

Modern supplementary strategies of filling material removal in non-surgical root canal retreatment

Estratégias complementares modernas de remoção de material obturador no retratamento não cirúrgico do canal radicular

Modernas estrategias complementarias de remoción de material de obturación en el retratamiento no quirúrgico del conducto radicular

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Abstract

Non-surgical retreatment is currently the most affected therapy in Endodontics in terms of clinical outcome. The present study aims to evaluate modern strategies for supplementary approaches in filling material removal. A narrative literature review was conducted in PubMed, Cochrane Library and Web of Science databases with the following keywords in different orders: “root canal”, “filling material removal”, “non-surgical retreatment” and “supplementary”. For the studies selection outline, after titles screening, removal of duplicates and inclusion criteria was applied, followed by analyses of abstract, and finally full-text review was performed for final selection of studies. Further research was conducted manually on demand. Six types of cleaning strategies were identified in the literature for supplementary approach in non-surgical retreatment: Passive ultrasonic & sonic activation, active ultrasonic activation, plastic instruments for mechanical agitation, metallic instruments for mechanical agitation, multisonic activation and laser activation. Those addressed in the literature have mainly been associated with higher performances of filling material removal compared to instrumentation systems only. However, none of them were able to completely remove filling material within the root canal system. Randomized controlled clinical studies are needed to understand the real influence of these strategies on the non-surgical retreatment. There is a notable discrepancy between the volume of studies for each strategy, more studies are needed in certain systems already covered. There are still systems for activating irrigation solutions not covered in non-surgical retreatment.

Keywords: Root canal; Filling material removal; Non-surgical retreatment.

Resumo

O retratamento não cirúrgico é atualmente a terapia mais afetada na Endodontia em termos de desfecho clínico. O presente estudo tem como objetivo avaliar estratégias modernas para abordagens complementares na remoção de material de obturador. Assim foi realizada uma revisão narrativa da literatura nas bases de dados PubMed, Cochrane Library e Web of Science com as seguintes palavras-chave em diferentes ordens: “root canal”, “filling material removal”, “non-surgical retreatment” e “supplementary”. Para o delineamento da seleção de estudos, após a triagem dos títulos, foi realizada a retirada das duplicatas e aplicados os critérios de inclusão, em seguida foi feita a análise dos resumos e, por fim, realizada a revisão dos textos completos para seleção final dos estudos. Pesquisas adicionais foram conduzidas manualmente sob demanda. Seis tipos de estratégias de limpeza foram identificados na literatura para abordagem complementar em retratamento não cirúrgico: ativação ultrassônica e sônica passiva, ativação ultrassônica ativa, instrumentos plásticos para agitação mecânica, instrumentos metálicos para agitação mecânica, ativação multissônica e ativação a laser. Aqueles abordados na literatura têm sido associados a desempenhos mais elevados de remoção de material de obturador em comparação com sistemas de instrumentação apenas. No entanto, nenhum deles foi capaz de remover completamente o material obturador dentro do sistema de canais radiculares. Estudos clínicos controlados e randomizados são necessários para entender a real influência dessas estratégias no

retratamento não cirúrgico. Há uma discrepância notável entre o volume de estudos para cada estratégia, mais estudos são necessários em alguns sistemas já contemplados. Ainda existem sistemas de ativação das soluções irrigadoras não elucidados no retratamento não cirúrgico.

Palavras-chave: Canal radicular; Remoção de material obturador; Retratamento não cirúrgico.

Resumen

El retratamiento no quirúrgico es actualmente la terapia más afectada en Endodoncia en términos de resultados clínicos. El presente estudio tiene como objetivo evaluar estrategias modernas para enfoques complementarios en la eliminación de material de obturación. Así, se realizó una revisión narrativa bibliográfica en las bases de datos PubMed, Biblioteca Cochrane y Web of Science con las siguientes palabras clave en diferentes órdenes: "canal de raíz", "remoción de material de relleno", "retratamiento no quirúrgico" y "suplementario". Para el diseño de selección de estudios, luego de la selección de títulos, se eliminaron los duplicados y se aplicaron los criterios de inclusión, luego se analizaron los resúmenes y, finalmente, se revisaron los textos completos para la selección final de los estudios. Se realizaron búsquedas adicionales manualmente bajo demanda. En la literatura se identificaron seis tipos de estrategias de limpieza para un enfoque complementario en el retratamiento no quirúrgico: activación ultrasónica y sónica pasiva, activación ultrasónica activa, instrumentos plásticos para agitación mecánica, instrumentos metálicos para agitación mecánica, activación multisónica y activación láser. Los cubiertos en la literatura se han asociado con un mayor rendimiento de eliminación de material de obturación en comparación con los sistemas de solo instrumentación. Sin embargo, ninguno de ellos pudo eliminar completamente el material de obturación dentro del sistema de conductos radiculares. Se necesitan estudios clínicos controlados y aleatorizados para comprender la influencia real de estas estrategias en la retratamiento no quirúrgico. Existe una discrepancia notable entre el volumen de estudios para cada estrategia, se necesitan más estudios en algunos sistemas ya contemplados. Aún existen sistemas de activación de soluciones irrigantes no dilucidados en retratamiento no quirúrgico.

Palabras clave: Conducto radicular; Remoción de material de obturación; Retratamiento no quirúrgico.

1. Introduction

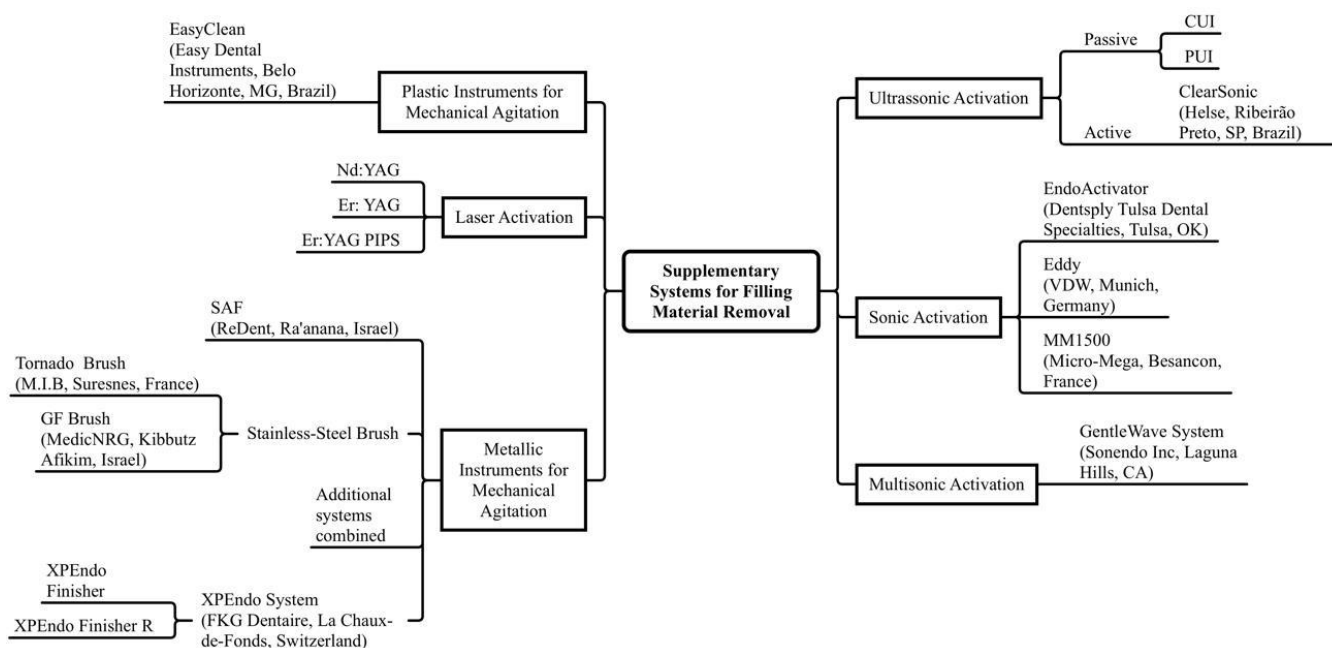
Non-surgical retreatment (NSR) is the first resource to be used in cases of signs of postoperative periapical lesions that configure endodontic failure (Siqueira & Rôças, 2008). The etiological factors that lead to the failure of primary endodontic therapy are equivalent at the time of reintervention, with the difference that in this context there is also a filling of dense material from the obturation previously performed in the primary treatment.

Non-surgical reintervention is commonly associated with the most unfavorable outcome of endodontic therapy when compared to primary treatment and microsurgery with modern approaches (Imura et al., 2007; NG et al., 2007; NG et al., 2008; Kang et al., 2015). This is a sign that further investigations need to be carried out to change this scenario.

The current preparation systems available are unable to completely remove the filling material within the root canal system (RCS). However, a new generation of devices and complementary strategies to optimize the irrigation solutions demonstrate promising results that may be the path to more favorable prognoses in NSR (Del Fabbro et al., 2016; Rossi-Fedele & Ahmed, 2017) (Figure 1).

The present study aims to elucidate the main supplementary strategies for the removal of filling material remnants previously published through a literature review.

Figure 1 - Flowchart summarizing the types of supplementary strategies mentioned in the literature for filling material removal.



Source: Authors.

2. Methodology

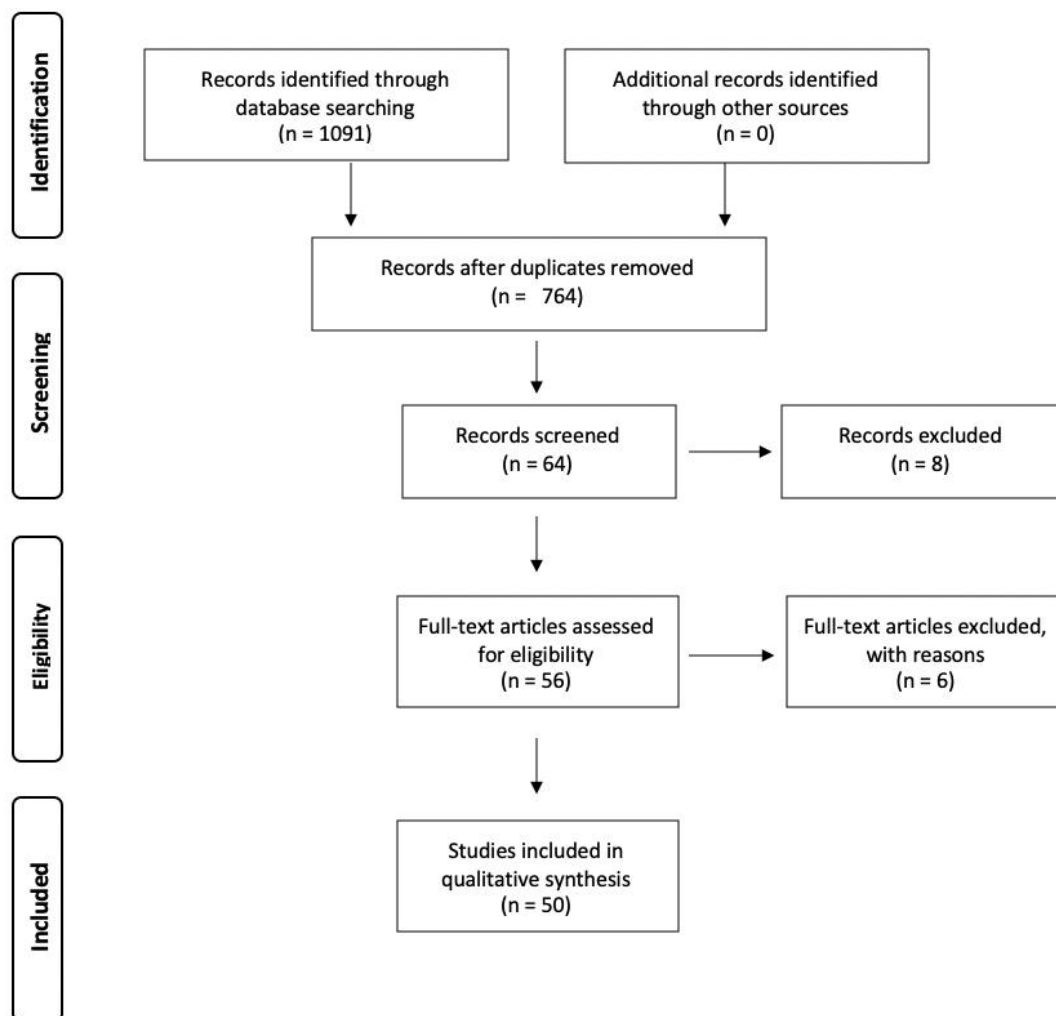
For this narrative review, literature research was carried out through the PubMed, Cochrane Library and Web of Science databases with the following keywords arranged in different orders: “root canal”, “filling material removal”, “non-surgical retreatment” and “supplementary”. The inclusion criteria were only studies in the English language, trials that evaluate the ability to remove remaining filling material and present at least one supplementary approach. No minimum publication date was applied. The exclusion criteria were reviews, clinical or biological study designs, studies that evaluates only isolated preparation systems with no supplementary addition, studies in primary teeth and deviated from the non-surgical retreatment procedure theme. The literature selection was divided into the following stages: titles screening, duplicates removal, inclusion criteria application, abstracts analysis, and finally full-text review for final eligibility. Other studies were included through manual search on thematic demand (Green et al., 2006).

3. Results and Discussion

A total of 1091 articles were found in the three selected databases. Of these, 327 were duplicates and after application of the inclusion criteria, 64 papers were selected for abstract analysis, where 8 articles were excluded. Thus, after reviewing 56 full-text studies, there was a final selection equivalent to 50 (Figure 2). Other 15 studies were retrieved through manual search on demand.

The Nickel-Titanium (NiTi) alloy allowed the use of more robust instruments in endodontic treatment due to the characteristics of superelasticity and shape memory (Del Fabbro et al., 2018). However, the literature still reports a critical result that there are considerable volumes of not prepared walls with the current systems, being in circular canals 10 to 50% and oval or flattened, reaching up to 80%. The results in circular or narrow canals are even more unfavorable when analyzed separately in the apical third, especially when associated to curvatures (Siqueira et al., 2018).

Figure 2 - PRISMA flowchart (Moher et al., 2009) for outlining the literature research results.



Source: Authors.

Considering that similar systems are also used to remove filling material in the retreatment procedure, it is justified that filling materials will remain attached to the internal dentinal wall. This argument was confirmed with unanimous evidence in the literature that no endodontic preparation system is capable of complete removal of the filling material, even if it is a specifically designed system for NSR or in addition with strategies for final irrigation optimization (Rossi-Fedele et al., 2017).

It is important to highlight that although there is no complete removal of filling material, there is a significant reduction in the overall volume of filling material as more strategies for final activation of the irrigation solution are carried out (Alves et al., 2016a; Silveira et al., 2018; Machado et al., 2019). The study that achieved the highest volume of samples with complete cleaning found a final volume of approximately 60% of all samples with total removal of filling material (Machado et al., 2019). However, this study only evaluated the apical third of mesial roots of mandibular molars.

Anatomical areas such as marginal recesses of flattened / oval canals, isthmus and lateral canals can compact filling material, mainly with the presence of solvents (Castro et al., 2018; Rivera-Pena et al., 2018; Campello et al., 2019). Apical portions in general have greater difficulty in removing filling material (Alves et al., 2014; Alves et al., 2016a; Alves et al., 2016b). Thus, it is understood that such areas are only affected by irrigation and its activation devices.

Ultrasonic and sonic activations basically differ in frequency, the first one operates a higher (1-6KHz) and the sonic a lower (25-30KHz). Passive ultrasonic irrigation (PUI) is one of the most studied approaches for activating irrigating solutions in the literature and is based on a passive ultrasonic tip vibrating at ultrasonic frequency inside the root canal with an irrigation

solution. Despite controversial results, most studies indicate better performances in the addition of this resource for removing filling materials remnants after initial bulk removal with NiTi preparation systems (Bueno et al., 2017; Gomes et al., 2017; Castro et al., 2018; Silveira et al., 2018; Kaloustian et al., 2019; Crozeta et al., 2020). The influence of PUI on the outcome of secondary treatment is still unknown, the only study published on the subject to date is a retrospective clinical study that found higher survival rates in retreatments associated with PUI (Bartols et al., 2020).

A modern delivery method has been proposed in the literature with interesting results regarding cleaning efficacy within the RCS, which is the continuous ultrasonic irrigation (CUI) (Bueno et al 2019). It is promoted by a Piezo Flow tip (Dentsply, Maillefer) that vibrates in ultrasonic frequency and simultaneously delivers irrigating solution during preparation. However, there is no evidence in filling material removal so far.

In sonic activation for NSR, EndoActivator (Dentsply Tulsa Dental Specialties, Tulsa, OK), Eddy (VDW, Munich, Germany) and MM1500 (Micro-Mega, Besancon, France) stand out. These are based on a handpiece with a plastic tip suitable for sonic vibration during the final irrigation of the endodontic treatment. Although cleaning results are similar to PUI in primary therapy (Kumar et al., 2020), in retreatment it did not show further efficacy when compared to other supplementary methods (Ozyurek et al., 2016; Martins et al., 2017; Volponi et al., 2020). Between the different types available, a study showed no significant difference (Kaloustian et al., 2019).

A recent proposal brings ultrasonic tips designed to directly remove remnants of filling material in anatomical recesses, especially in straight canals. The FlatSonic and ClearSonic tips (Helse, Ribeirão Preto, SP, Brazil) are designed for flattened and oval canals, respectively. ClearSonic has promoted significantly better results removing filling material when compared to NiTi systems alone (Rivera-Pena et al., 2018, Tavares et al., 2020; Silva et al., 2021). In the study by Rivera-Pena et al. (2018), better results were found for the use of the ClearSonic tip initially followed by a single reciprocating instrument.

Instruments with a flattened design and made of plastic material used in the handpiece to mechanically agitate irrigating solutions. EasyClean (Easy Dental Instruments, Belo Horizonte, MG) is the only type found in the literature regarding non-surgical retreatment. It can be used in continuous rotation, reciprocating or oscillating. The hard tissue debris removal results are satisfactory and similar to the PUI, even in isthmus areas (Duque et al., 2017; Cesario et al., 2018). Corroborating these findings, the only study that addressed the ability to remove remnants of filling material with EasyClean in a rotating motion also found similar results to PUI. The authors emphasized that both strategies were superior to the use of preparation systems alone (Rodrigues et al., 2017).

The mechanical agitation instruments are tools for activating irrigating solutions activated in a rotating movement, which can be of NiTi or stainless-steel alloys.

Firstly, there is the simple use of an additional preparation system. Studies indicate that the association of different systems benefits the removal of filling material (Alves et al., 2014; Rodrigues et al., 2016; Gomes et al., 2017). Rodrigues et al (2016) evaluated different sequences of preparation for retreatment and concluded that the association of reciprocating and rotary instruments obtained excellent results, in addition the foraminal enlargement up to a 50 / .01 instrument was significantly more effective. Using a multiple instruments sequence for NSR also may promote positive disinfection results (Xavier et al., 2018).

Another proposal for mechanical agitation is the stainless-steel brushes. These instruments feature a spiral design that extends into metal wires with passive tips that expand in a rotating motion. GF Brush (MedicNRG, Kibbutz Afikim, Israel) was associated with better results of filling material removal in the apical third than PUI in straight canals (Nguyen et al., 2017). The Tornado Brush (M.I.B, Suresnes, France) has the same design as the GF Brush, the only study found in the literature regarding retreatment reported equivalent results with PUI (Pedulla et al., 2019).

XP-Endo Finisher R (XPF) (FKG Dentaire, La Chaux-de-Fonds, Switzerland) is one of the most studied tools for removing filling material in the literature (Uzunoglu-Ozyurek et al., 2021). It is a rotary file without cutting action with a MaxWire alloy, a modification of NiTi capable of modulating its morphological state according to the difference in ambient and body temperature, thus reaching a format capable of adapting to the internal anatomy while activated in the RCS.

From an anatomical perspective, studies comparing its effectiveness in retreating curved canals were unanimous in reporting a significant improvement in the use of XPF (Alves et al., 2016a, Ozyurek et al., 2016, Campelo et al., 2019, Aksel et al., 2019). In straight canals with flattened or oval sections, the literature also showed very favorable results (Silva et al., 2018; De Deus et al., 2019; Kapasie et al., 2020; Tavares et al., 2020, Volponi et al., 2020; Abumostafa et al., 2021; Crozeta et al., 2021; Silva et al., 2021). XPF was also associated with lower preparation defects in retreatment (kapasi 2020, abumostafa 2021).

Retreatment with XPF as a supplementary step generally held results superior to PUI (Ozyurek et al., 2016; De Deus et al., 2019; Volponi et al., 2020). Only one study was controversial and concluded that the removal of filling material in oval canals using bioceramic cements was more effective with PUI (Crozeta et al., 2021). In comparison to the Clearsonic tip for active ultrasound in retreatment, both studies published to date have reported results more favorable to XPF (Tavares et al., 2020; Silva et al., 2021). It is worth mentioning that in both studies, these strategies were effective in reducing the volume of filling material in comparison with instrumentation system alone.

The Self-Adjusting File (SAF) (ReDent, Ra'anana, Israel) is a NiTi instrument with a disruptive design that formats the channel with anatomical vertical vibrations and simultaneous irrigation (Solomonov et al., 2012). As a complementary resource in the removal of filling materials, SAF presented favorable results when compared to other well-established preparation systems (Solomonov et al., 2012; Keles et al., 2014; Pawar et al., 2016; Machado et al., 2019); however, there are controversies (Yuruker et al., 2016). In NSR of extracted teeth with C-shaped canals SAF had inferior results in removal of filling material when compared to hand files H.

The GentleWave System (Sonendo Inc, Laguna Hills, CA) is an innovative approach in endodontic therapy, where there is minimal instrumentation and great optimization of irrigation by an irrigation delivery device that simultaneously generates multisonic activation (Molina et al., 2015; Zhang et al., 2019). Two prospective, randomized and multicenter clinical studies found 97.3% and 97.7% of success, respectively, in primary therapy with GentleWave with a follow-up period of 1 year (Sigurdsson et al., 2016; Sirgudsson et al., 2018).

In the literature to date, only three studies have analyzed its performance in retreatment. Two studies that used oval anatomies and compared with PUI obtained results equivalent or unfavorable to GentleWave (Crozeta et al., 2020; Park et al., 2020). A study comparing with manual needle irrigation and Endovac (SybronEndo, Orange, CA) found results superior to GentleWave (Wright et al., 2019). However, it is noteworthy that the other groups do not have agitation technology, since one is the control group with manual irrigation and the other is a negative pressure irrigation system that aims to promote aspiration at working length to avoid foraminal extrusion of irrigation solution for safety purposes.

Laser activation in NSR was approached in two different methods. The high energy pulsed lasers Nd: YAG and Er: YAG were initially used for disinfection and removal of debris in Endodontics (Harashima et al., 1997). The first study to evaluate the filling material removal ability of Nd: YAG laser in NSR suggested benefits when compared to manual techniques, especially regarding preparation time (Anjo et al., 2004). Regarding different Er: YAG laser pulse intensities, there are no significant differences (Tachinami et al., 2010; Gorduysus et al., 2017; Adbulijalil et al., 2020). In comparison with PUI, Er: YAG was associated with inferior results even in different energy outputs (Gorduysus et al., 2017).

Photon-Induced Photoacoustic Streaming (PIPS) is an Er: YAG laser configuration with promising RCS cleaning and disinfection results (Mohammadi et al., 2017). The first published study regarding its performance in removing filling

materials compared it to Er: YAG and Nd: YAG, but the results were unfavorable to PIPS when compared to Er: YAG (Keles et al., 2015). On the other hand, PIPS has shown better results compared to PUI (Jiang et al., 2016). In different types of root canal obturation cements, it also showed positive results (Suk et al., 2017). However, the study by Domnez et al. (2019) found no significant differences between PIPS and manual needle irrigation in filling material removal. In view of such controversy, PIPS filling material removal ability appears to be unknown.

4. Conclusion

Supplementary strategies for removing filling materials are scientifically validated and represents benefits in non-surgical retreatment therapy, even though they are not yet able to completely remove all filling material remnants. Although there is still no clear evidence to establish a causal relationship between remnants of filling material and the therapeutic outcome, it is plausible to state that lower volumes of filling material can contribute to success. Furthermore, the current understanding of the performance of such strategies is based on in vitro / ex vivo studies, therefore, controlled clinical studies are necessary to understand whether the mechanical advantages corroborate better prognoses of non-surgical retreatment therapy.

Several strategies for activating irrigating solutions have not yet been addressed in studies with the purpose of analyzing the ability to remove filling materials. Among the strategies already mentioned in the literature, there is a considerable scarcity of studies for most systems. Further studies are needed especially for laser activation, stainless-steel brushes, active ultrasound and plastic instruments for mechanical agitation.

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