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The Effect of Repeated Sterilization on the Properties of Orthodontic Temporary Anchorage Devices

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Abstract

Context: Temporary anchorage devices (TADs) have been introduced to orthodontic treatment for enhancing anchorage control. It is claimed that they are not disposable and can be used several times after sterilization process. However, the question is whether this repeated sterilization has any effect on the properties of these devices. This study was done to review the available articles that had addressed various aspects of this issue.

Evidence Acquisition: The authors searched several electronic data bases including PubMed, Google Scholar, Scopus and Embase with several key words related to orthodontic temporary anchorage devices and sterilization. The relevant articles were reviewed and categorized in the following subjects: mechanical properties, primary stability and clinical success, and histologic and microscopic characteristics.

Results: Sterilizing the temporary anchorage devices seems not to affect the mechanical properties of these devices.

Conclusions: In terms of primary stability, and clinical success, very few studies are available. Histologic and microscopic evaluations showed some alteration in the surface characteristics of TADs including some mineral precipitation.

Keywords: Temporary Anchorage Devices, Orthodontics, Repeated Sterilization

1. Context

One of the most important factors for a successful orthodontic treatment is anchorage control. Preserving maximum anchorage was done previously with extra oral appliances, intra oral elastics and some other traditional ways which had some side-effects and needed full patients' compliance (1). Temporary anchorage devices has been introduced to orthodontics since 1983 as a method for enhancing anchorage control and it made some issues like absolute anchorage possible (2, 3). Their usage spread among orthodontists promptly and nowadays they have several applications such as maximum to absolute anchorage for space closure in cases of premolar extraction, total arch distalization or mesialization in the correction of class II or class III malocclusion, molar intrusion in cases of open bite, incisor intrusion in cases of deep bite, molar uprighting, molar protraction and also in growth modification like class III treatments (4). Temporary anchorage devices are used in the form of plates (miniplates) and screws (miniscrews) depending on the aim of their application, patient situation and clinician's preference (5). Since the application of these devices is rising among orthodontist it is crucial to fully understand their characteristics, biomechanics, placement protocol and method of their sterilization and the infection-control protocol during their placement (6). It is also important to mention that not all TADs are successful and there have been reported to have a success rate of 83.3 to 94.7 (7). Several factors has been reported to be associated with TAD success and failure, including surface characteristics, maximum insertion torque, the bone quality and density, the location of TAD and so on (8). It has been reported that repeated cycle of sterilization could change the surface of temporary anchorage devices (6). However, it is inevitable to sterilize TADs since although sometimes they are commercially available as single-dose sterile packs, occasionally they come in clinical kits with several TADs inside. In the latter case, the clinician usually choose the favorable size and diameter from the kit and should sterile it before clinical application. On the other hand, it is also claimed that one TAD can be used for several patients after it had been totally clean and the sterilized according to recommended protocols (9). Scholz et al. presented a statement about the sterilization requirements for orthodontic TADs,

and they named some common situation in which TAD can get contaminated in clinical environment including touch of nonsterile gloves, nonsterile tray cover or instruments or any damage to the sterile pack (10). They also provided a summary of the sterile instrument package protocol which meet the FDA requirement for implantable devices (10).

Although there are several data in the literature about the effect of sterilization on other orthodontic material and instruments (11-15), not enough articles are available to investigate the effect of sterilization procedure on mechanical properties and clinical success of temporary anchorage devices. Accordingly, this study was done to review the available articles that had addressed the effect of repeated sterilization on temporary anchorage devices.

2. Evidence Acquisition

The authors searched several electronic data bases including PubMed, Google Scholar, Scopus and Embase with several key words related to orthodontic anchorage devices and sterilization. Keywords related to orthodontic temporary anchorage devices were included: mini-implant, min-plate, mini-screw, orthodontic bone screw, orthodontic bone anchorage devices. Keywords related to sterilization were included sterilization, autoclaving, disinfection. The found articles were studied by the authors and the relevant articles were selected and reviewed. To organize the subjects the relevant articles were categorized in the following subjects: mechanical properties, primary stability, clinical success and Histologic and microscopic characteristics.

3. Results

3.1. Mechanical Properties

Fracture of orthodontic and surgical mini plates and screws is a relatively rare but not impossible complication. However its mechanism is not precisely determined yet (16, 17). Collela et al. studied the effects of repeated cycles of sterilization on the mechanical properties of titanium mini-plates. They exposed the plates to increased sterilization cycles including a standard autoclave and a water jet steam at 403 K for 30 minutes. The mechanical tests included the Penetration Resistance test, Surface roughness, the Finite Elements Method analysis (FEA), traction test, bending test and static traction test. They concluded that the studied group did not show significant differences and thus sterilization cycles would not affect mini-plate's mechanical properties (18). They compared their results with those of Adelson et al. (19) in which craniofacial plating systems were tested for torque to fracture after 10 and 50 autoclaving cycles without any noticeable effect on the integrity of the titanium mini-plates.

According to Eliades et al. eleven retrieved mini screws after successful service of 3.5 to 17.5 months in orthodontic patients were compared with as-received ones. They performed vickers microhardness test and reported no differences between the groups which indicated that no strain-hardening phenomena occurred (20). Estelita et al. evaluated the influence of recycling process on the mechanical strength of orthodontic mini screws. They compare four groups: new mini screws, mini screws inserted in pig iliac bone and removed mini screws underwent sonication for cleaning and autoclave sterilization, and mini screws who had sandblasting (Al2O3-90 μ) in addition to and autoclave sterilization. They broke the mini screws and measured the fracture torque and finally it was observed that recycling did not change the torsional strengths of the screws. The authors considered the diameter of the screws as the main factor affecting their torsional strengths (21). Mattos et al. compared the fracture torque of 5 commercially available min screws with one cycle of autoclaving with the control group and reported that autoclave sterilization did not affect their resistance to fracture. They considered the brand of mini screws as the more influencing factor on a mini screw torsional fracture (22). Instrumented indentation testing did not showed any differences between used an as-received mini screws in another recent study (23).

3.2. Primary Stability and Clinical Success

Akyalcin et al. evaluated the effect of repeated sterilization on the primary stability of orthodontic mini-screws. They cycled the min-screws of four different brands five and ten times and then insert them in synthetic blocks that stimulated mandibular bone. Maximum insertion torque and lateral displacement force were measured. They concluded that the differences between mini-screw groups in terms of maximum insertion torque, was very brand-specific and they reported no clinical relevance between the stability of mini-screws when they were sterilized up to 10 times (6). El-Wassefy et al. compared new mini screws with those sterilized with one of the three methods of autoclave, Ultraviolet, and Gamma ray. They inserted the screws into the tibia of rabbits for 1 month. After sacrification, all mini screws of the four group were steady and showed a good mechanical fixation while they were probed by forceps. There was not any inflammation or adverse tissue reaction in any of the groups (24).

3.3. Histologic and Microscopic Characteristics

Catharino et al. evaluated histologic, histomorphometric and bone density around (in-office-sterilized) or-

thodontic mini-implants with or without immediate load. They inserted the mini-implants into the tibiae of 18 rabbits and immediate load (50 cN) was applied on half of them. Cortical bone thickness was measured by digital radiographs and bone sections were stained and underwent histologic study. Finally they reported a 100% success for the whole mini-implants. However, they did not compare it with unsterilized implants (for ethical reasons) or with factory-sterilized ones. They claimed that in-office sterilization is safe relative to those sterilized by the manufacturers and also have lower cost (25).

In the study of Eliades et al. who compared the retrieved and as-received mini screws, scanning electron microscopy and X-ray microanalysis indicated some alterations in the morphology of mini screws and optical microscopic evaluations showed that the retrieved mini screws had some discoloration and gloss-loss. Some materials was also precipitated on the surface of screws including phosphorus, calcium, sodium, potassium, chlorine and iron in the form of sodium chloride, potassium chloride, and some other substances related to oral biologic fluids. However, no alterations in the bulk structure of the mini screws was reported by X-ray microtomography analysis (20). Same results in the terms of loss of gloss and precipitation of bone-like materials including calcium, sodium, phosphorus was also reported by Schatzle et al. (23).

In another study also the surface of sterilized mini-implants were analyzed by scanning electron microscopy to find out any deformation. The samples were tested after being drilled and removed in artificial bone for four times. Head deformation and distances between threads were also measured. They also reported no structural deformation and suggested that mini screws can tolerate at least four cycles of insertion, removal, and sterilization (26).

In the study of El-Wassefy et al. who compared the three methods of sterilization (autoclave, Ultraviolet, and Gamma ray), the scanning electron microscopy (SEM) did not show any significant changes in the topography of mini screws. However, it was reported that the surfaces of screws got smoother and their tips was not as sharp as the new ones. They also mentioned some abrasion marks which might be the result of the insertion-removal procedure. Histologically, the authors recommended the autoclave method better than the other two for mini screw sterilization. Although, they believed that sterilized mini screws would never be the same as new ones in the issue of surface morphologic, ion release, and histologic cell response (24).

4. Conclusions

- Sterilizing the temporary anchorage devices seems not to affect the mechanical properties of the devices according to the following tests: penetration resistance test, surface roughness test, traction test, bending test, static traction test, fracture torque test, micro-hardness test, and instrumented indentation test. According to many studies, the two factors of TAD manufacturer (commercial brand) and the size of TAD (diameter and length) are the main factors affecting the mechanical characteristics of TADs.

- Regarding the primary stability and clinical success rate of sterilized temporary anchorage devices, very few studies are available (on synthetic blocks of bone or animal bones). According to available data, sterilized TADs were as stable as the original ones. However, these studies only considered very short duration. (not more than one month has been reported yet.) Not any randomized clinical trial had yet considered this issue. It is recommended for further studies to compare the success rate of sterilized TADs in clinical set-up although, it could be quite difficult to design such clinical studies due to ethical affairs and multiple interfering factors.

- Histologic and microscopic evaluations revealed that mostly retrieved TAD showed some microscopic alterations in their surface morphology including loss of gloss, loss of sharpness, and precipitation of materials which can be the result of the insertion and removal process, exposure to biological fluid in oral tissue or sterilization cycles.

- There is a high variety in the available studies' methodology, in the terms of the applied TADs, mechanical tests, materials in which TADs are inserted, the number of sterilization cycles, and the sterilization protocols which make it difficult to reach a clear outcome regarding the effect of sterilization on the clinical success of temporary anchorage devices. These factors make further well-designed study and a subsequent systematic review on this issue necessary.

Footnotes

Authors' Contribution: Atefe Saffar Shahroudi designed the study and performed the searches. Behrad Tanbakuchi wrote the article and submitted it.

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