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PROGRAMA DE PÓS-GRADUAÇÃO EM ODONTOLOGIA

ALEXIA DA MATA GALVÃO

Influência do acesso endodôntico, da profundidade da lesão e do uso de dessensibilizantes na resposta a dor dentária

Tese apresentada à Faculdade de Odontologia da Universidade Federal de Uberlândia, como requisito parcial para obtenção do Título de Doutor em Odontologia na Área de Concentração de Clínica Odontológica Integrada

Uberlândia, Julho de 2022

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Reuniu-se em Web Conferência pela plataforma Zoom, em conformidade com a PORTARIA Nº 36, DE 19 DE MARÇO DE 2020 da COORDENAÇÃO DE APERFEIÇOAMENTO DE PESSOAL DE NÍVEL SUPERIOR - CAPES, pela Universidade Federal de Uberlândia, a Banca Examinadora, designada pelo Colegiado do Programa de Pós-graduação em Odontologia, assim composta: Professores Doutores: Maria Antonieta Veloso Carvalho de Oliveira (UFU); Paulo Vinícius Soares (UFU); Lívia Fávaro Zeola (UFMG); Thaiane Rodrigues Aguiar Barretto (UFBA); Gisele Rodrigues da Silva (UFU); orientador(a) do(a) candidato(a).

Iniciando os trabalhos o(a) presidente da mesa, Dr(a). Gisele Rodrigues da Silva, apresentou a Comissão Examinadora e o candidato(a), agradeceu a presença do público, e concedeu ao Discente a palavra para a exposição do seu trabalho. A duração da apresentação do Discente e o tempo de arguição e resposta foram conforme as normas do Programa.

A seguir o senhor(a) presidente concedeu a palavra, pela ordem sucessivamente, aos(às) examinadores(as), que passaram a arguir o(a) candidato(a). Ultimada a arguição, que se desenvolveu dentro dos termos regimentais, a Banca, em sessão secreta, atribuiu o resultado final, considerando o(a) candidato(a):

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O competente diploma será expedido após cumprimento dos demais requisitos, conforme as normas do Programa, a legislação pertinente e a regulamentação interna da UFU.

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EPÍGRAFE

"Tudo pode ser, só basta acreditar"
Michael Sullivan / Miguel Plopschi / Paulo Massadas

SUMÁRIO

RESUMO

RESUMO

A hipersensibilidade dentinária (HD) e as lesões cervicais não cariosas (LCNCs) são alterações que possuem altos índices de prevalência e incidência e que influenciam de maneira expressiva na qualidade de vida da população mundial. Nesse sentido é importante entender melhor a relação da dor em dentes com LCNCs, além de propor manejos das doenças na fase de HD e de LCNCs mais profundas que necessitem de tratamento endodôntico. **Capitulo 1:** avaliar por meio de estudo clínico randomizado, a eficácia de diferentes concentrações de oxalato de potássio (5 e 10%) na redução da HD, após um protocolo de quatro sessões de aplicação, com acompanhamento de 12 meses. **Capitulo 2:** avaliar por meio de um estudo observacional os efeitos da profundidade e espessura da dentina em dentes com LCNC na resposta à dor dental quando testes de diagnóstico clínico foram aplicados. **Capitulo 3:** avaliar por meio de um estudo in vitro o ângulo de flexão do instrumento, a resistência à fratura dos dentes, áreas preparadas, áreas superpreparadas e não preparadas, após diferentes acessos endodônticos em dentes com LCNC. Após a análise dos resultados, pode-se concluir que ambas as concentrações de oxalato de potássio (5 e 10%) testadas podem ser consideradas um tratamento eficaz para HD por pelo menos 6 meses. Dentes com LCNCs de até 2mm de profundidade apresentam níveis semelhantes de dor para: hipersensibilidade dentinária, polpa e tecido perirradicular independente da profundidade da LCNC, porém lesões com ≤1,0mm de profundidade apresentaram maior espessura de dentina remanescente nos achados tomográficos. Acesso conservador em dentes com LCNC pode resultar em maior ângulo de flexão de lima, sobrepreparo, e pior instrumentação no terço médio (mesiodistal/ vestibulolingual) do que o acesso tradicional, mas os dentes se apresentaram maior resistencia à fratura. Dessa forma é possível apresentar o manejo da HD e LCNCs profundas que necessitam de endodontia, além de compreender melhor o diagnóstico de dentes em diferentes profundidades.

Palavras chaves: hipersensibilidade dentinária, lesões cervicais não cariosas, diagnóstico, endodontia.

ABSTRACT

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Dentin hypersensitivity (DH) is a condition with high prevalence and incidence rates, which influences the quality of life of the world population. In this sense, it is important to better understand the relationship between pain in teeth and NCCLs, in addition to proposing a treatment in the HD phase and for deeper NCCLs that require endodontic treatment. **Chapter 1:** to evaluate, by means of a randomized clinical study, the efficacy of different concentrations of potassium oxalate (5 and 10%) in the relieving of DH, after a protocol of four sessions. **Chapter 2:** to evaluate, by means of a observational the effects of NCCL dentin depth and thickness on the response to dental pain when clinical diagnostic tests were applied. **Chapter 3:** evaluate by means of a in vitro the flexion angle of the instrument, the fracture resistance of the teeth, prepared areas, over prepared and the unprepared areas, after different endodontic access in teeth with NCCL. After analyzing the results, it can be concluded that to evaluate, by means of a randomized clinical study, the efficacy of different concentrations of potassium oxalate (5 and 10%) in the relieving of DH, after a protocol of four sessions. tooth with NCCL up to 2mm depth presents similar levels of pain for: dentin hypersensitivity, pulp and periradicular tissue independent to NCCL depth, however, lesions with ≤1.0mm-depth showed greater remain detin thickness in tomographic findings. Conservative access in teeth with NCCL can result in a more flexion angle of the file, over prepared showed worse instrumentation in middle third (bucclingual/ mesiodistal) than tradicional access, but the teeth became more resistant to fracture. In this way, it is possible to present the management of HD and deep NCCLs that require endodontics treatment, in addition to better understanding the diagnosis of teeth at different depths.

Keywords: dentin hypersensitivity, non-carious cervical lesions, diagnosis, endodontics.

INTRODUÇÃO E REFERENCIAL TEÓRICO

1. Introdução e Referencial Teórico

A camada de esmalte dentário na região cervical é fina e considerada uma área de fragilidade estrutural (1). Doenças como a hipersensibilidade dentinária (HD) e lesões cervicais não cariosas (LCNCs) podem acometer essa região. A etiologia de ambas é multifatorial, envolvendo uma associação entre fricção (desgaste dentário por atrito ou abrasão), corrosão (degradação química causada por ácidos extrínsecos e intrínsecos) e tensão (2).

Na corrosão, os tecidos duros dentais são removidos quimicamente, camada por camada, pela ação de ácidos intrinsecos ou extrinsecos (3). A fricção, por outro lado, ocorre por objetos ou substâncias que entram em contato frequente com as superfícies dos dentes, resultando em desgaste mecânico (4). Para o fator tensão as forças de carga oclusal causam flexão dentária, o que resulta em microfraturas e perda dos tecidos dentários na região cervical. Os principais mecanismos envolvidos na concentração de tensão por forças oclusais são as interferências oclusais, contatos prematuros, bruxismo e apertamento dentário (5). Quando esses fatores são associados podem remover a fina camada de esmalte ou produzir desintegração do esmalte na região cervical, e então a dentina ou a polpa podem ser expostas (1).

A exposição dentinária na região cervical causa sensação dolorosa, devido a estimulos evaporativos, térmicos, táteis, osmóticos ou químicos que atingem dentina exposta (6). A dor é sentida de forma subjetiva e depende do processo de estimulação das fibras nervosas e do ambiente psicossocial em que o indivíduo vive (7). A teoria mais aceita para explicar essa sintomatologia dolorosa foi proposta por Brännström, que explica a dor pelo movimento, a qual estimula o processo odontoblástico e causa um quadro agudo de dor a curto prazo, e denominada HD (8).

A HD apresenta prevalência média de 33,5% (9). E tende a causar impacto negativo na rotina relacionada à saúde bucal, resultando em prejuízo significativo nas atividades bucais diárias dos pacientes, como comer, beber, escovar os dentes e respirar (10). Essa influência indesejável é a principal motivação que leva os indivíduos a procurarem assistência odontológica para melhorar sua qualidade de vida (11). Portanto, não é um problema recente ou raro e deve ser considerado como uma condição clínica contínua importante que necessita de tratamentos (12).

A HD é um fator predisponente para a formação das LCNCs (13) e, apesar de ser um dos problemas mais comuns encontrados por profissionais de odontologia, ainda existem dificuldades associadas a seu diagnóstico e tratamento, uma vez que a hipersensibilidade dentinária é diagnosticada por exclusão (14).

Os testes realizados para diagnosticar a HD são subjetivos, dada as percepções individuais que afetam os valores gerados pela escala analógica visual (14). Várias condições dentárias por apresentarem sintomas que podem ser similares a HD em diferentes estágios de sua progressão, como: dentes trincados, restaurações fraturadas, preparo dentário (geralmente recente) para restaurações ou hiperemia pulpar induzida por restauração, clareamento dental, traumatismo dentário, trauma oclusal, doença periodontal, e outros problemas da polpa dentária/endodônticos (15), dificultando seu diagnóstico. Assim, o diagnóstico diferencial é essencial para identificar a etiopatogenia das LCNCs e excluir comprometimento pulpar e apical (16).

A perda de estrutura dentária na junção cemento-esmalte, que não está associada à presença de cárie, é identificada como lesões cervicais não cariosas e tem taxa de prevalência de até 46,7% em adultos (17). Clinicamente, as LCNCs apresentam-se em diferentes morfologias, desde leves depressões até grandes cunhas ou formas arredondadas (18).

O fator tensão e um dos principais relacionados ao rompimento da microestrutura cristalina do dente (1) , e pode levar à progressão das HD e LCNC (19) ou dano à polpa, nesse caso seria necessário o tratamento endodôntico.

O aumento da profundidade das LCNCs resulta na concentração de tensões na lesão próxima a polpa, e isso pode ter um efeito prejudicial progressivo, não só na dentina, mas também na polpa (20). Porém, ainda hoje não temos estudos que associem a profundidade das LCNCs e sensibilidade pulpar, esse diagnóstico ainda é um desafio na prática clínica.

Um dente que apresente comprometimento pulpar a ponto de necessitar de tratamento endodôntico, necessitará de um acesso endodôntico (21). Cavidades de acesso mínimo têm sido apresentadas como alternativa à cavidade de acesso endodôntico tradicional e têm sido defendidos para preservar estrutura dental , especialmente o teto da câmara pulpar e, assim, teoricamente preservar a resistência à fratura de dentes obturados (22). Clinicamente, alguns dentistas já realizam acessos minimamente invasivos na tentativa de manter estrutura dentária sadia (23).

Muitas questões relacionadas a esse tema ainda precisam ser esclarecidas. Nesse sentido, apesar da existência de um grande número de estudos sobre as lesões cervicais não cariosas e hipersensibilidade dentinária é interessante elucidar alguns aspectos de diagnóstico e tratamento em fase inicial e tardia dessas doenças.

Objetivo Geral

As lesões cervicais não cariosas e hipersensibilidade dentinária, consistem em doenças de alta relevância para odontologia. Nesse sentido, é importante entender melhor a relação da dor em dentes com LCNCs, além de propor um manejo na fase de HD e de LCNCs mais profundas que necessitem de tratamento endodôntico.

Objetivos específicos:

Objetivo específico 1

Capítulo 1 - ***A long-term evaluation of experimental potassium oxalate concentrations on dentin hypersensitivity reduction: A triple-blind randomized clinical trial***

Estudo clínico randomizado, triplo-cego e de boca dividida que objetivou avaliar a eficácia clínica, pelo período de 12 meses, da concentração experimental de oxalato de potássio (10%) no alívio da hipersensibilidade dentinária, após um protocolo de aplicação de quatro sessões.

Objetivo específico 2

Capítulo 2 - ***Can non-carious cervical lesions depth affect clinical response in pain intensity and remaining dentin thickness?***

Este estudo observacional avaliou os efeitos da profundidade e espessura da dentina em dentes com LCNCs na resposta à dor dental, quando testes de diagnóstico clínico foram aplicados.

Objetivo específico 3

Capítulo 3 – ***Conservative access in teeth with non-carious cervical lesions affects prepared canal areas and resistance***

Estudo *in vitro* que objetivou avaliar o ângulo de flexão do instrumento, a resistência à fratura dos dentes, áreas preparadas, áreas superpreparadas e não preparadas, após diferentes acessos endodônticos em dentes com LCNC.

CAPÍTULOS

1. **CAPÍTULOS**

2.1 CAPÍTULO 1

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A long-term evaluation of experimental potassium oxalate concentrations on dentin hypersensitivity reduction: A triple-blind randomized clinical trial

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A long-term evaluation of experimental potassium oxalate concentrations on dentin hypersensitivity reduction: A triple-blind randomized clinical trial

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ABSTRACT

Objective: The aim of this split-mouth, triple-blind, randomized clinical trial was to evaluate the long-term clinical efficacy of experimental potassium oxalate concentration (10%) in relieving dentin hypersensitivity (DH), after a four-session application protocol.

Methods: Potassium oxalate gels with different concentrations (5 and 10%) were randomly assigned to half of the 31 patients from the sample in a split-mouth design. The desensitizers were applied following a four-session protocol, one session every 48 h. The primary outcome was the assessment of pain level with the visual analog scale (VAS, 0–10), at baseline, immediately after each desensitizing session, and also after the seventh day and along 1-,3-, 6-, 9- and 12-months follow-ups. Statistical analyses were performed using Friedman repeated measures and Wilcoxon signed rank tests ($\alpha = 0.05$).

Results: For both groups, the minimum of three sessions were required for the achievement of lower DH levels. Regardless of the concentration, the desensitizing effect was maintained all the way to the end of the 6-month follow-up. The 10%-potassium oxalate group was more effective for both 9 and 12-months follow-up periods ($p < 0.001$). No complications and adverse effects were observed.

Conclusions: When a four-session protocol is applied, both concentrations of potassium oxalate (5 and 10%) proved to be effective on DH reduction for up to six months. However, the higher concentration promoted better long-term results.

Clinical Significance: The DH is an increasing condition in clinical practice, which affects the patient's life quality. This study provides primary clinical evidence, suggesting that multiple application sessions and higher concentrations of potassium oxalate may result in maintenance of the desensitizing effect for more extended periods.

Trial registered under number: ClinicalTrials.gov [illegible].

1. Introduction

Over the last decades, the public health strategies and technological developments have led to the improvement of individuals' quality of life and to an increase in life expectancy [1,2]. This situation, associated with the awareness of the population concerning of oral hygiene, is promoting the maintenance of natural teeth in the oral cavity for a longer period [1,2]. In addition, the reduction in the incidence of caries (due to successful oral health prevention strategies), daily stressful routine and new eating habits (acidic and industrialized products) have led patients to seek treatment for diseases that are not related to microorganisms, such as noncarious cervical lesions and dentin hypersensitivity (DH) [3].

The DH is characterized as a brief and sharp pain caused by thermal, chemical, tactile, and evaporative stimuli. To date, several data supports a theory (hydrodynamic) that these types of stimuli can induce the flow of fluids inside the dentinal tubules, which triggers receptors near the pulp (mainly A-delta fibers) and results in painful sensations for the patient [4,5]. The prevalence of DH is considerably wide in adult populations, ranging from 1.3% [6] to 92.1% [7,8] and its etiology is

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Abstract

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Keywords: dentin sensitivity, desensitizing agents, potassium oxalate, randomized clinical trial

Trial registered under number: ClinicalTrials.gov NCT03083496

Introduction

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Plenty of agents with different mechanisms of action have been described and evaluated in DH management-related literature. The dentin desensitizers can be classified, according to their action, as neural (blocking neural responses, e.g. potassium nitrate and low power lasers), tubule-blocking (obliterating the dentinal tubules, e.g. oxalates, glutaraldehyde, and high-power lasers) and, agents with both actions (e.g. potassium oxalate) [10–12].

Among the desensitizers, the potassium oxalate has been widely used in clinical practice, presenting satisfactory results, with no side effects [13–15]. This agent's mechanism of action is based on the obliteration of exposed dentin tubules (through the precipitation of calcium oxalate crystals) [16] and depolarization of the nerve endings [10]. Although a few studies have been carried out evaluating different potassium oxalate concentrations [17,18], to the best of the author's knowledge, no information is currently available regarding the long-term effect of this agent when a multiple-session protocol is applied.

The DH is a clinical condition that affects the population's quality of life [19,20]. Even though there is a large number of DH relief therapies, there is still no established protocol for an effective lasting treatment [21,22]. Therefore, this study aimed to evaluate the long-term efficacy of experimental potassium oxalate (10%) in the reduction of DH, after a four-session protocol application.

2. Materials and methods

2.1. Study design and ethics approval

This study was designed as an interventional, single-center, triple blind (operators, patients and evaluator), split-mouth randomized clinical trial. The clinical investigation was approved (protocol #108076) by the local university's ethics committee. The research protocol was also registered at clinicaltrials.gov (#NCT03083496) and carried out according to the Consolidated Standards of Reporting Trials (CONSORT) guidelines with an extension for within-person designs [23]. The research was carried out at the Non-Carious Cervical Lesions and Cervical Dentin Hypersensitivity Ambulatorial Rehabilitation Clinic of the local School of Dentistry from March 2017 to August 2018.

2.2. Recruitment and eligibility criteria

The recruitment occurred by means of a written advertisement posted at the local university's bulletin board. Patients were recruited in the order they showed up for screening, thus establishing a convenience sample. Before being enrolled in the study, all individuals were informed regarding its nature and objectives, and signed a written consent form. Participants included in this study should be at least 18 years old, in good overall and oral health, and were required to have two teeth with DH in contralateral quadrants. Teeth with dental caries, restorations or fractures were excluded.

Participants who underwent recent periodontal surgery or desensitizing treatment in the last three months and those with dental prostheses and orthodontics appliances or with symptoms of pulpitis were not included. Also, pregnant and lactating women, individuals with bruxism or any systemic/psychological disease, users of anti-inflammatory or analgesic medication, smokers, and patients undergoing tooth-whitening procedures were excluded.

2.3. Sample size calculation

The primary result obtained in this study was the DH level. A sample size calculation was performed on the website (www.sealedenvelop. com), using an alpha of 0.05 and 80%-power. Thus, the minimum sample size in this equivalence trial was 31 patients in order to detect a 30% difference in DH level between groups [24]. The sample size calculation was performed without accounting for the potential correlation coefficient between the paired treatment outcome. Published within-person trials do not report this correlation coefficient, and for this reason, the authors decided to adopt a conservative strategy.

2.4. Randomization and allocation concealment

The randomization process (simple random scheme) was carried out using computer-generated reports through www.sealedenvelope.com, which was operated by a researcher, not involved in the intervention and evaluation processes. The identification of the treatment to be applied on the right side of the patients' arches were kept concealed in sequentially-numbered, opaque and sealed envelopes, which were opened by the operator immediately before the procedures. The left side of the mouth was assigned to receive the other concentration of desensitizer. No negative control group was allowed by the ethics committee [25,26].

2.5. Blinding

This study consisted of a triple-blind clinical trial in which the patient, the operator and the and the evaluator were blinded to the group assignment. The randomization process, delivery and guidance on the administration of the gel were carried out by a researcher who was not involved neither in the application, nor the evaluation procedures. Both desensitizing gels (potassium oxalate 5 and 10%) had similar color and consistency and were delivered from identical tubes labeled as "A" and "B" so that it could not be identified by operators and patients. The coding structure was known by the research coordinator only.

2.6. Study intervention

The desensitizing procedure was carried out in all patients by one researcher with clinical experience. The desensitizers used in this study were synthesized as 5 and 10% potassium oxalate gels (Homeocenter, Ribeirão Preto, Brazil) and the protocol for the gel application was the same for both agents (Table 1). The teeth were cleaned with pumice and a rubber cup coupled in a slow-speed handpiece. The operating field was isolated with cotton rolls, suction, and a retraction cord #000 (Ultrapak, Ultradent, South Jordan) inserted into the gingival sulcus of the hypersensitive tooth. The operator placed the experimental concentration (10%) on one side of the arch, and the other side received the gel (5%). The side of the product application was randomly defined.

Each gel was applied to the cervical area of the teeth during one minute with friction movements and left undisturbed in contact with the dental structure for ten minutes. The gel was removed with a suction tip and water. Four desensitizing sessions were performed every 48 h. All participants received oral hygiene recommendations and were requested not to use desensitizing or bleaching toothpaste during the study.

2.7. Dentin hypersensitivity level assessment

An evaporative stimulus (controlled air blast), generated by a threeway syringe, was used to determine dentin hypersensitivity levels. The air was directed perpendicularly to the cervical buccal surface of the hypersensitive tooth for two seconds from a distance of 1 cm. Adjacent teeth were protected with cotton rolls to avoid false positive results. After the stimulus, the evaluator requested the participants to quantify their pain, according to a visual analog scale (VAS) [27]. The used VAS scale was a 10-cm horizontal line, where 0=no sensitivity and 10=severe sensitivity. To ensure the application of the same stimulus during the study, the three-way syringe was constantly calibrated at 25–28 psi [28] and the evaluator was previously instructed to apply the same pressure during the assessments. The efficacy of agents was measured at baseline and immediately after each application session. The participants attended appointments after one week and 1, 3, 6, 9 and 12 months from treatment and the DH levels were measured using the same previously described procedures. All measuring was carried out by the same evaluator.

2.8. Statistical analyses

Data distribution normality was checked with the KolmogorovSmirnov test. In this study, nonparametric tests were used, as the data did not present normal distribution. The analyses at different periods in each group were conducted using the Friedman repeated measures test and posthoc Tukey test. For comparisons among groups at each assessment point, the Wilcoxon sign-rank test was applied. The data analysis was performed by using the statistical software Sigma Plot version 12.0 (Systat Software Inc, San Jose, California), and the level of significance was determined as $\alpha = 0.05$.

3. Results

Thirty-one subjects were enrolled in this study, and their baseline characteristics are presented in Table 2. All participants attended the recall visits and completed the 12-month trial period (Fig. 1). For both groups, only one session was necessary to promote a significant DH reduction in comparison with the baseline. At least three sessions were required to achieve the lower levels of DH found in the study. No significant difference in the DH was observed between the groups when the number of application sessions was compared (Table 3). Regardless of potassium oxalate concentration, the desensitizing effect was maintained until the 6-month follow-up (Table 4). On the other hand, the group treated with 10% potassium oxalate showed better desensitizing effects for both 9 and 12-months timepoints when compared with 5% ($p < 0.001$) (Table 4). No complications, such as the presence of spontaneous pain and allergic reactions, were observed throughout the study.

4. Discussion

This trial was designed to evaluate the clinical behavior of a different potassium oxalate concentration in an attempt to find an effective long-term treatment for DH relief.

Oxalate-based agents were introduced as desensitizing agents between the 1970s and the 1980s [5,29–31] and since then, they have been well accepted by practitioners [32], demonstrating satisfactory results in the reduction of DH [17,30,31,33,34]. Several in vitro studies have reported significant decreases in hydraulic conductance across dentinal tubules treated with oxalates, suggesting that this kind of desensitizer limits fluid flow in exposed dentin due to their ability to promote the precipitation of insoluble calcium oxalate crystals on the surface and inside dentin tubules walls [35–37]. The oxalates can reduce more than 98% of the dentin permeability [38,39] and to promote the formation of calcium oxalate crystals 30 s after their application [31], which leads to immediate relief of DH levels [17,18]. When oxalate (oxalic acid) is associated with potassium (potassium hydroxide) [40], it becomes a combined agent, with mixed action.

Therefore, the potassium oxalate presents the capabilities of a neural as well as tubuleblocking agent in a single product. In this situation, the oxalate acts initially as a carrier, enabling the potassium to contact and promotes the depolarization of the odontoblast endings, favoring the long-term effectiveness of the agent [10].

In this study, 5 and 10% potassium oxalates were selected to be evaluated. The 5% was chosen because it is the highest concentration of potassium oxalate desensitizing gel available on the market, and the experimental 10% was tested as an attempt to improve the efficacy of this agent. Both concentrations of potassium oxalate presented a desensitizing effect until the 6-month evaluation, which can be explained by the action mechanism described above. Also, it is worthy of note that calcium oxalate crystals appear among the less soluble salts, with relative insolubility in acid and solubility almost comparable with the one of dentin hydroxyapatite [16], which makes them resistant to dissolution [16,18].

At least three sessions were necessary to achieve the lowest levels of DH in the study. Probably, only a single application may not be sufficient to induce the adequate precipitation of calcium oxalate crystals, which suggest that a multiple sessions approach might result in maintenance of the desensitizing effect for more prolonged periods [28,41,42]. Even though a four-session protocol has been applied, for 9 and 12 months timepoints, 10% potassium oxalate promoted better results when compared with 5%. The literature reported that the size and area of precipitated crystals depends on the active agent concentration, which may subsequently affect the desensitizer’s occlusive power in a long-term evaluation, supporting the results found in this study [17,30].

In order to assess the DH levels, at the baseline and follow-up sessions, an evaporative stimulus (air blast) was applied. This type of stimulus has been recommended in literature for years [26,41,43–45] and acts promoting the evaporation of the fluid from the inside the tubules and reducing the dentin surface temperature. This fact reduces the difference of pressure inside the tubule and consequently triggers the receptors in the pulp, causing the painful sensation [46]. After the stimulus, the DH level was determined using VAS. This evaluation type was employed due to being regarded as an adequate and reproducible method that is easily understood by patients [47,48]. The advantage of this method is that it consists of a continuous numerical scale with easy application, allowing the conversion of the subjective response into objective data [44].

This RCT was performed under rigorous randomization control, avoiding conscious and subconscious interventions and preventing allocation bias. Adequate blinding avoided performance and detection bias by both operators and participants. A split-mouth design was selected so that within-patient and tooth-related variables could be controlled. Within-paired designs allow the use of robust statistical methods of analysis which take advantage of repeated measures and promote a reduction in the variability within a subject [49] as each individual serves as their own control [50]. The carry-across effect is the most worrisome aspect for this type of design. For this reason, in this study, only teeth located in contralateral quadrants were included, retraction cords were used to isolate the field during the desensitizing procedure [51] and agents with great thixotropy were applied in order to avoid cross over possibilities. In addition, due to the professional application of the agents, the desensitizers' topical action, and the fact that patients can differentiate pain in both sides of the mouth, the cross over possibility were not a concern for this trial.

In this study, only one type of desensitizer (potassium oxalate) was tested. Future studies evaluating the number of application sessions with larger sample sizes for different agents and concentrations are required in order to reconfirm the findings of this study and to clarify the stability and longevity of each agent.

5. Conclusion

Within the limitations of this study and in the absence of a negative control group, it may be concluded that when a four-session protocol is applied, both 5 and 10%-potassium oxalates can be considered effective in the DH reduction for at least six months. However, the highest concentration promoted better results in the long-term evaluation.

Declaration of Competing Interest

The authors declare no conflict of interest.

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Tables

Table 1. Composition and application methods of the desensitizer agents

Agents	Composition	Application Method
5%-Potassium Oxalate	Potassium oxalate monohydrate 2.266 g; lauryl sulfate 0.299 g; glycerin 4.989 g; sorbitol 7.484; benzoate sodium 0.125; sucralose 0.050 g; aristoflex gel 36,947 g	1- Prophylaxis with an oil-free product 2- To apply the agent uniformly on the cervical region of the tooth (using a micro-applicator), rub for 10 s and wait for 10 min. 3- To remove the gel from the teeth with cotton and plenty of water
10%-Potassium Oxalate	Potassium oxalate monohydrate 5.252 g; lauryl sulfate 0.284 g; glycerin 4.972 g; sorbitol 7.090; benzoate sodium 0.118; sucralose 0.047 g; aristoflex gel 35.003 g	

Table 2. Characteristics of the participants and the distribution of teeth

Characteristic	Total
Sex	
Male	12
Female	19
Age (years)	
18-25	10
26-35	9
36-45	4
>45	8
Tooth type	Group A/B
Central incisors	3/7
Lateral incisors	4/3
Canines	3/2
First premolars	10/10
Second premolars	3/5
First molars	5/3
Second molars	3/2

Table 3. Dentin hypersensitivity levels for baseline and after each application session.

Treatment/ Assessment point	Potassium oxalate 10%		Potassium oxalate 5%		p-value**
	Mean (±SD)	Median (interquartile range)	Mean (±SD)	Median (interquartile range)	
Baseline	8.16±1.65	8 (7-10) Aa	7.93±1.73	8 (7-10) Aa	0.46
Session 1	5.03±2.54	5 (4-8) Ab	4.65±3.14	5 (2-7) Ab	0.43
Session 2	3.00±2.72	3 (0-6) Abc	3.03±3.27	2 (0-6) Abc	0.95
Session 3	1.77±2.34	1 (0-3) Acd	2.32±3.07	0 (0-5) Ac	0.45
Session 4	0.83±1.69	0 (0-2) Ad	1.80±2.82	0 (0-3) Ac	0.12
p-value*		<0.001		<0.001	

*Friedman Repeated Measures and Tukey test for comparison of pain levels between assessment points, for the same treatment group. Values followed by the same lower-case letter (columns) are statistically similar (p>0.05).

** Wilcoxon sign-rank test for comparison of pain levels between treatments groups, in each assessment point. Values followed by the same upper-case letter (lines) are statistically similar (p>0.05).

Table 4. Dentin hypersensitivity levels for each follow-up timepoint, according to each group.

Treatment/ Assessment point	Potassium oxalate 10%		Potassium oxalate 5%		p-value**
	Mean (±SD)	Median (interquartile range)	Mean (±SD)	Median (interquartile range)	
AT	0.83±1.69	0 (0-2) Aa	1.80±2.82	0 (0-3) Aa	0.12
1 week	0.90±1.70	0 (0-2) Aa	2.19±2.99	0 (0-5) Ab	0.045
1 month	1.00±1.73	0 (0-2) Aa	2.25±3.07	0 (0-5) Abc	0.074
3 months	1.01±1.73	0 (0-2) Aa	2.26±3.07	0 (0-5) Ac	0.074
6 months	1.01±1.73	0 (0-2) Aa	2.26±3.07	0 (0-5) Ac	0.074
9 months	2.74±1.21	2 (2-3) Ab	4.93±1.80	5 (4-6) Bb	<0.001
12 months	3.32±1.35	3 (2-4) Ab	6.80±1.74	7 (5-8) Bb	<0.001
p-value*		<0.001		<0.001	

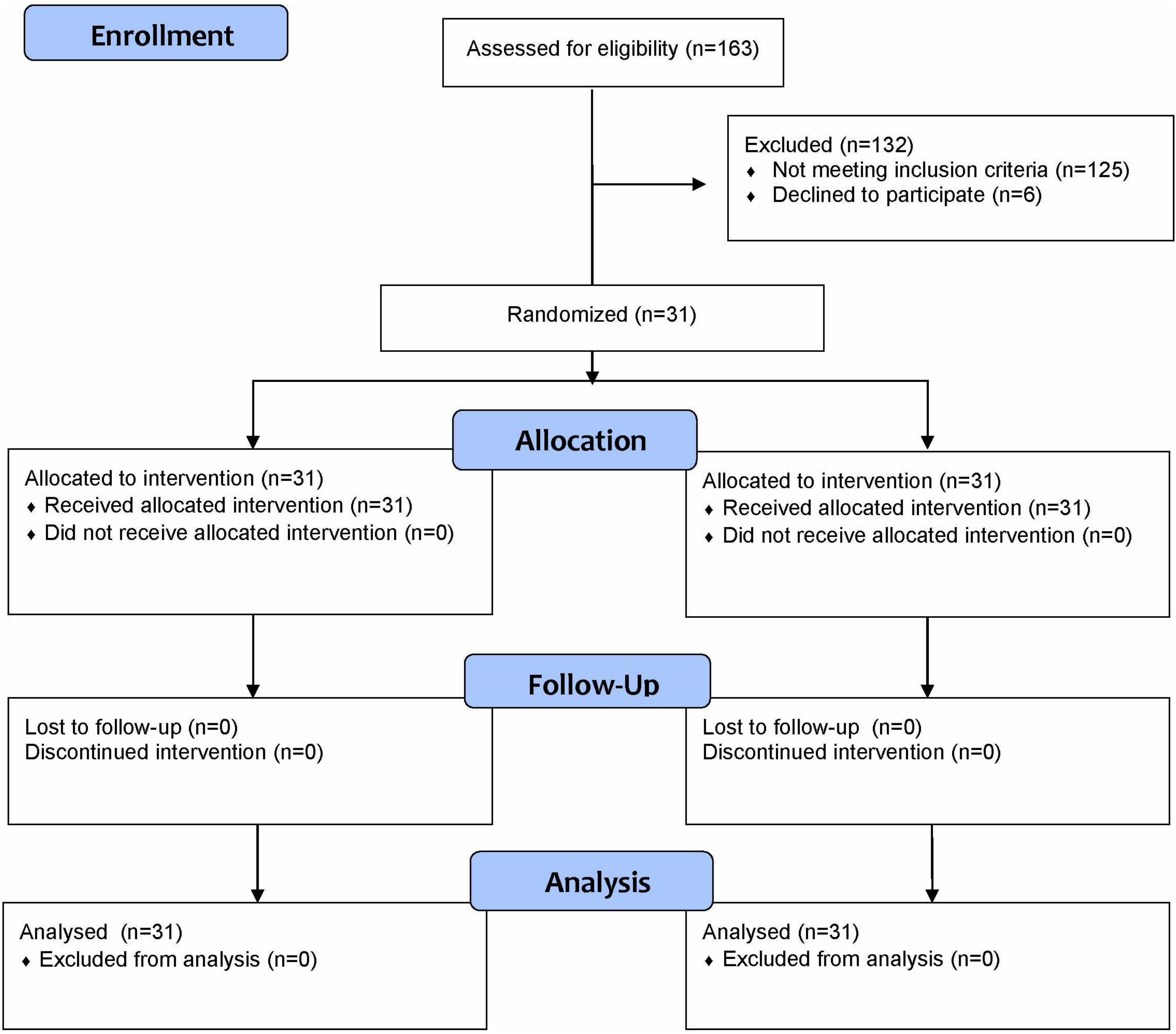
AT. Post treatment

*Friedman Repeated Measures and Tukey test for comparison of pain levels between assessment points, for the same treatment group. Values followed by the same lower-case letter (columns) are statistically similar (p>0.05).

** Wilcoxon sign-rank test for comparison of pain levels between treatments groups in each assessment point. Values followed by the same upper-case letter (lines) are statistically similar (p>0.05).

Figures

Figure 1. CONSORT flow diagram of the clinical trial.



CAPÍTULOS

2.2 CAPÍTULO 2

Artigo submetido no periódico: Brazilian Dental Journal

Can non-carious cervical lesions depth affect clinical response in pain intensity and remaining dentin thickness?

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ABSTRACT

Non-carious Cervical Lesions (NCCL) are dental tissue defects, non-related to caries, frequently observed in the dental practice. The aim of this study was to evaluate the effects of NCCL on dentin depth and thickness and the response to dental pain by means of clinical diagnostic tests. 86 teeth from 14 patients with NCCL were assessed by: depth of NCCL, clinical tests (evaporative stimulus, to detect pain levels of dentin hypersensitivity, cold thermal test to classify pulp health, percussive stimuli to evaluate the periradicular tissues and cone beam computed tomography (tomography to evaluate remaining dentin thickness (RDT). In terms of depth, the sample was divided into two groups: G1- teeth with NCCLs ≤1.0mm and G2- teeth with NCCLs between 1.1- 2.0 mm. Dental pain data were compared by Mann-Whitney test and RDT by Student's t-test and correlations by the Pearson test ($p<0.05$). The depth of NCCL does not influence dental pain response to evaporative stimulus ($p=0.129$), cold thermal test ($p = 0.125$), vertical ($p = 0.317$) and horizontal ($p = 0.119$) percussion clinical diagnostic tests. However, G1 showed more RDT ($p<0.001$), and the correlation test showed that deeper NCCL presents smaller remaining dentin thickness ($p=0.011$/$r=-0.273$). In conclusion, tooth with NCCL up to 2mm depth presents similar levels of pain for: dentin hypersensitivity, pulp and periradicular tissue independent to NCCL depth, however, lesions with ≤1.0mm-depth showed greater RDT in tomographic findings.

Keywords: Clinical Competence; Cone Beam Computed Tomography; Dental Pulp Test; Dentin Sensitivity;

INTRODUCTION

Tooth structure loss at the cementum-enamel junction that is not associated to the presence of caries has been identified as non-carious cervical lesions and has up to 46.7 % prevalence rate in adults (17, 24). Clinically, non-carious cervical lesions present in different geometries, ranging from mild depressions to large wedges or rounded forms (25). Current studies suggest that the formation and/or progression of these lesions have multifactorial etiology, the association between factors such as corrosion, friction, attrition, and abrasion, besides occlusal stress (26-28). There are involved in cervical dentin exposure and are a predisposing factor of hypersensitivity (29). Dentin hypersensitivity can be defined as a short sharp pain that arises from the exposed dentin in response to thermal, tactile, osmotic, chemical, or evaporative stimuli (6).

Currently, there are several clinical tests for dentin hypersensitivity such as an air blast, ice stick or mechanical stimulation with an exploratory probe (30). One challenge when using these tests in clinical settings is the subjectivity of individual perceptions that affect the values generated by the visual analogue scale (14). Dentin hypersensitivity is diagnosed by exclusion and in some cases, it can be misinterpreted as pain caused by pulpitis. Thus, differential diagnosis: pulp sensibility and sensitivity to percussion test are essential to identify the etiopathogenesis of cervical lesions and exclude pulp and apical commitment (16).

Many studies have suggested that periapical intraoral radiographs only present loss of structure when it achieves levels of 30 to 40% (31, 32). The detection of periapical lesions in radiographs are affected by tissue densities, X-ray angulation, location and shape of the structures, its inherent two-dimensional projection of the lesions, not exposing their full extent and depth, which may lead to treatment failure (32). Cone beam computed tomography can be a frequent imaging technology to analyze the periradicular region in three dimensions in order to overcome those limitations, without overlaps and with better image quality (32, 33).

Still, observacional studies that associate depth and pulp sensitivity are not common. Therefore, the aim of this study was to evaluate the effects of NCCL dentin depth and thickness on the response to dental pain when clinical diagnostic tests were applied.

The null hypotheses were that: 1) Non-carious cervical lesions depth does not influence dental pain response to evaporative stimulus, cold thermal test, vertical and horizontal percussion tests. 2) The depth of non-carious cervical lesions does not influence the remaining dentin thickness (RDT) by means of cone beam computed tomography.

MATERIALS AND METHODS

The Institutional Review Board of Federal University of Uberlândia (#1.301.696) approved this observational study. Registry (no. 11968), the individuals included in the study were patients in a rehabilitation program for subjects with NCCL at the School of Dentistry of the Federal University of Uberlândia and all participants signed an informed consent.

The total number of teeth included in the study was 86 (5 incisors, 9 canines, 55 premolars and 17 molars) from 14 individuals (6 to 7 teeth per subject). A statistical test was performed to make sure that the variability of the type of tooth would not influence the outcome of the study. The age ranged from 25 to 50 (means of 48) years old and most patients were older, divided among men and women. Participants included in this study, should be at least 18 years old, in good general and oral health and were required to have non-carious cervical lesions. Teeth with presence of dental caries and restorations or fractures were excluded. Participants who underwent recent periodontal surgery or desensitizing treatment in the last three months and those with dental prostheses and orthodontics apparatus, teeth with or under endodontic treatment. In addition, pregnant and lactating women, individuals with bruxism or any systemic/psychological diseases, anti-inflammatory or analgesic drug users, smokers or patients undergoing tooth-whitening procedures were also excluded. For all individuals, we performed an analysis between 6 and 7 teeth for patient.

Sample size

To measure sample size calculation, a pilot study was made, tomography scans of patients with non-carious cervical lesions was carried out. With these data, a t-test on Sigma Plot (version 12.0; Systat Software Inc, Chicago, IL, USA) was performed considering a difference between the means (0.290) and standard deviation (0.450), power of the test of 80%, and alpha of 0.005, totaling a sample calculation of 39 teeth. Thus, these data were not included in our definitive study, a total of 86 teeth was reached due to the need of achieving a minimum of 39 teeth per group, which is dependent on the number of patients.

Clinical assessments

Depths of lesions in this in vivo study were impressed with polyvinyl siloxane (PVS) elastomeric material (HydroXtreme; Coltene/Whaledent, Altstätten, Switzerland) that was inserted in the lesion to cast the lost structure (Figure 1). This was an initial measurement of the lesion following the methodology of previous studies (26, 34). Because in the first contact with the patient, there was still no CT scan. After polymerization, the cast was removed and the depth of the lesion was measured using a digital caliper (Mitutoyo 500-171-30B; Mitutoyo, Santo Amaro, Brazil) (26). According to the depth recorded, the sample (n = 86) was divided in two groups: Group 1 (G1) - teeth with NCCLs ≤1.0mm (n=41); Group 2 (G2) -teeth with NCCLs between 1.1mm - 2.0mm (n=45). The cervical region surface was observed macroscopically, all non-carious cervical lesions recognized were counted. To classify the depth, three previously calibrated evaluators visually analyzed the cast obtained in the previous assessment (24, 35). Tests were first performed on healthy teeth. The calibration was carried out using a dental mannequin (training, adjustments and calibration exercises). Then the operator classified lesions under the supervision of an experienced clinician. The calibrated operator's questions were presented to an experienced operator. Only after the calibrated operator could classify the depth. However, the allocation of teeth in the groups was confirmed by measurements performed later by tomographic images. The depth of each lesion was measured considering the distance (mm) from a vertical line drawn parallel to the cavo-superficial angle and the deepest portion of the lesion.

Each tooth was subjected to: (evaporative stimulus to detect pain levels of dentin hypersensitivity, cold thermal test to classify pulp health, vertical and horizontal percussion (to detect periradicular tissues heath). These tests were conducted by an expert examiner, other than the operator. Tests were first performed on healthy teeth. The calibration was carried out using a dental mannequin (training, adjustments and calibration exercises). Then the operator performed the tests under the supervision of the experienced clinician. The calibrated operator's questions were presented to an experienced operator. Only after the calibrated operator could perform the tests.

An evaporative stimulus (controlled air blast) generated by an air-water syringe was used to determine the tooth sensitivity level. The air jet was perpendicularly directed to the cervical buccal surface of the hypersensitive tooth for two seconds at an approximately 1 cm-distance. The adjacent teeth were protected with a polyester strip to avoid false-positive results. The operator requested the participants to rate their pain according to a 10-point visual analog scale (VAS) and the value was recorded. The recorded values were distributed according to their level: 0 – no pain; 2 – mild pain (36); 3 – moderate pain (28); 4 – severe pain (29) (Gnatus Medical-Dental Equipments, Ribeirão Preto, Brazil).

Cold thermal test was made to test pulp health, with refrigerant spray (Endo-Frost; Coltene/Whaledent, Altstätten, Switzerland) that was applied to a small cotton pellet (SS Plus, Maringá, Brazil) and placed on the middle third of the buccal surface (SSWhite Duflex, Rio de Janeiro, Brazil), for a maximum of 5 seconds or until the participant raised a hand to indicate that he or she felt a cold sensation. Then, pain level was classified as negative, positive or severe.

To test periradicular pain, vertical and horizontal percussion tests were performed. The occlusal surface of the tooth was tapped with mild force using a dental mirror handle (SSWhite Duflex, Rio de Janeiro, Brazil). The test was conducted vertically, then laterally on the incisal edges of anterior teeth and on the buccal and lingual cusps of posterior teeth (37).

Tomographic assessments

Cone beam computed tomography images were acquired in a Gendex CB-500 unit (Gendex Dental Systems, Hatfield, PA, USA) using the following parameters: 120 kV, 5 mA, 14x8 cm FOV and 0.2 mm voxel size. The images were randomly evaluated in blocks of 10 images, using CS 3D Imaging software (version 7; Carestream Health, Rochester, NY, USA), in a secluded, dimly lit room. In relation to the tomographic appraisal, although cone beam computed tomography allows examination of entire structures and provides precise dimensions, shapes and locations, when it comes to discrete conditions, its spatial resolution limits the accuracy in the range of half a millimeter at best (29), in addition to its high cost and radiation exposure that are limiting factors for its indication for this specific use. In this sense, cervical lesions are often observed in tomographic images acquired for different or supplementary purposes that often use 0.2mm voxel sizes, as well as the present study. High resolution cone beam computed tomography scans, using smaller voxel sizes, could provide better images for such small lesions, but it would not represent the common scenario in dental offices. Further studies comparing the influence of this parameter in lesions examination should be performed (38).

One evaluator, with experience in tomographic appraisal, was previously calibrated regarding tomographic aspects of non-carious cervical lesions, characteristics to be assessed and software tools that should be used during image evaluation. During these evaluations, the software's curved sling tool was used to acquire cross-sectional reconstructions along the long axis of the tooth. The inclination and definition of these reconstructions were established for each tooth along its long axis. Once the tooth/reconstruction inclination was defined, the most representative cervical lesion image (Figure 2A) was used to measure the remaining dentin thickness (RDT): the distance (mm) between the deepest portion of the lesion (internal angle of lesion) and the pulp chamber. The orientation of the linear measurements was standardized by first using the angle mode tool to generate two perpendicular lines: one line along the long axis of the tooth and another one at a 90-degree angle toward the lesion (Figure 2B). The software's linear measurement tool was used to determine RDT under the lesion by measuring the distance (along the axis perpendicular to the long axis of the tooth) from the pulp chamber to the internal angle of the lesion (Figure 2C), providing a linear measurement in mm (Figure 2D). Half of the sample was revaluated after one month to evaluate intraobserver reproducibility. Intraobserver agreement was calculated by intraclass correlation coefficients using MedCalc software, version 15.2 (MedCalc Software, Mariakerke, Belgium).

After the assessments previously described, the obtained data were analyzed at the 5% level of significance using Sigma Plot (version 12.0; Systat Software Inc, Chicago, IL, USA). An analysis of the RDT for the tooth type study factor was performed groups were compared by the Kruskal Wallis test. Data from pain level for dentin hypersensitivity, pulpal and the periradicular health in NCCL teeth from G1 and G2 groups were compared by the Mann-Whitney test. The t-test compared the RDT on G1 and G2. Then data from lesion size and RDT were correlated using the Pearson's test. Spearman correlation to correlate lesion size and pain level of dentin hypersensitivity. were considered statistically significant (P-values of <0.05).

RESULTS

Regarding the variability of the types of teeth in the study, the statistical test showed no difference between the tooth types considering the RDT (p=0.902). The results of the hypersensitivity clinical tests for vertical and horizontal percussion, cold sensitivity test, are described in figure 3. The average of the RDT values according to the depth of the lesion are described in table 1.

Depth of lesion did not influence the evaluations of hypersensitivity (p=0.129), cold thermal test (p=0.125), horizontal (p=0.119) or vertical percussion (p=0.317). There was no correlation between lesion depth and pain level for sensitivity (p=0.089/r=0.184) (Figure 4).

The depth of the lesion influenced the RDT (p<0.001), with the G2 (1.627 ± 0.312 mm) group having a lower RDT compared to G1 (1.922 ± 0.459 mm) (Table 1). There was a negative correlation between the depth of the lesions and the RDT (p=0.011/r=-0.273) (Figure 4). So the first hypothesis was accepted. The second was rejected since the remaining dentin was influenced by the depth of the lesion.

DISCUSSION

Exposed dentin in the oral cavity, as in teeth with non-carious cervical lesions, subjects dentin tubules to chemical, mechanical and thermal stimuli (39). These exposed tubules filled with fluid may change after exposure to stimuli and activate intra-dental nerve fibers, via a mechanoreceptor response, causing pain (8). Dentin exposure irritates dental pulp, which causes pulp nerves to release neuropeptides that in turn produce local inflammation (40), a mechanism that can explain why most of teeth in the present study, regardless of group, presented an exacerbated response for pain on the pulp health test (more than 70%).

The response of dental pulp to stimuli increases not only because dentin tubules are exposed but also because inflammatory mediators are present (41). Teeth that do not have hypersensitivity present lower levels of inflammation, whereas teeth with hypersensitivity have a reduction in the activation threshold and an increase in the innervated area of the dentinal tubules (42). However, the present study did not show a relationship between the degree of pain detected in the pulp sensitivity test and the level of dentin hypersensitivity reported in hypersensitivity test. The results of the present study suggest that inflammation was limited to the dental pulp tissue since pain was not elicited by the percussion tests in either of the groups (G1 and G2). Worn dentition is rarely sensitive if occurring over many years, whereas rapid wear in a young adult is often sensitive (19). This may explain the level of dentinal hypersensitivity both groups had; mostly absent or mild pain level. Despite of the patients' age ranged from 25 to 50 years old, in this research the patient's age means was 48-year-old and most patients were above 48.

Non-carious cervical lesions depth did not influence the degree of dental pulp sensitivity in the present study. This is probably because pulp tissue inflammation was similar given that both groups suffered from exposed dentin, continuous infiltration and bacterial penetration through unsealed dentin tubules (20). After external stimuli the tooth presented dentin sclerosis formation (19). Teeth without painful levels exhibit more occluded tubules (43). The result is formation of sclerotic dentine or of dead tracts and underlying ''secondary'' reparative dentine formation (44). It could have been expected that teeth with greater loss of structure could also present greater deposition of reparative dentine, with a consequent reduction in the volume of the pulp chamber. However, in our study, the thickness of the remaining dentin was inversely correlated with the depth of the lesion. As previously described, sclerotic dentine consists of many tubules that are completely filled with a material similar to the one of peritubular dentin, but that the capacity and speed of the repair processes depend on factors such as age, which can hinder or increase the dentin deposition capacity (44, 45). In group G2 smaller remaining dentin thickness was observed, indicating that the repair capacity of the pulp in terms of dentin thickness is smaller than the loss of structure that occurs in teeth with NCCL. Although deeper non-carious cervical lesions are closer to the pulp, dentin hypersensitivity levels may also have been influenced by the quality of the dentin formed (19), leading to a similar pain level presented by teeth with shallower lesions

The significant differences observed in the present study are an isolated consequence of the depth of the NCCL and is not a consequence of the anatomical variation among different teeth, as presents in results section, with this analysis it is possible to confirm that data of the study are reliable. Limitations were present in present study, first the wide age range of patients and even individual characteristics that could influence the different levels of pain sensation (subjective) and quality of dentin deposition. Furthermore, it was not possible to standardize or determine the time of non-carious cervical lesions formation or the supporting factors of cervical lesions in each individual. However, the literature shows that the process of dental aging is not just associated to age. This process is affected by multiple factors, such as lifestyle, environment and genetics. These changes can be considered as diseases, such like(as) non-carious cervical lesions (46). Thus, we understand that although the age difference, teeth with non-carious cervical lesions are in an aging process independent of the individual's age. Other limitation were the etiological factors, such as, age, sex, oral hygiene behavior, type of saliva, diet, brushing force, status of periodontium, number of teeth, occlusion, occlusion contact area, occlusal corrosion and attrition, severity of gastroesophageal diseases (26, 47). Was not possible to control all these etiological factors due to the particularity of each patient, to minimize patient factor we insert in our study the largest number of teeth in a single patient and insert some inclusion criteria.

For future studies, there is a need to clinically investigate cervical lesions with greater depths, standardized ages and associated individual etiological factors. This study shows that teeth with a depth of non-cervical lesions up to 2mm do not show differences in pulp or periradicular response in clinical diagnostic tests. Furthermore, cone beam computed tomography assessment indicated that the RDT is related to the depth of the lesion. A better understanding of non-carious cervical lesions signs and symptoms will lead to better diagnosis and treatment planning, improving patients' quality of life and professional clinical practice.

In relation to the tomographic appraisal, although cone beam computed tomography allows examination of entire structures and provides precise dimensions, shapes and locations, its high cost and radiation exposure are limiting factors for its indication for this specific use. In this sense, cervical lesions are often observed in tomographic images acquired for different or supplementary purposes that generally use 0.2mm voxel sizes, as well as the present study.

High resolution cone beam computed tomography scans, using smaller voxel sizes, could provide better images for such small lesions, but it would not represent the most common scenario in dental offices. Further studies comparing the influence of this parameter in lesions examination should be performed.

For future studies there is a need to clinically study non-carious cervical lesions with higher depths, with standardization of age and associated individual etiological factors. This study shows that teeth with non-carious cervical lesions depth up to 2mm did not show differences in pulp or periradicular response in clinical diagnostic tests. Furthermore, the tomography assessment of the remaining dentin thickness is related to the depth of the lesion. A better understanding of the signs and symptoms of non-carious cervical lesions will lead to better diagnosis and treatment planning, improving patients' quality of life and professional clinical practice.

CONCLUSION

Within the limitations of this observational study, it was concluded that the depth of non-carious cervical lesions between 0.1 and 2mm neither affect clinical response in dentin hypersensitivity intensity nor the pulp, and periradicular health condition. However, lesions with ≤1.0mm in-depth showed more remaining dentin thickness in the tomographic findings.

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FIGURES

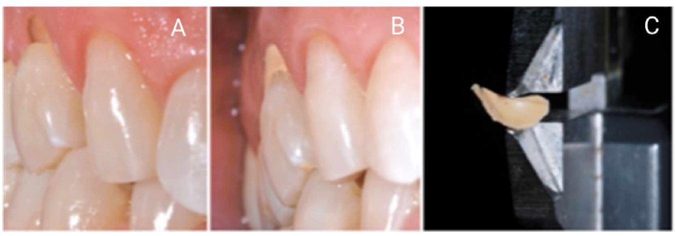


Figure 1- A- NCCL identification; B- Addition silicone lesion molding, resuming the lost tooth structure; C- Measured with a caliper to identify the depth of the lost tooth structure (NCCL)

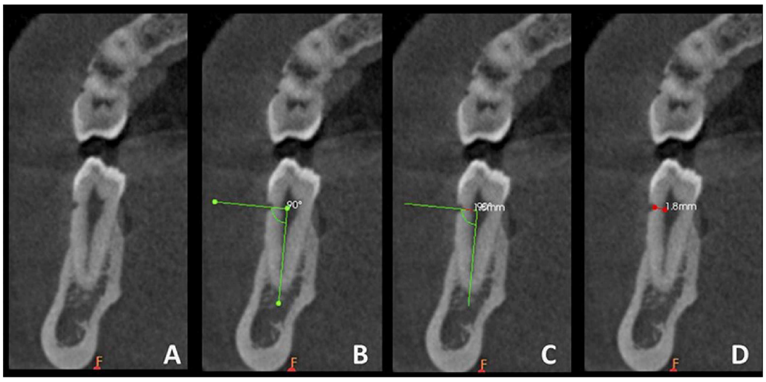
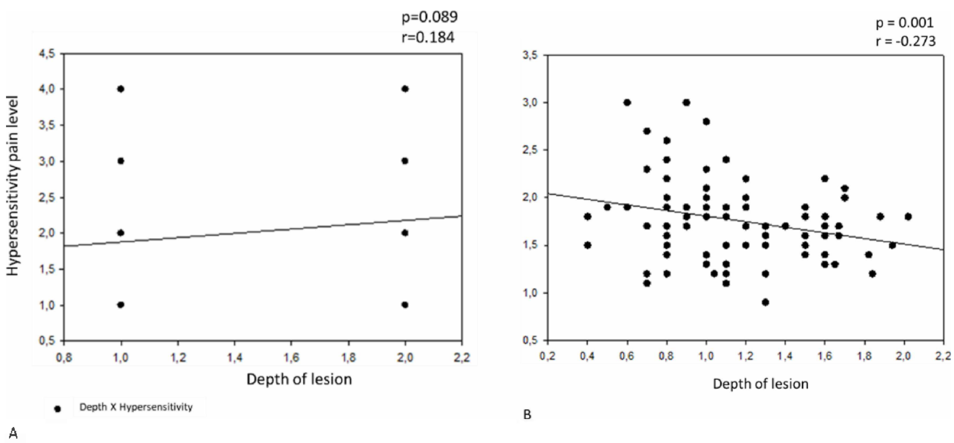


Figure 2. RDT measurement: A -Selection of the most representative NCCL image cross-sectional reconstruction; B- definition of the guidelines (green lines); C- superimposition of the linear measurement tool; D- final linear measurement (red line) of the distance from the pulp chamber to the internal angle of the lesion

Figure 3. Dental pain response (%) to clinical diagnostic tests according to the group: A- Percentage of DH levels according to VAS; B- Findings to pulp health test (cold); C- Horizontal percussion response; D- Vertical percussion response.

Figure 4. Correlation between lesion depth and pain level for hypersensitivity and depth of the lesions and the RDT.



A- Spearman's correlation between lesion depth and pain level for hypersensitivity;
B- Pearson's correlation depth of the lesions and the RDT.

TABLE

Table 1. Average of the RDT values according to the depth of the lesion

	G1 (≤ 1.0)	G2 (≥1.1 - ≤ 2.0)
RDT	1,922 ± 0,459	1,627 ± 0,312
p value	<0.001	

T- test ($p<0.05$).

CAPÍTULOS

2.3. CAPÍTULO 3

Artigo será submetido ao periódico Journal of Esthetic and Restorative Dentistry

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Conservative access in teeth with non-carious cervical lesions affects prepared canal areas and resistance

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Abstract

Objective: To evaluate the flexion angle of the file (FAF), prepared, unprepared, and over prepared in different thirds of teeth with a non-carious cervical lesion (NCCL), beyond fracture resistance (FR) in different endodontic access. Materials and methods: Twenty mandibular incisors were divided into two groups (n=10): Teeth with NCCL prepared with traditional access cavity (TradAC) or conservative endodontic access through the lesion (AA). The Image J software evaluated the areas using two radiographic incidences – mesiodistal (MD) and buccolingual (BL), before and after canal prepare with reciprocating files, after filled and restored specimes were then loaded to fracture in a mechanical material testing machine. The data were analyzed with proper statistical tests (α <0.05). Results: The TradAC resulted in more prepared area at the middle third (MD/BL), which was also similar for AA in coronal (BL) (p <0.001). Over prepared areas, were the most affected regions at the middle third (MD), coronal third (MD/BL) (p <0.001), and AA showed more over prepared areas than TradAC (BL). The AA presented more unprepared areas in the coronal third than TradAC (MD) (p <0.001) and the apical third presented the least (MD/BL). The AA presented higher FAF and showed the highest FR values than TradAC (p<0.001). Conclusions: TradAC in teeth with NCCL can result in a more FAF, over prepared showed worse instrumentation in middle third (MD/BL) than TradAC, but the teeth became more resistant to fracture. Clinical significance: AA in teeth with NCCL is less safe and effective when using automated instrumentation, but it improves dental fracture strength.

Keywords: root canal preparation, digital radiograph, fracture resistance, conservative access

Introduction

Access is consider an essential step of the endodontic therapy, usually traditional access cavity (TradAC) (1). This access purpose the removal of caries and restorations, maintaining the healthy structure of the tooth. The shape of the access cavity is defined by the morphology of the individual pulp chamber of the tooth to be treated. The roof of the pulp chamber is completely removed in order to find all orifices of the root canals (2, 3).

The advanced in the field of imaging, materials, instruments, and computers has considerably transformed dental practice. Some of the progress in the endodontic practice that make possible to preserve dentin tissue include, flexible instruments (4), visual magnification, superior illumination, enhanced root canal irrigation systems (5, 6), and three-dimensional imaging technology [cone beam computed tomography (CBCT) (7). Less invasive endodontic access used by endodontists has challenged the conventional approach and could conserve structure and decrease the possibilities of tooth fracture and loss after root canal treatment (8).

Currently, the profile of patients referred to endodontic treatment has not been exclusively due to caries lesions, but also non-carious cervical lesions (NCCL), which are described by the loss of hard tissue at the cemento-enamel junction without caries presence, commonly found in patients (9). It is frequently accepted that the initial and progression of NCCL present a multifactorial etiology and they could be caused by the association of factors such as corrosion, friction, attrition, abrasion, and occlusal trauma (10). There are findings of associations between occurrences of NCCL and tooth wear, this trauma could be intimately related to pulp condition (11).

The NCCL exposes the dentinal tubules, and the microorganisms through reach the tubules of pulp may cause damage and pulp degenerate, which makes an endodontic intervention necessary (12, 13). However, TradAC design removes more healthy dentine tissue, which may decrease fracture resistance (14). The purpose of this in vitro study was to evaluate the flexion angle of the instrument, the fracture resistance of the teeth, prepared areas, over prepared and the unprepared areas, after different endodontic access in teeth with NCCL. The null hypothesis is that the endodontic access does not affect the preparation of dental thirds, flexion angle of the file, and fracture strength in teeth with NCCL.

Materials and Methods

Sample selection

After the study was approved by the ethics committee (02019618.2.0000.5152), a total of Twenty single-rooted human mandibular incisors extracted for reasons not related to this study, with totally formed apices and intact crowns, were selected using periapical radiographs. Teeth were selected following inclusion criteria: straight and fully formed root with single root canal and similar general dimensions related to length and pulp chamber dimensions. These samples were cleaned, maintained in a 0.9% saline solution at 4 °C and used within 6 months after extraction.

Endodontic access cavities preparation

All the procedures (access, preparation of canal, filling and restoration) were realized by a single endodontic specialist. NCCL were simulated with a 3118 diamond bur (KG Sorensen, São Paulo, Brazil) measuring approximately 2.5 mm in depth and 2.5 mm of mesiodistal opening, with the center located at the cemento-enamel junction (9). Later, 20 teeth were randomly selected (n=10). The sample size calculation was based on a previous study (14), at alpha=0.05, beta=0.2, and 90% study power (2-sided test), with fracture resistance as the primary outcome. The calculation was performed using the statistical software package Sigma Plot (version 12.0; Systat Software Inc, Chicago, IL, USA).

For TradAC first, the NCCL was restored with selective etching using 35% phosphoric acid for 15 seconds e (Ultradent Products Inc, South Jordan, UT, USA) and a self-etching adhesive system (Scotch Bond Universal, 3M ESPE) for hybridization. The composite resin (Filtek Z350 XT body, A2 Shade, 3M ESPE) was inserted in 2.0-mm increments, photoactivated for 20 seconds using an LED curing unit (Radii-Call SDI).

After the restoration of the NCCL, TradAC were prepared with high-speed diamond burs 1011 (KG Sorensen, Sao Paulo, SP, Brazil) and endo Z (Dentsply Sirona Endodontics, Ballaigues, Switzerland); following conventional guidelines already described in the literature (60). The primary point of entry was the lingual surface of the crown, 1 mm upward the cingulum. The cavity was extended until the complete removal of the pulp chamber roof. Thus, establishing direct access to the root canal.

Alternative endodontic access through NCCL (AA), in this conservative access were performed through the NCCL, without restore NCCL region. One single operator performed the entire endodontic access with high-speed diamond burs 1011 (KG Sorensen, Sao Paulo, SP, Brazil). The primary point of entry was 4 mm, above the cemento enamel junction. The cavity was not extended, preserving part of the pulp chamber roof, maintaining direct access to the root canal.

Initially root canals in both access were explored with a size 10 K-file (Dentsply Sirona Endodontics, Ballaigues, Switzerland) until its tip was visualized at the apical foramen, and the working length (WL) was established 1.0 mm shorter. Three digital periapical radiographs were taken using the phosphor plate (Dental Durr, Biertigheim-Bissingen, Germany) for each sample: without access, after canal preparation, and with an automated file into the root canal (Wave One Gold 25.07 and 30.06; Dentsply Sirona Endodontics, Ballaigues, Switzerland) after the prepare. Radiographs were taken in two directions - MD (mesiodistal) and BL (buccolingual) - according to the methodology of a previous study (17).

These teeth were instrumented with reciprocating sequence file Wave One Gold (25.07 and 30.06; Dentsply Sirona Endodontics, Ballaigues, Switzerland), following the manufacturer's instructions. An X-Smart plus motor (Dentsply Sirona Endodontics, Ballaigues, Switzerland) was used to passively insert the file into the root canal. Each instrument was used in a single tooth and then discarded. The irrigation was executed after each instrument insertion, with 2 mL 2.5% sodium hypochlorite (NaOCl), with 30-G Endo-Eze needles (Ultradent Products Inc., South Jordan, UT, USA) inserted up to 2 mm from the WL. The final irrigation was performed with 5 mL of 2.5% NaOCl followed by 5 mL of 17% EDTA for 1 min and another 5 mL of 2.5% NaOCl.

Afterwards, the teeth were filled using the single cone technique, AH Plus sealer (Dentsply Sirona Endodontics, Ballaigues, Switzerland) was used, gutta-percha cones (Dentsply Sirona Endodontics, Ballaigues, Switzerland) size 30.06 taper was used. After these each pulp chamber was cleaned, the filling material remnants were removed with the heated condensers and cotton pellets soaked in 70% alcohol. All the samples were etched with 37% phosphoric acid (Ultradent Products Inc, South Jordan, UT, USA), rinsed for 30 s with water and gently air-dried. Then, 2 layers of adhesive (Scotch Bond Universal, 3M ESPE) were applied by a light jet of air and then polymerized for 20 s using an LED device (Radii-cal; SDI, Bayswater, Australia). Subsequently, increments of up to 2-mm-thick composite resin (Z350 XT; 3M ESPE, Sumare, SP, Brazil) were applied and each of these was polymerized for 20 s. Finally, the teeth were stored in a 0.9% saline solution for one week until the fracture resistance test.

To standardize these positions of samples during all radiographs, a silicone mold (Panasil, Kettenbach, Eschenburg, Germany) was positioned into an acrylic resin cylinder device. The radiographs were taken in the BL and MD positions. All measurements were performed using image processing and analysis software (ImageJ, Oracle Corporation, California, USA). The flexion angle of the file and areas were measured at the BL and MD positions. Were analyzed prepared, unprepared, over-prepared. Each tooth was divided into three thirds for analysis of the coronal, middle, and apical regions (Figure 1). In analyzed areas, a wall contour was digitally marked with lines and filled with yellow, red, orange, and green colors. Standardization was performed in the PowerPoint software to verify the size of the radiographs (Figure 1) (Microsoft, New Mexico, USA) (17). The flexion angle was measured with a line following the long axis of the canal, considering its trajectory without curvature interference, and another line following the point toward the end of the file. The angle formed between these two lines is the flexion angle (Figure 2).

Load at fracture

The specimens were mounted up to 2 mm apical to the cementoenamel junction in a customized cylinder fabricated with self-curing resin (JET; Classico, Campo Limpo Paulista, Brazil) as reported in a previous study (18). The specimens were fixed in a device (Odeme, Luzerna, Brazil) coupled to the bottom of the universal testing machine simulating the angle of 135° that is clinically formed by contact between the maxillary and mandibular central incisors in a Class I occlusal relationship (EMIC DL2000; EMIC, Sao José dos Pinhais, Brazil) and received a load on the incisal surface. A continuous compressive force was applied with a cylindrical crosshead at 1 mm min^{-1} until failure occurred. The load at fracture was recorded in newtons (N).The fracture mode was determined using modifications of the classification proposed by Santos-Filho: I - crown fracture and II - root-and-crown fracture involvement (19).

The data of the areas were verified by equal variance and Shapiro Wilk normality test and then the different thirds in each group were analyzed using Two-Way Repeated Measures ANOVA (2-way RM ANOVA) and post hoc Tukey's test. The Student T-test was applied to compare the groups for flexion angle and fracture strength. The failure mode was analyzed by Fisher's Exact Test. Data analysis was performed using the statistical software Sigma Plot, version 12.0 (Systat Software Inc, San Jose, California), and the level of significance was determined at $\alpha = 0.05$.

Results

The means and standard deviations of the prepared area (Table 1) showed a statistical difference in the BL position for the AA to the coronal and middle thirds (p= interaction *0.015). Other areas were prepared with AA in the coronal third (BL) and TradAC in the middle third (BL and MD). Both access were prepared similarly in the apical region.

As for the over prepared areas (Table 2), AA showed a higher over prepared areas than TradAC (p = 0.044) in the BL radiographic position. The MD position showed no statistically significant difference (p= 0.219). The coronal (p<0.001) and middle (p<0.001) thirds were the most affected areas in both positions.

Regarding the unprepared area (Table 3), the BL position showed a statistically significant difference in all thirds in both groups (p <0.001). For the MD position, there was an interaction difference between the access and the coronal third in the AA group (p= interaction *<0.001). The AA presented, in the coronary third, more unprepared areas (p <0.001) (MD). Additionally, for both groups, the apical third was the least unprepared area (BL and MD).

Moreover, the flexion angle showed a statistical difference between the groups in both positions. The AA presented a higher flexion angle than TradAC (Table 4) but AA showed the highest fracture strength (p<0.001) (Figure 3). There was no statistical association (p = 0.057) between failure mode and endodontic access (Table 5).

Discussion

One of the most important causes of fractures in root-filled teeth is the loss of tooth structure and the amount of remaining tooth structure and strength of the final coronal restoration (20). The preparation of the endodontic access cavity following the TradAC principals was reported as the second largest cause of loss of tooth structure (21). Thus, a proper and reduced endodontic access design could improve the prognosis for an endodontically treated tooth (22). Attempts are ongoing to offer more conservative access cavity designs: include the contracted design, the truss design, and the ninja design. These designs have been proposed to enhance the fracture strength of endodontically treated teeth and decrease the dependence of the tooth on complex and high-cost postendodontic restorations, as well as the conservative access proposed by this study (1, 23).

The progress of NCCL may cause endodontic commitment and currently, any protocols have been developed for conservative endodontics in NCCL teeth (24). According to results, first and second hypotheses were rejected, consider that AA cannot prepare root thirds effectively. Furthermore, there was more over prepared areas, especially in the coronal and middle thirds, and AA presented a larger flexion angle than TradAC. The last hypothesis was rejected, once endodontic access affects fracture strength.

The conservative AA promotes a major flexion angle of the file and it presents more prepare areas in lingual region of canal at the middle third (Figure 2-B). When compare prepared areas, there was an interaction between thirds and the access. TradAC prepare better at the middle third due to flexion angle, files touch the walls of this region more regular. In turn, the AA presented a larger flexion angle and the coronal and middle thirds presented more wear. The file contact occurs only on the buccal wall in the coronary and middle thirds, so the possibility to contact the other wall is reduced in the BL position. Opposed, the apical region did not show a higher deviation, probably because this region has a diameter similar to the file. Furthermore, this automated file is sufficiently flexible to return to the primary root canal.

Oval anatomy supports the unprepared areas in the TradAC, considering that 59.6% to 79.9% of root canals remained unprepared (25). Similar, AA presented in coronal third, more unprepared areas (MD). The file contacts a small portion of the dentin walls in this third, as shown in figure 2A, but both groups presented critical unprepared areas. In TradAC file can contact the center of the canal, providing better instrumentation, but it may result in areas with untouched permanent irregularities (26). Files in root canals are subject to flexion, as seen in the results for both positions. After canal preparation, the file presents a new position. The force vectors presented by the flexion angle of the files during instrumentation cause deviation (17). According to the results, group AA presented a greater flexion angle on both radiographic positions during the instrumentation process, which leads to increased deviations (27). Therefore, the curvature angle of the file in group AA potentially generated higher stress and an easier file fracture. Cyclic fatigue may be more frequent in automated instruments, and there is a bending point in which the metal is stressed at the outer portion and compressed at the inner portion, simultaneously (28).

Neither access was able to clean the entire root canal and studies have shown, there is no instrument or technique currently available capable of cleaning and disinfecting the entire root canal system (29). Moreover, it is not possible to remove all debris from the canal, especially in oval canals (13). Success could be affected by the treatment type, especially when perform AA access, once conservative access cavities have been shown to negatively affect the angle of entry of the instrument in the canal (31). In this technique, prepared areas reduce drastically in the coronal third and might affect clinical prognosis, to optimize irrigant action in unprepared areas, ultrasonic tips, and active files such as XP finisher and Easy clean are used (32, 33).

The results of the present study are in agreement and corroborate reports that showed improved fracture strength of teeth because of dentin preservation obtained by conservative cavity (34-35). Some articles reported that endodontic conservative cavity improved the fracture strength of teeth in comparison with the ones accessed by a TradAC, allowing residual dentin preservation (8, 18). These contrasting findings could be related to differences in the methodologic design including the type of teeth considered, type of access, the use of restoration, and the type of material used for restorative procedures and methodologic issues related to the design of the fracture test.

Imaging technologies in endodontics have advanced, therefore several methods have been used in endodontic research, using radiographs, conventional computed tomography (37, 81), and micro-computed tomography (micro-CT) (33). The phosphor plate methodology has been extensively used, as it is effective and respects the quality aspect (7). Although limited to a 2D view, in this study digital radiographs were performed in two radiographic positions for better evaluation, this is one of the limitations of this study.

Conclusions

Within the limitations of this study, it can be concluded that AA access in NCCL tooth can result in more flexion angle of automated file, over prepared and unprepared areas. Moreover, this technique shows the worst performance to instrumentation on tooth areas than TradAC access, especially in middle third. In this way, alternative canal access in NCCL tooth is less safe and effective when using automated instrumentation, but the tooth is more resistant to fracture.

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Tables

Table 1. Mean and standard deviation (mm²) for the tooth thirds analyzed in the instrumentation within the canal limits in the BL and MD positions.

Radiograph position	Access	Coronal	Middle	Apical
BL	AA	3.12 ± 0.95 Ab	4.38 ± 1.16 Ba	2.06 ± 1.07 Ab
	CA	2.13 ± 0.81 Bb	5.34 ± 0.88 Aa	1.57 ± 0.65 Ab
MD	AA	2.76 ± 1.51 Aa	3.80 ± 2.02 Ba	2.942 ± 1.16 Aa
	CA	2.86 ± 0.37 Ab	5.86 ± 1.78 Aa	2.19 ± 1.69 Ab

Means followed by different uppercase letters in the columns (compare access in different radiograph positions) and lowercase letters in the rows (compare tooth thirds) are significantly different; Two-Way RM ANOVA ($p < 0.05$).

Table 2. Mean and standard deviation (mm^2) for tooth thirds analyzed in the instrumentation outside the canal limits in the BL and MD positions.

Radiograph position	Access	Coronal	Middle	Apical
BL	AA	1.08 ± 0.75 Aa	1.20 ± 0.93 Aa	0.31 ± 0.26 Ab
	TradAC	0.43 ± 0.30 Ba	0.69 ± 0.38 Ba	0.28 ± 0.42 Bb
MD	AA	1.13 ± 1.08 Aab	1.57± 1.06 Aa	0.67 ± 0.61 Ab
	TradAC	0.58 ± 0.40 Aab	1.05 ± 0.55 Aa	0.34 ± 0.35 Ab

Means followed by different uppercase letters in the columns (compare access in different radiograph positions) and lowercase letters in the rows (compare tooth thirds) are significantly different; Two-Way RM ANOVA ($p < 0.05$).

Table 3. Mean and standard deviation (mm^2) for tooth thirds analyzed in the non-instrumentation of canal limits in the BL and MD positions.

Radiograph position	Access	Coronal	Middle	Apical
BL	AA	2.02 ± 1.38 Aa	2.02 ± 0.98 Ab	0.48 ± 0.45 Ac
	TradAC	0.78 ± 0.22 Aa	1.86 ± 0.98 Ab	0.54 ± 0.49 Ac
MD	AA	3.90 ± 2.15 Aa	3.09 ± 1.20 Aa	0.98 ± 1.25 Ab
	TradAC	1.12 ± 0.29 Bb	2.44 ± 0.94 Aa	1.13 ± 1.17 Ab

Means followed by different uppercase letters in the columns (compare access in different radiograph positions) and lowercase letters in the rows (compare tooth thirds) are significantly different; Two-Way RM ANOVA ($p < 0.05$).

Figures

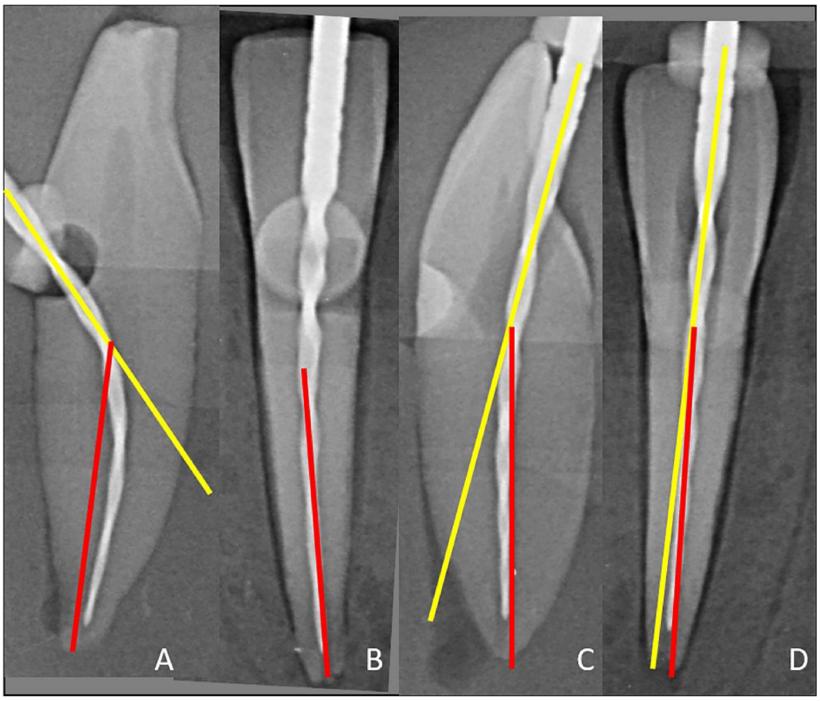

Figure 1. Flexion angles of the MD position (A, C) of the files in groups AA (A) and CA (C). Flexion angles of the BL position of the files (B, D) in groups AA (A) and CA (C). *The red line represents the long axis of the canal and the yellow one is the direction of the file*

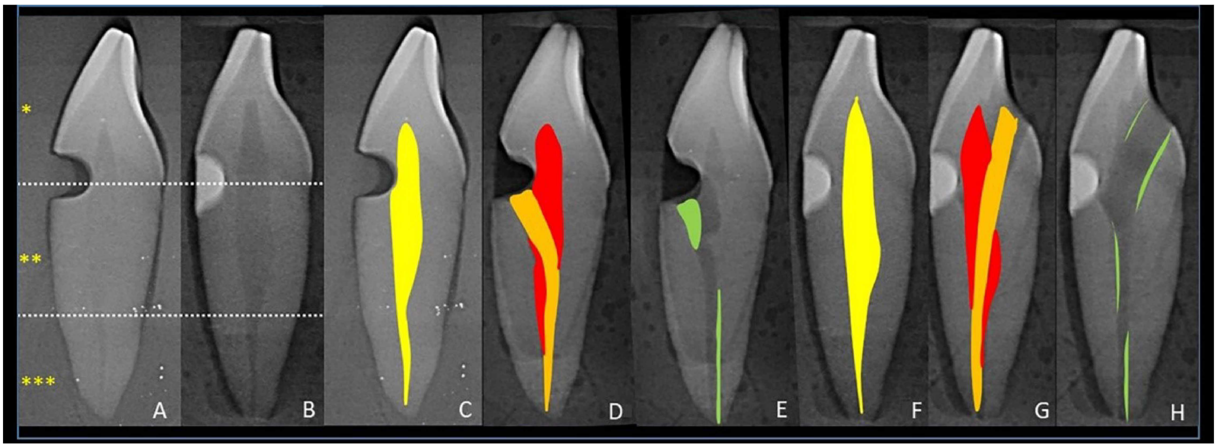

Figure 2. Representative image of the MD position of the tooth. Division of the thirds in both groups (A, B), * coronal, ** middle, and *** apical third. The yellow color represents the canal area before instrumentation (C, F). Instrumented area (orange- D, G), non-instrumented area (red- D, G), prepared outside the canal limits (green- E, F) in CA (C-E), and TradAC (F-H) groups.

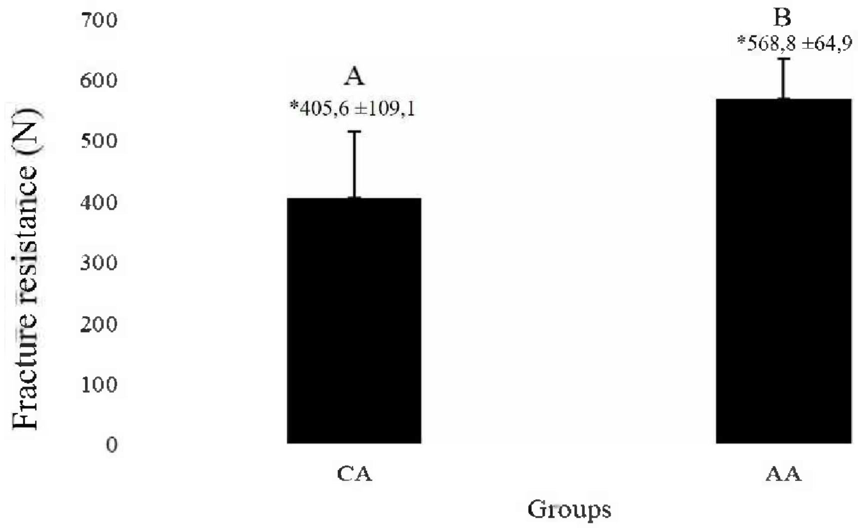

Figure 3. Fracture strength values (N) of the teeth with different endodontic access; *Mean ± standard deviation. Student T-test ($p<0.05$)

CONCLUSÕES

3. CONCLUSÕES

De acordo com os delineamentos experimentais propostos e metodologias utilizadas, pode-se concluir que:

- **Capítulo 1:** Quando aplicado um protocolo de quatro sessões, ambas as concentrações de oxalato de potássio (5 e 10%) mostraram-se eficazes na redução da HD por até seis meses. No entanto, a maior concentração promoveu melhores resultados a longo prazo.

- **Capítulo 2:** A profundidade das lesões cervicais não cariosas entre 0,1 e 2mm não afeta a resposta clínica na intensidade da hipersensibilidade dentinária da polpa e condição de saúde perirradicular. No entanto, lesões com ≤1,0mm de profundidade apresentaram maior espessura de dentina remanescente nos achados tomográficos.

- **Capítulo 3:** O acesso alternativo no dente LCNC pode resultar em maior ângulo de flexão da lima automatizada, sobre áreas preparadas e não preparadas. Além disso, esta técnica apresenta o pior desempenho para instrumentação em áreas dentárias do que o acesso tradicional, principalmente no terço médio. Desta forma, o acesso alternativo ao canal no dente NCCL é menos seguro e eficaz quando se utiliza instrumentação automatizada, mas o dente é mais resistente à fratura.

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RERERÊNCIAS

4. REFERÊNCIAS

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