Comparison of Tensile Strength of Orthodontic Wires when Subjected to Sterilization

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Abstract

Objective: The purpose of this study was to evaluate changes in tensile strength of 0.016" Beta- Titanium and Nickel Titanium wires after sterilization.

Materials and method: Four common methods of sterilization /Disinfection methods - Dry heat, Autoclave, Ultrasonic cleaner and 2% Glutaraldehyde, were evaluated in three test trials involving zero, one and five sterilization cycles. For each of the test trials, five pieces each of 0.016" Beta-Titanium and Nickel Titanium wires were sterilized using a standard dry heat sterilizer. Five other pieces of each of the same wires were sterilized in an autoclave, five pieces in ultrasonic cleaner, while an additional five pieces of each of the two wire types were sterilized using 2% glutaraldehyde.The ultimate tensile strengths of the wires were determined using an universal testing machine. The data were compared for statistical difference using analysis of variance.

Results: Dry heat sterilization significantly increased the tensile strength of Beta-Titanium (TMA-Titanium Molybdenum Alloy) wires after one cycle but not after five cycles. Autoclaving, Ultrasonic cleaning and Gluteraldehyde did not significantly alter the tensile strength of Beta-Titanium wires. Dry heat and autoclave sterilization also significantly increased the tensile strength of Nickel Titanium Wires, but the mean strength after five sterilization cycles was not significantly different than after one cycle. Ultrasonic cleaner and gluteraldehyde did not significantly alter the tensile strength on the Nickel Titanium Wires.

Keywords: Sterilization, Beta Titanium wire, Nickel-Titanium wire, Tensile strength.

INTRODUCTION

Recent advances in orthodontic material technology have resulted in a varied array of wires that exhibit a wide spectrum of properties. With continued research, several other alloys with desirable properties have been adopted in orthodontics. These include Cobalt - Chromium, nickel-titanium, beta-titanium, multi-stranded stainless steel wires and many others.

The newer orthodontic wires display an excellent combination of strength, resiliency and low-load deflection rates. But, one of the drawbacks of these wires remains their comparatively high cost. Beta-titanium wires are approximately three times more expensive than stainless steel arch wires, while nickel-titanium wires are usually twice as expensive. These two types of titanium wires are extremely popular and it is unlikely that orthodontists will discontinue their use due to high price. As a consequence of both cost factor and indispensable desired mechanical properties, some clinicians are prompted to sterilize and reuse these wires.[1,2,3]

The reports of surveys done on the use of recycled wires in orthodontic practice indicate a high rate of prevalence. However, majority of the clinicians using recycled wires were found to be concerned with the deterioration of mechanical properties of the wires after subjecting them to sterilization.[4] The changes in the tensile strength will have a direct impact on clinical re-use of the wire. If a wire's ultimate tensile strength is decreased due to sterilization / disinfection, it is more prone to breakage, which presents a problem for the patient and orthodontist alike.[3,5]

The ability to recycle orthodontic wires relies on effective sterilization prior to re-use without resulting in deterioration of their clinical properties and without causing health hazard to the patient. The present study was undertaken to evaluate the changes in the tensile strength of Beta titanium and Nickel Titanium wires after repeated sterilization.

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MATERIALS AND METHODS:

The sterilization methods investigated were dry heat (Techno media, at 375 F for 20 mins), Autoclave (Kavoklave, at 250 F for 20 mins under 15 psi pressure), Ultrasonic cleaner (Biosonic, Whaledent, for 15 mins) and 2% gluteraldehyde (korsolex for 8-10 hours). Beta Titanium (TMA, ORMCO) and Nickel titanium (Ortho organizers) wires were tested.

Sample Grouping:

Test Wire Segment: Two groups of 45 segments, each representing 7" straight length 0.016" Beta Titanium (A) and Nickel Titanium (B) wires were procured.

The above two groups were further divided into three sub groups depending upon the number of sterilization/disinfection cycles they underwent prior to tensile strength testing.

(I) Group A – consisted of 45 segments of Beta Titanium wires grouped as below

- **A_0** - Consisted of 5 segments of as received wires (control group).
- **A_1** - Consisted of 20 segments, which were subjected to one sterilization cycle.
- **A_5** - Consisted of 20 segments, which were subjected to five sterilization cycle.

(ii) Group B - Consisted of 45 segments of Nickel-Titanium wires grouped as below

- B_0 - Consisted of 5 segments of as received wires (control group)
- B_1 - Consisted of 20 segments, which were subjected to one sterilization cycle.
- B_5 - Consisted of 20 segments, which were subjected to five sterilization cycle.

For the first test trial, five segments of each Beta-Titanium and Nickel Titanium (Subgroups A_1 and B_1) were sterilized one time using one of the four sterilization/disinfection methods: dry heat, autoclave, ultrasonic cleaner or 2% glutaraldehyde. The ultimate tensile strength of each wire segment was then tested.

The samples were prepared for tensile strength testing by embedding the ends of the wire into acrylic blocks. Lengths of all wire samples were standardized to 7 inches. The acrylic blocks aided in attaching the wire samples to the universal testing machine.

A 500 kg load-cell was attached to the universal testing machine and was set with a cross-head speed of 1mm/min. The tensile strength recorded was the maximum stress value in KgF just prior to fracture of the test wires. Only those breaks which occurred within the inter-grip span were recorded.

For the next test trials, the same procedure was repeated for five segments of 0.016" Beta-Titanium and five segments of 0.016" Nickel-Titanium wire (subgroups A_5, B_5), which were sterilized five times, using one of the four sterilization/disinfection techniques. As before, the wires' tensile strengths were tested and recorded. All the listed samples were tested within seven days of their respective sterilization treatments.

The final group of five segments of each type of wire (subgroups A_0, B_0) served as the control group and their tensile strengths were determined without any sterilization /disinfection procedures.

Statistical Analysis: Tensile strength was expressed as Mean and Standard deviation. Intergroup comparisons were made by one factor ANOVA followed by Newman-Keul's Range test for pair wise comparisons.

RESULTS

The results of the ANOVA tests evaluating the tensile strength of Beta-Titanium and Nickel- Titanium wires were as follows.

Beta-Titanium: The tensile strength of the Beta-Titanium wires after zero, one and five cycles of dry heat sterilization revealed that dry heat significantly increased the tensile strength of the Beta-Titanium wires after one cycle. However, there were no significant differences in the tensile strength of unsterilized wires and wires sterilized five times. Autoclave sterilization of Beta-Titanium wires showed no statistical differences in the tensile strength following zero, one and five cycles. Ultrasonic cleaning and cold sterilization with 2% Glutaraldehyde did not have any effect on the tensile strength of Beta-Titanium wires after zero, one and five cycles.

Nickel-Titanium: - The tensile strength of Nickel-Titanium wires after zero, one and five cycles of dry heat sterilization demonstrated a significant increase when compared. Yet, Newman-Keul's Range test did not demonstrate a significant difference in tensile strengths between one and five cycles. Autoclaving Nickel-Titanium wires produced a statistically significant increase in the tensile strength after one and five sterilization cycles. However, the mean tensile strength after five cycles was not significantly different than after one cycle. Ultrasonic cleaning and cold sterilization with 2% glutaraldehyde did not have any effect on tensile strength of Nickel-Titanium wires after zero, one and five cycles.

The average tensile strength of the two types of wires following sterilization is summarized in the table I.

Table 1: Ultimate Tensile strength of 0.016" Beta Titanium and Nickel-Titanium wires with Standard deviations in N/mm²

Wire	Sterilization method	0 cycle	1 cycle	5 cycles
TMA	Dry heat	1087±48	1282±57	1212±95
NiTi	Dry heat	1226±11	1382±60	1364±31
TMA	Autoclave	1087±48	1251±75	1238±161
NiTi	Autoclave	1226±11	1366±54	1382±29
TMA	Ultrasonic cleaning	1087±48	1086±41	1084±65
NiTi	Ultrasonic cleaning	1226±11	1232±8	1233±19
TMA	Glutaraldehyde	1087±48	1091±38	1088±47
NiTi	Glutaraldehyde	1226±11	1222±15	1234±14

DISCUSSION

When considering the reuse of Orthodontics wires one must evaluate the effect of sterilization/disinfection on the physical properties of wires.

The purpose of the present study was to examine the effect of repeated cycles of four different methods of sterilization/disinfection on tensile strength of Beta-Titanium and Nickel-Titanium wires. Tensile strength was chosen as the parameter as it has a direct impact on the clinical use of a wire.

The four different sterilization/disinfection techniques adopted in the present study were those which are commonly practiced in an orthodontic set-up. The results of the present study suggest that sterilisation and reuse of Orthodontic wires does not alter the tensile strength as expected.

In this study the tensile strength of both Beta-Titanium and Nickel-Titanium wires increased after sterilization using dry heat or autoclave. Dry heat sterilization produced statistically significant increase in the tensile strength of Beta-Titanium wire following one cycle, and produced no further statistically significant increase in the same following five cycles. Dry heat sterilization of Nickel-Titanium wires produced increase in its tensile strength, when sterilized one time than when sterilized five times. However, these differences were not statistically significant.

Autoclave sterilization did not significantly alter the tensile strength of Beta-Titanium wires. This sterilization procedure however significantly increased the tensile strength of Nickel-Titanium wires, though the mean strength after five sterilization cycles was not significantly different than that after one cycle.

Cold sterilization using Glutaraldehyde or Ultrasonic cleaning did not alter the tensile strengths of any of the two types of wires.

Hence, the results of the present study suggest that the currently accepted regimes for sterilization/disinfection do not have any detrimental effects on the mechanical properties (viz., tensile strength) of the BetaTitanium and Nickel-Titanium wires. The results are in accordance with findings of Buckthal and Kusy (1988)[6], Mayhew and Kusy (1988)[7] and Sung Ho Lee and Young Il Chang (2001)[8].

In a 1986 survey, Buckthal et al[6] had reported that 52% of the orthodontists using Nickel-Titanium wires were recycling them, and 55% of these orthodontists were concerned about the changes in the physical properties of the Nickel-Titanium wires resulting from heat sterilization. This explains the reluctance of the orthodontists in using heat sterilization for recycling. This is despite the fact that the temperatures used in the manufacturing process are far higher than those encountered during heat sterilization procedures. Furthermore, the findings that autoclaving was not detrimental to the wires' performance should allay the concerns of those who avoid heat sterilization techniques (Thompson and Bogues, 1977; Buckthal et aI., 1986) for recycling them[5].

The results of this investigation added scientific credence to the clinicians' who have been saying that the performance of recycled BetaTitanium and Nickel-Titanium wires were clinically acceptable, as there was no overall statistically significant difference in tensile strengths of as received versus sterilized wires. These findings agree with the work of Smith, Von Fraunhofer and Case[9] did on Nickel-Titanium and Beta-Titanium wires.

Thus wire recycling maybe one method of reducing Orthodontic practice overhead. However not every wire maybe recycled. Beta-Titanium wires with bends are not candidates for recycling since the same bends will rarely fit more than one patient. Nickel Titanium wires are usually placed without orthodontic bends which make these wires ideal for sterilization and reuse. Still, breakage and patient abuse of these wires may prevent them from being recycled.

One must consider whether reduction of overhead achieved through recycling outweighs the risk of contamination between patients. Whether or not recycling is a practical method of reducing overhead must be left for every practitioner to decide.

CONCLUSION

The results of this study suggest that the Orthodontists who choose to recycle Beta Titanium and Nickel Titanium wires need not be concerned about reducing the wires' ultimate tensile strength by sterilization procedure.

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