mentioning that the increase in the diameter of the apical foramen naturally occurs when using hand or mechanically driven files regardless of whether the working length is established at the apical foramen or 1 mm beyond that measurement[37,38]. The present study used 2% chlorhexidine gel as an ACS, and active syringe irrigation was performed with a saline solution. A few studies have investigated the successful outcomes of endodontic treatments and retreatments when using 2% chlorhexidine gel as the ACS[11,18,28,39,40]. Furthermore, although sodium hypochlorite is the most used ACS worldwide, studies comparing the 2 substances demonstrate that 2% chlorhexidine in different formulations can be considered a viable and safe option for use in primary treatments or endodontic retreatments[19,39]. Chlorhexidine gel at 2% concentration was chosen as the main ACS because the foraminal enlargement technique is known for causing a greater extrusion of endodontic filling materials[41]; thus, it is feasible to say that sodium hypochlorite poses a greater risk of causing accidents if extruded to the periapical tissues[42], and, therefore, 2%

chlorhexidine gel is more suitable for safely performing this instrumentation technique because of its high biocompatibility[15].

The SR of teeth with AAP undergoing primary endodontic treatment without foraminal enlargement and using sodium hypochlorite from 1%–5.25% as an ACS ranges from 74% when considering only complete repair to 85.4% when loose criteria are applied[43]. Thus, the SR obtained from the present cohort study under the same evaluation criteria as the previously cited study is similar to that obtained using the conventional protocols that are considered standard by the American Association of Endodontics, which recommends the use of sodium hypochlorite or chlorhexidine and root canal instrumentation 1 mm short of the apical foramen[21].

The findings of the present study corroborate the results of a classic systematic review with meta-analysis by Ng et al[44], who showed no statistical difference in the SR of primary treatments using different ACS. Moreover, when performing foraminal enlargement, it is expected to have greater postoperative pain in the first hours posttreatment because of the mechanical trauma caused in the periodontal ligament[45,46]. However, no difference is observed in the postoperative pain between chlorhexidine and sodium hypochlorite when performing this technique[39]. Thus, we can extrapolate these findings that reducing the number of viable bacteria in the canal to the lowest level possible at the time of filling through mechanical preparation has a more critical role in achieving endodontic success than choosing between the use of sodium hypochlorite or chlorhexidine[18]. Furthermore, foraminal enlargement can result in an increase in the filling material extrusion[47], and in the present study, we have observed that root canal sealer extrusion was present in 74.3% of the cases; however, this accident does not impact the overall SR as previously discussed by Ricucci et al[48]. Even so, it is highly recommended that sealer extrusion be unintentional because it can delay periradicular healing[49]. Moreover, the SR of cases performed in a single-visit treatment or multiple visits with the use of intracanal dressing containing 2% chlorhexidine gel mixed with calcium hydroxide also did not show a significant difference, thus endorsing the studies that investigate the effect of this variable[50-52].

Current practice guidelines suggest that posttreatment periradicular lesions need a minimum of 12 months to be reassessed, and if they persist for more than 4 years, additional interventions may be required[53]. In the high-impact literature, the follow-up period varies in a range of 6 months–30 years[44,54]. The same studies discuss that when evaluating the complete repair of the periradicular lesions, the clinical trials that carried out more extensive follow-up periods showed better SR. Therefore, in our study, the cases were reassessed between 1 and 7 years and were classified into 2 categories (ie, $\leq$4 years of follow-up and >4 years of follow-up), with no statistically significant difference between these 2 categories. This finding can be explained by the inclusion criteria of our study, which included only patients with at least 12 months since the intervention, thus respecting the average time required for periradicular healing[55]. Moreover, systemic health conditions such as diabetes and cardiovascular diseases can significantly impact the SR[56], and in the current study, we included only healthy patients with no chronic illness.

Among the classic prognostic factors evaluated in endodontics, patient age is among the most investigated in the literature. In the present study, the percentage of periradicular healing showed no statistical difference between age groups when considering the strict criteria, corroborating some studies that showed no difference in age-related success and periradicular lesion repair[57,58]. However, in this study, when loose criteria were considered, the mean age of patients in cases with positive SR was significantly lower ($P \leq .05$). Also, sex is not known for playing a significant role in periradicular healing of endodontically treated teeth[44]. Nevertheless, the present study's findings show a statistical difference favoring the periradicular healing of female patients when considering the strict criteria; however, these data have yet to be confirmed by future studies because sex bias is an issue that has been underinvestigated in clinical trials[59].

Regarding the type of rehabilitation evaluated at the follow-up visit, no significant difference was observed between placing direct restorations or prosthetic crowns ($P > .05$), as previously reported by several studies[28,44,60-62]. Therefore, more important than the type of rehabilitation that is placed on the endodontically treated tooth is whether this restoration is adequate, without coronal leakage and in masticatory function[63].

The limitations of this retrospective cohort study involve the small sample size and low recall rate. Future trials should be performed in a randomized method following the Preferred Reporting Items for Randomized Trials in Endodontics[64] in order to assess the SR of root canal treatment performed with foraminal enlargement and compare it with the conventional instrumentation technique recommended by the American Association of Endodontics. Novel recall methods should be further investigated to increase the follow-up of patients who underwent root canal treatment.

CONCLUSION

Within the limitations of this study, it was observed that patients diagnosed with AAP who underwent primary root canal treatment with 2% chlorhexidine gel and the foraminal enlargement instrumentation technique had an SR of 81.1%–87.4%. Sex and age were prognostic factors that may have negatively influenced the SR of the treated patients. Future randomized controlled trials should further investigate the effects of foraminal enlargement and 2% chlorhexidine gel as an ACS and evaluate the influence of prognostic factors on the treatment outcome.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Tamares Andrade da Silva: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing – original draft. **Lucas Peixoto de Araújo:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Visualization, Writing – review & editing. **Leandro Bueno Gobbo:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing – review & editing. **Adriana de-Jesus-Soares:** Supervision, Writing – review & editing. **Brenda P.F.A. Gomes:** Supervision, Writing – review & editing. **José Flávio Affonso de Almeida:** Conceptualization, Supervision, Writing – review & editing. **Caio Cezar Randi Ferraz:** Conceptualization, Investigation, Supervision, Writing – review & editing, Project administration.

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The authors deny any conflicts of interest related to this study.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found in the online version at www.jendodon.com (https://doi.org/10.1016/j.joen.2023.06.005).

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