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Surface Morphology and Performance of New and Reused Microblade for Dental Surgery

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Abstract

Objectives: Several dental surgical procedures use disposable and reusable instruments. This study aimed to compare the clinical performance of new and reused microblades to perform dental surgery.

Methods: The clinical performance of the microblade was evaluated by the cutting capacity during root coverage modified tunnel surgery. The surgery involved cutting the initial portion of the sulcus in the mandible of ex-vivo pigs. After each surgery, the microblades were cleaned, sterilized, and the surface was analysed by scanning electron microscopy and surface roughness measurement. The surface roughness parameters (Ra, Rq, PV, the number of peaks, the number of valleys, and the density of the peaks and valleys, respectively) were determined by a 3D optical profile-rugosimeter.

Results: Clinical results showed that in the first, second, and third uses, the forces applied to the microblade to perform the soft tissue flaps were similar. During the fourth surgery, there was a need to increase the force on to microblade to perform the dissection. In a visual inspection of the microblade, no differences were observed in the surface morphologies after any uses. Scanning electron microscopy (SEM) analysis showed that the number of grooves increased as the number of reuses increased. The surface roughness parameters increased after each use.

Conclusions: Based on the clinical results, it is possible to conclude that it is feasible to sterilize and reuse microblades a maximum of three times. Visual inspection proved to be an inadequate procedure to identify surface damage and impairment of instrument performance.

Clinical Significance: Visual inspection and scanning electron microscopy analysis are inadequate procedures to identify surface damage and impairment of surgical cutting instrument performance. It is advisable to efficiently use the same instrument a maximum of 3 times.

Keywords: Instrument surface degradation; Microblade wear; Reusable surgical instruments; Sharp edge retention; Microblade coating; Transmission of infectious agents

Introduction

Disposable or reusable instruments are used in various surgical procedures, especially in dental surgeries. There is no doubt that the reuse of medical and dental instruments can be a source of pathogens transmitted between patients. However, it is essential to analyze the type, shape, and application of the surgical instruments to identify the feasibility of their reuse. In the case of reusable medical devices, there are handling, cleaning, and sterilization protocols [1].

ISO Technical Standard 17664-1:2021 (ISO 17664-1:2021. Processing of health care products - Information to be provided by the medical device manufacturer for the processing of medical devices - Part 1: Critical and semi-critical medical devices) describes the procedures that must be adopted in the handling of medical and dental devices that are reused. To reuse the instruments, adequate processing is required between each use. Procedures may involve one or several cleaning, disinfection, and sterilization steps. It is important to emphasize that both disposable and reusable surgical instruments influence the financial costs of surgical procedures. However, the main analysis when reusing instruments should be the risk of crosscontamination [2].

Among several reused instruments in dental practice, mouth mirrors, periodontal probes, and low and high-rotation dental pens are considered semi-critical instruments. During use, these instruments have contact with intact mucous membranes or nonintact skin, although without penetration. These instruments are reusable and have a low infection rate [3]. On the other hand, critical instruments such as forceps, scalpels, bone chisels, scrapers, and surgical drills are used to penetrate tissues or bones and have contact with the bloodstream or other tissues, which increases the risk of transmitting infections. These instruments are sterilized after each use. Sterilization can be done by steam autoclaving under pressure, dry heat, or chemical heat/steam.



In the specific context of clinical dental practice, the process of reusing sharp instruments requires strict use control and inspection. The evaluation of these instruments is not limited only to physical integrity but also involves checking their cutting capacity to ensure adequate performance. It is essential to follow the recommendations of the technical standards, which include precise instructions and specific care for cleaning, storing, and sterilizing these instruments. The specific guidelines are described in the Supplementary Instructions of the ISO Standards 17664-1:2021 (Processing of health care products - Information to be provided by the medical device manufacturer for the processing of medical devices - Part 1: Critical and semi-critical medical devices); ISO 15883-1(Washer-disinfectors - Part 1: General requirements, terms and definitions and tests); 11135 (Sterilization of health-care products - Ethylene oxide - Requirements for the development, validation and routine control of a sterilization process for medical devices); 16409 (Dentistry - Oral care products - Manual interdentally brushes); 15841 (Dentistry - Wires for use in orthodontics); and in ANSI/AAMI ST8: 2013 (Hospital Steam Sterilizers, European Directive 2007/47/EC, which amends the EU Medical Devices Directive MDD 93/42/EEC.

During surgical procedures, instruments are reused, such as dissection forceps, Metzenbaum and Mayo scissors, Galipot, Deaver retractors, Landenberg retractors, and curved Mosquito artery forceps, among others. To prevent bacterial cross-contamination, surgical operating centers follow strict procedures for examining and cleaning reusable instruments.

In procedures for installing osseointegrated dental implants and for bone reconstruction, it is common to reuse drills and osteotomes to cut the bone. Although these instruments undergo rigorous cleaning, visual inspection, and sterilization procedures after each use, the quality of the blade edge is generally not quantitatively evaluated. This can lead to variations in cutting capability and affect the success rate of the surgery. Clinically, surgeons evaluate instruments during surgery, based on their experience and individual perception. The surgeons must discard the instruments after a certain number of uses proposed by the manufacturers. The assessment of the cutting ability is subjective for several reasons. The assessment depends on the surgeon's skill and technique in using the instruments, the condition of the patient's teeth and oral cavity, as well as the quality of the instruments themselves. In addition, the assessment depends on the surgeon's tactile perception and the effectiveness of the instrument in removing dental or bone tissue, which can vary among professionals.

Many surgical centers reuse discardable medical devices. This procedure is a normal practice in several countries, but it generates intense debates among surgeons, technicians, and regulatory bodies. The reuse of products involves economic and patient safety aspects. Scientific works indicate that there is risk in the reuse of some products, but there is no data that relates negative results to reuse. Supervision by the Food and Drug Administration (FDA) has been heightened, however available information does not indicate that reuse presents an elevated health risk.

Data available in the medical literature are not conclusive about the safety risks of reprocessing single-use products. The decision to reprocess and reuse single-use medical devices requires special care and involves reviewing procedures to ensure patient safety [4,5]. Surgeons must understand the restrictions on the practice of reprocessing and the related risks.

The medical literature shows a consensus that, for the reuse of products, it is necessary to observe the same safety standard adopted

for single use. Several products are reused safely, but this practice requires the adoption of protocols and efficient inspection, which already occur in several countries [6-8]. In the specific case of the reuse of microblades, the risk is associated with loss of cut, which can make the procedure difficult and cause tissue damage.

The present work aims to analyze the changes in the surface and the cut performance of microblades before and after 4 reuses. Changes in the microblade cut surface were evaluated using visual inspection, scanning electron microscopy, and quantification of roughness by interferometer before and after *in vivo* use. Visual inspection of the edge of the blade was compared with the qualitative measurement of the blade sharpness index. SEM images were qualitatively evaluated for morphological variation. In the clinical cutting tests, the force necessary to cut and penetrate to the proper depth required by the technique was measured. Using the interferometer technique, the roughness parameters were measured.

Materials and Methods

In the present work, cutting instruments named Micro Blade Tunnel manufactured by Keydent Co (American Dental Systems, Reference 4326200, Batch 1722, made in 2022/05) were used. These instruments are commonly used in periodontal plastic surgeries.

The modified tunnel surgery technique with coronary advancement was chosen to evaluate the change in microblade cutting performance after different uses. Tunneling is a surgical procedure performed to obtain root coverage of the tooth. This surgical technique requires skill from the surgeon, instruments with a special shape, and good cutting capacity. This surgical technique does not involve coronal displacement of the mucogingival junction, minimizes damage to the blood supply, reduces the risk of scar tissue formation, and there is no need for relief incision or papilla dissection. During the procedure, the microblade is used to divide the flap in the sulcus region and create a unique path to the mucogingival line. The proposed surgical technique is a modification of the one indicated by Sculean A, et al., [9]. This technique allows the use of the next instrument (tunneling tool) to completely detach the entire flap, without its division. With the use of the microblade, there is no pressure on the bone, and the periodontal fibers are partially cut, remaining attached to the bone and flap.

The cutting capacity of the microblade is greater than that of the tunneler instrument. The microblade allows the creation of paths that serve as guides for inserting the tunneler. After tunneling, the microblade is used again to loosen and break the muscle fibers in the mucogingival line. With this procedure, it is possible to break the muscle fibers until the flap covers the defect more than a millimeter.

For the flap to be mobile it is necessary to loosen the tissue in the region of the papilla and the flap must passively cover the recession, one millimeter above the cement-enamel line. The connective tissue is then inserted with simple sutures in the mesial, and distal, and, finally, a suture proposed by Zuhr O, et al., [10], called a double cross, is performed. Figure 1 shows each step of the procedure.

To simulate the clinical procedure, the cutting capacity of the instruments was evaluated by performing surgeries on 3 mm defects in the upper molar in swine. One tooth with recession and two for tunneling were used. All procedures were conducted by the same professional with extensive experience in this type of intervention. After performing the surgery, the recession was measured using the Hufriedy millimeter probe and documented using photographs.

Each microblade was used four times. After each use, the microblade was cleaned and sterilized in an autoclave. The procedure



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Figure 1: Pictures of the surgical procedure: A) Retraction of the defect; B) Measurement of the defect size; C) Connective tissue positioned over the defect to verify the graft size; D) Microblade advancing to the mucogingival line; E) Use of the tunneler in selecting the tunnel; F) Positioned graft; G) Double cross suture; H) Final picture.

guarantees the integrity of the instruments and allows evaluation of their behavior, as shown in the flowchart in figure 2.

Before use and after sterilization, visual analyses of the instruments were performed to verify the integrity of the cutting edges and the overall integrity of the instrument. Inspection of instruments before each use can minimize the risk of using damaged, non-functional, or malfunctioning instruments in modified coronary advancement tunnel technique surgery for root coverage.

Before and after each use the surface morphology of the instruments was analyzed using a scanning electron microscope Field Emission Gun FEI QUANTA FEG 250 (FEI Corporate, Hillsboro, Oregon, USA). Instruments surface roughness was measured with a New View 7100 optical laser profilometer (Zygo Co, Laurel Brook Road, Middlefield, CT 06455 - USA). The measured surface roughness parameters were Ra (average difference between peaks and valleys), PV (maximum surface variation that may occur), Rq (standard deviation of the height distribution), number and density of peaks, and number, and density of valleys. The roughness measurements were taken in 3 regions on each instrument. Surface roughness parameters were analyzed by analysis of variance (ANOVA) and Turkey's test with 5% significance.

Results

In the visual analyses, no changes were identified on the surfaces of the instruments after four uses. The surface morphologies analysis of the instruments in the SEM before and after reuse is shown in figures 3 to 7. In the as-received state, both surface sides of the instruments have different morphologies. On one side, the surface is homogeneous and smooth and on the other side, there are grooves from the manufacturing process. The grooves in the center are running the length of the instrument, while the grooves in the borders are transverse. After using the instruments, new grooves were created in random directions.

Analyzing the instruments in the SEM after cleaning and sterilization, the presence of pathogens that could lead to the transmission of microorganisms and create a risk of injury to the patient, including infection of the respiratory site, was not observed. With cleaning, it was possible to remove dirt from the clinical procedure. With subsequent sterilization it is possible to reduce or eliminate viable microorganisms, allowing the safe reuse of medical devices. After four uses, it was possible to identify an increase in the number of grooves on the microblade surface, which could harm the clinical procedure.

After using the instruments in four surgical procedures, it was found that there was loss of cutting capacity. However, due to its use restricted to the sulcus and a single path to the cement-enamel junction, it was clinically verified that the blade in question was still effective and suitable for use in 3 surgeries. Only in the fourth surgery was it difficult to make the incisions with the instruments.

Figure 8 shows the 3D optical laser profilometer surface morphology of the instrument before and after reuse. Table 1 and figure 9 show the surface roughness parameters before and after using the microblade.

Table 1: Mean data of the surface roughness parameters of the microblades before and after reuses.

Condition	Ra (µm)	Rq (μm)	PV (μm)	Peak #	Valley #	Peak density (1/mm ²)	Valley density (1/mm ²)
New	0.27 ± 0.03	0.37 ± 0.04	15.03	290	284	1991 ± 30	1960 ± 139
1 st Use	0.36 ± 0.02	0.46 ± 0.02	18.64	308	327	2056 ± 86	2169 ± 139
2 nd Use	0.42 ± 0.01	0.58 ± 0.01	16.21	335	354	2152 ± 149	2240 ± 86
3 rd Use	0.48 ± 0.01	0.69 ± 0.02	15.05	355	366	2152 ± 1152	2219 ± 376
4 th Use	1.30 ± 0.01	1.40 ± 0.02	17.23	543	495	3305 ± 358	3010 ± 256

*F calculated \geq F tabulated.



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The groove density increased after the third use. After the fourth use, the grooves were distributed over the entire surface, indicating a loss of blade sharpness. During surgeries, performance is impaired and cut degradation is observed in the fourth use.

For a significance level of 5%, ANOVA indicated that at least one group had mean values of groove density significantly different from each other. To identify which groups had significant differences in mean values, Tukey's test was applied with a significance level of 95%. The results showed an increase of 3% in the density of peaks and valleys after the second use (p-value = 0.000), 8% after the third use (p-value = 0.000), and 65% after the fourth use, all compared

with the initial condition. Tukey's statistical analysis revealed that the condition after the fourth was significantly worse than after the third use.

Discussion

It can be observed in the SEM analysis that the new microblade surface has grooves inherited from the manufacturing process (Figures 3-7). The grooves and machining marks have different orientations. Some differences in the morphologies were observed between the two microblade sides. After use, new grooves appear in random directions, showing wear and deformation.





Figure 4: Surface morphology of an instrument after the first use.





Figure 6: Surface morphology of an instrument after the third use.

Several reusable surgical and diagnostic instruments have contact with tissues and organs during different types of surgical intervention. The reusable instruments are used in general surgery, digestive and urological endoscopies, orthopedic, plastic, maxillofacial, and dental surgeries. Before being reused, these instruments need to be properly sterilized or disinfected to avoid transmitting infectious agents to patients during the surgery [11,12]. In the present work, in human eye analyses of the microblade, it was not possible to identify changes in physical integrity after multiple uses. This indicates that the naked-eye analysis methodology is inadequate to identify small defects created by the reuse of instruments. Some instruments, such as the parts that compose the dental endoscope, may have complex shapes and lumens, making cleaning more difficult, and requiring more care. The presence of biofilm inside the lumens is particularly problematic as it is difficult to locate, quantify, and remove. Mechanical and chemical action is required to remove the biofilm [13]. However, the microblades analyzed in the present work have a simple shape, and flat surfaces, and do not have lumens, which facilitate cleaning by any process.

Due to the simple architecture of the microblade, it was possible to remove coarse dirt from the entire surface to avoid the presence of



Figure 7: Surface morphology of an instrument after the fourth use.



organic material and debris. Organic material and debris are easier to remove from surgical instruments when they are flat and do not have internal parts, as has been verified in the literature [14-17]. Removal of organic material and debris in the cutting region of the microblade improves the efficiency and precision of the incisions.

The presence of blood, organic matter, debris, and the chemical solution used for cleaning instruments is highly corrosive to metal instrument surfaces and can cause corrosion when allowed to dry on surgical instrument surfaces. These materials can be difficult to remove from all surfaces during the cleaning and decontamination process when instruments are irregularly shaped. Surface degradation reduces the effectiveness of cleaning and sterilization processes for reusable lumen instruments [18-20].

The methodology used in the present work to clean, sterilize, and reuse the microblade was safe. Cleaning and sterilization protocols were adequate. Efficient removal of dirt, organic material, and debris from these instruments is essential to prevent the transmission of infectious agents during surgical interventions.



Figure 9: Surface roughness parameters Ra and Rq of new microblades and after reuse.

Hogg and Morrison [21] evaluated the effectiveness of resterilization of instruments used in oral and maxillofacial surgery. The instruments were subjected to a manual cleaning process and subsequently sterilized in a steam autoclave. Microbiological tests were performed to assess the effectiveness of the sterilization process. The results showed that all instruments tested were sterile after the sterilization process, demonstrating the effectiveness of the method used. The authors concluded that instrument reprocessing is a safe and viable option, provided proper cleaning and sterilization protocols are followed.

Regarding the surface morphology changes, the evaluation by scanning electron microscopy showed that after three uses there was mechanical damage to the cutting edges of the microblade. The observed loss of blade sharpness corroborates the degradation in cutting performance often reported by surgeons. This loss of sharpness compromises the performance of the instruments, making incisions difficult during the fourth use. Therefore, it is necessary to monitor the condition of the blades over time and consider replacing them when loss of sharpness significantly compromises their functionality.

Restrepo-Restrepo and collaborators [22] analyzed the microstructural, chemical, and mechanical changes of two nickeltitanium endodontic instruments after clinical reuse. Scanning electron microscopy, energy-dispersive X-ray spectroscopy, and mechanical torsion tests were performed on instrument samples after one, five, and ten cycles of clinical use. The results showed that clinical reuse of the instruments changed the morphology and reduced the torsional resistance, especially after five and ten cycles of use. Therefore, clinical reuse in routine endodontic practice is not recommended, corroborating the results observed for the present work with microblades.

It is important to consider the effects of corrosion on the surfaces of metallic instruments due to the presence of blood, organic matter, debris, and corrosive chemical solutions used during the cleaning process. Surface degradation compromises the effectiveness of sterilization procedures and can negatively affect the performance of instruments during surgical incisions.

The results of the present work showed that the microblades can be safely reused as long as they are properly cleaned, decontaminated, and inspected before each use. However, it is important to be aware that these instruments experience progressive wear, resulting in loss of sharpness and compromised cutting performance after multiple uses. Therefore, measures must be taken to monitor the condition of the blades over time and ensure their effectiveness during surgical interventions. In addition to clinical performance, professionals must consider the environmental influences on instrument disposal. Byrne D, et al., [23] evaluated the influence of disposable and reusable dental examination kits. He compared environmental impacts across several categories, such as greenhouse gas emissions, water consumption, and use of natural resources. The results showed that disposable kits had a greater environmental impact in all evaluated categories compared to reusable ones. Therefore, it is relevant to consider environmental aspects when making decisions regarding materials and devices used in dental practice.

In the statistical analysis, the null hypothesis was that the means of all selected datasets are equal and the alternative hypothesis was that the means of one or more selected datasets are different. The statistical One-way ANOVA test of all roughness parameters showed that at the 0.05 level, the population means are significantly different. The same result was achieved, for comparison, using the Bonferroni test, Scheffe's test, and Tukey's test.

Conclusion

Based on the obtained results it is possible to conclude that:

a) In the visual analysis of the microblade, it was not possible to observe changes in physical integrity after multiple uses. This analysis is not able to identify small defects created by the reuse of the instrument.

b) The analysis by scanning electron microscopy (SEM) showed morphological differences on the surfaces of the microblade before and after reuse.

c) After uses and sterilizations, the presence of elements that could transmit pathogenic microorganisms was not identified, ensuring patient safety during surgeries. Proper cleaning and decontamination were effective in removing dirt and viable microorganisms, making the instruments safe to handle.

d) The shape of the microblades facilitated their cleaning, decontamination, and sterilization. The use of other instruments with complex shapes, lumens, and irregular surfaces requires greater care and effort to ensure the complete removal of unwanted materials, especially biofilms present inside the lumens.

e) The cutting performance of the microblade worsened after three uses.

f) Microblades can be safely reused provided they are properly cleaned, decontaminated, and inspected before each use.

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The authors report no conflicts of interest related to this work.

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