

Effect of Repeated Sterilization Cycles on the Physical Properties of Scaling Instruments: A Scanning Electron Microscopy Study

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Abstract:

Background: Repeated sterilizations cycles cause undesirable alterations in the material properties of the instruments, such as corrosion, alterations in the hardness of the metal and the loss of the cutting sharpness of the instrument. This research examined the effect of repeated dry heat sterilization and autoclaves cycles on carbon steel (CS) and stainless steel (SS) curettes during the scaling and root planning.

Materials and Methods: A total of 77 Gracey curettes were used in this study. Of these, 35 were SS and 42 were CS curettes submitted in different process: Dry heat, autoclave, inhibition of corrosion and autoclave, scaling, root planning and dry heat, scaling, root planning, inhibition of corrosion and autoclave. The inhibition of corrosion used on the carbon curettes (prior to sterilization in the autoclave) was sodium nitrite at 2%. The curettes received 10 consecutive cycles of sterilization and after that the cutting edges were examined in the electronic microscope, at 60 and 100 magnification times.

Results: The images were evaluated by three independent examiners, who compared the photographs of each group with the control group.

Conclusion: The surface corrosion products and a deterioration of the edges were observed and the results showed that the SS curettes suffered little alteration with sterilization, scaling, root planning whereas the CS curettes were visibly affected by sterilization in the autoclave, but when the inhibition of corrosion was used prior to the sterilization, the oxidation was considerably reduced.

Key Words: Inhibition of corrosion, root planning, scaling, sterilization

Introduction

Dental calculus is considered to be a mineralized bacterial plaque, which acts as a secondary etiologic factor in periodontitis,

although extremely important in the maintenance and aggravation of the disease.¹ Due to keeping the plaque in close contact with the gingival tissue, dental calculus creates areas unfavorable to removal by brushing.^{1,2} Professional removal of calculus, plaque, and factors that favor their accumulation is usually performed by scaling and root planning (SRP).³

SRP are often time-consuming treatment procedures, whose mechanics can become tire some for the operator.¹ A number of instruments in different shapes and angles have been designed to perform satisfactorily the SRP procedure.⁴ Gracey curettes are widely used for removal of subgingival calculus and for performing root planning with the removal of contaminated cementum.^{5,6} Curettes can be made of carbon steel (CS), stainless steel (SS) and tungsten carbide. Among these types of curettes, those of CS stand out in terms of constant usage for maintaining their cutting ability for a longer time than the other types.^{4,6,7} Tungsten carbide curettes have the disadvantage of being costly and difficult of sharpening, reasons that led these instruments to be no longer marketed.⁷ Sharp curettes are found to be more efficient than blunt one in obtaining adequate root surface and lesser formation of smear layer.⁶ Sterilization of instruments is a routine in the dental offices, and the most widespread means of sterilization are: Oven (dry heat) and autoclave (moist heat). In ovens, temperatures ranging from 160°C to 170°C, for at least 2 and 1 h, respectively, must be set in the oven. In this method, the heat penetrates unevenly in the instrument and requires greater exposure and high temperatures.⁸ In the autoclave, temperatures ranging between 121°C and 134°C are required for 15-30 min to achieve the sterilization.^{3,9} This method is faster and more effective but has the disadvantage of causing corrosion mainly in CS instruments.¹⁰

The method for autoclave sterilization is more sensitive, especially when the drying process is not properly completed and the sealing of the instruments is not done with suitable paper. Sterilization cycles cause undesirable changes in the physical properties of the instruments, such as corrosion, temper shifts and loss of cutting.^{11,12} These changes cause great inconvenience, either for the time taken for a new sharpening or even for the loss of the instrument.¹³⁻¹⁵

Thus, this study evaluated by scanning electron microscopy (SEM), the effect of repeated oven and autoclave sterilization

cycles on the cutting edge of CS and SS periodontal Gracey curettes after SRP.

Materials and Methods

This study was approved by the Research Ethics Committee of UNITAU under protocol #120-03. A total of 77 Gracey curettes were used in this study. Of these, 35 were SS (Trinity Ind & Com Ltda, São Paulo, Brazil) and 42 were CS curettes (G Hartzell & Son Co., Concord, California, USA). The sterilization methods used were oven and autoclave. Autoclaving was performed at a temperature of 130°C for 15 min, followed by drying at 110°C for 30 min. Sterilization by dry heat was performed at 170°C for 60 min. The oven (Olidef, Ind. e Com. Equip Odontológicos, São Paulo, Brazil) was set up and the instruments were placed inside after temperature had reached 170°C. Then after the temperature was stabilized again, a 60 min countdown began. The sterilization efficacy for both treatments was checked by placing an envelope containing spores of *Bacillus subtilis* and *Bacillus stearothermophilus* in into the oven (Olidef, Ind. e Com. Equip Odontológicos, São Paulo, Brazil) and autoclave (Dabi Atlantis, Atlante Ind Medico Dental, São Paulo, Brazil), respectively. After the sterilization cycle, the strip was removed from the equipment and placed in culture medium (Tryptic Broth, Difco Laboratories, Detroit, Michigan, USA). After 24 h, it was possible to verify the efficiency of the sterilization process based on the turbidity of the medium. The oven temperature was monitored continuously using a mercury thermometer, in order to keep it constant.

Both types of curettes were distributed into groups, as shown in Table 1.

The corrosion inhibitor 2% sodium nitrite (Phloracea, Farm Manip. Ltda, Cuiabá, Mato Grosso, Brazil) was applied to CS curettes prior to autoclaving. The CS curettes were immersed for 2 min in the inhibitor and subsequently sterilized in an autoclave. SRP were performed in groups SS4, SS5, CS5 and CS6 in three human premolars extracted for orthodontic purposes, which were originated from the bank of teeth of the Discipline of Endodontics, University of Taubate. 50 short, strong traction movements were performed parallel to the tooth axis in a given area. After this procedure, each group of curettes underwent 10 consecutive sterilization cycles.

Initially, curettes were assessed after the use and before sterilization by means of a SEM (Leo model 1450 VP, Leo-Zeiss, England). A disc of carborundum was used to separate the blades from the grips of the SS curettes to be observed by SEM. This procedure was not necessary in CS curettes as these have threaded tips. Hence, a better positioning of the active tips was obtained inside the SEM. Photomicrographs of the blades with 60 and x100 magnification and 20 kV potency were taken.

The method of analysis followed the methodology proposed by Stach *et al.*¹⁶ Previously calibrated examiners compared

the micrograph of each treatment performed in the curettes with those obtained for the control group and provided scores according to the following scale: (1) No alteration; (2) minor and well-marked alteration; (3) moderate to major alteration. After analysis, the median of these indices was determined, and the results were analyzed.

Results

Visible changes in the edges of the curettes were observed by 10 examiners and classified according to the scale as shown in Table 2.

Scale for analysis: (1) No alteration; (2) minor alteration; (3) moderate to major alteration.

Figure 1a-k illustrates the conditions of the curettes after the different treatments by the magnification of x100.

Discussion

Sterilization of instruments is a routine in the dental office, and repeated sterilization cycles can lead to undesirable changes in the physical properties of the instruments, such as corrosion, temper shifts and loss of structure.¹⁷ Autoclave sterilization is used in most materials, although it is found to cause changes in the physical properties of CS instruments.¹¹ Oven sterilization is preferable to maintain the cutting edge of instruments and being microbiologically effective, but it requires high temperatures and long exposure periods.⁸ There are different types of packaging for sterilization of instruments in oven and autoclave. The corrosion of instruments increases considerably when CS samples are

Table 1: Curettes according to treatment types and sterilization.

(n)	Material	Treatment and sterilization	Group
07	Stainless steel	No sterilization	SS 1
07	Stainless steel	Oven	SS 2
07	Stainless steel	Autoclave	SS 3
07	Stainless steel	Scaling and oven	SS 4
07	Stainless steel	Scaling and autoclave	SS 5
07	Carbon steel	No sterilization	CS 1
07	Carbon steel	Oven	CS 2
07	Carbon steel	Autoclave	CS 3
07	Carbon steel	Scaling and oven	CS 4
07	Carbon steel	Scaling and autoclave	CS 5
07	Carbon steel	Scaling, inhibitor and autoclave	CS 6

Table 2: Average scores obtained by the 10 calibrated examiners after analysis of the curettes subjected to different treatments.

Type of treatment	Curettes Average±SD	
	SS	CS
Oven	1.80±0.40	1.52±0.51
Autoclave	1.60±0.53	3.00±0.76
Inhibitor and autoclave	Not tested	1.85±0.47
Scaling and oven	2.42±0.61	1.85±0.47
Scaling and autoclave	1.85±0.47	Not tested
Scaling, inhibitor and autoclave	Not tested	2.04±0.51

SD: Standard deviation, CS: Carbon steel, SS: Stainless steel

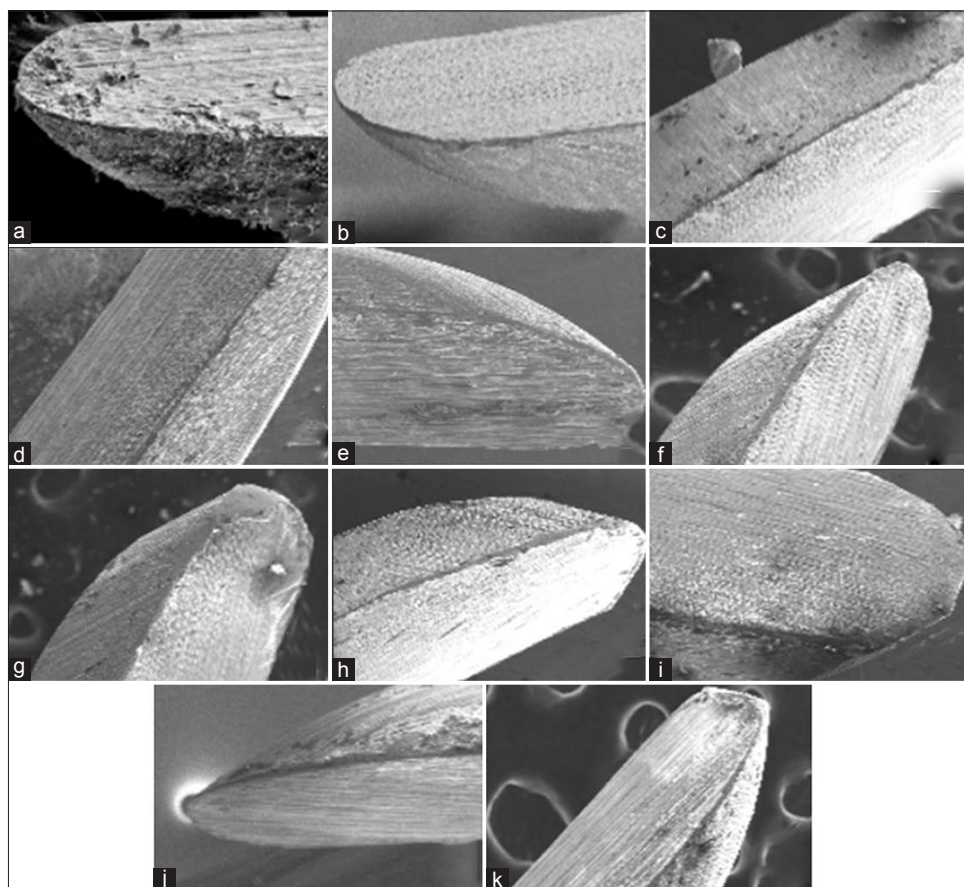


Figure 1: (a) Carbon steel (CS) curette subjected to autoclave sterilization without the use of a corrosion inhibitor ($\times 100$), (b) CS curette previously subjected to autoclave sterilization with a corrosion inhibitor ($\times 100$), (c) stainless steel (SS) curette with early formation of oxides after autoclave sterilization, scaling and root planning (SRP) ($\times 100$), (d) CS curette micrographed ($\times 100$) – Control, (e) CS curette micrographed after 10 oven sterilization cycles ($\times 100$), it is noted little or no change in the edges, (f) SS curette micrographed ($\times 100$) (control), (g) SS curette micrographed ($\times 100$) after 10 oven sterilization cycles, it is noted discrete presence of oxidation and bending of the tip of the curette with loss of structure, (h) SS curette micrographed ($\times 100$) after 10 autoclave sterilization cycles, it is noted little or no change in the edges, (i) SS curettes micrographed ($\times 100$) after 10 oven sterilization cycles, SRP, darkening and oxidation of the edges can be noted, (j) CS curettes micrographed ($\times 100$) after 10 oven sterilization cycles, SRP, discrete presence of oxidation products is noted on the edges, (k) CS curettes micrographed ($\times 100$) after 10 autoclave sterilization cycles (with previous use of a corrosion inhibitor), SRP, it is noted the presence of staining and bending of the edges with loss of structure.

autoclaved in different business envelopes, with an increase in the release of acid radicals of the package. Sasse¹⁵ verified that 100% light cotton fabric was the package that caused the lowest corrosion rates. The present study used the same type of material for the packaging of curettes for sterilization.

As Tal *et al.*⁶ reported that the cutting edge of the periodontal instrument was described as a well-defined, sharp edge, with a continuous line formed by two adjacent surfaces. This study found that CS curettes are more resistant to SRP procedure than are SS curettes. Geaman and Moser¹² observed that SS instruments are more resistant to corrosion. In contrast, CS instruments stand superior with regard to the hardness of the material and maintenance of cutting edge for a longer time. In the present study, CS instruments lost their cutting on the seventh cycle (sterilization, SRP). SS instruments, in its turn, lost their cutting on the fifth cycle.

Some authors have pointed out that sterilization of CS instruments using saturated vapor causes corrosion due to moisture and heat, that is why an inhibitor of corrosion was used in this study, prior to autoclaving.^{4,18}

In this study, the results showed that the CS curettes, subjected to autoclave sterilization, suffered severe degradation of their cutting edges and oxidation. This might have occurred because CS materials, unlike SS materials, do not have elements like nickel and chromium in their composition, which provide protection against corrosion. However, when an anticorrosive agent was used prior to sterilization, there was discrete oxidation and staining.¹⁰ Bertolotti and Hurst¹⁹ studied the effects of corrosion inhibitors (sodium nitrite, orthophosphate nitrite, and sodium perborate) applied to drills by dipping for 2 min. The authors concluded that 2% sodium nitrite was the most effective inhibitor against corrosion. According to

these authors, corrosion is a destructive attack of the metal by an electrochemical reaction with the environment, where iron steel is converted into ferrous oxide ($\text{Fe} + \text{H}_2\text{O} - \text{Fe}(\text{OH})_2 + \text{H}_2$) in the presence of oxygen and water. The ferrous hydroxide is converted to ferric hydroxide ($4\text{Fe}(\text{OH})_2 + \text{O}_2 + 2\text{H}_2\text{O} - 4\text{Fe}(\text{OH})_3$), After drying, the ferric hydroxide is converted to ferric oxide ($2\text{Fe}(\text{OH})_3 - \text{Fe}_2\text{O}_3 + \text{H}_2\text{O}$), which leads to oxidation on the instrument surface. In the present study, an anticorrosive agent was used prior to autoclave sterilization. The instruments were immersed for 2 min in a solution of 2% sodium nitrite; this solution in small amounts is non-toxic and does not interfere with the sterilization process. The SS curettes had their cutting edges deformed before SRP, which is inherent to an inadequate manufacturing process.

Conclusion

Based on the methodology and the results, it was possible to conclude that:

- The edges of the SS curettes suffered little or no alteration after repeated sterilization cycles. However, after SRP, we observed the formation of dark regions (staining) and early formation of oxides
- SS instruments were found to have their edges deformed before SRP, which seems to be inherent to the manufacturing process
- When a corrosion inhibitor (2% sodium nitrite) was applied to CS curettes prior to autoclaving, there was a discrete alteration or corrosion compared to autoclaving without using the inhibitor
- CS instruments subjected to oven sterilization cycles, SRP was the group with the lowest alteration of the cutting edges.

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