A COMPARATIVE EVALUATION OF EFFECTS OF DIFFERENT KINDS OF STERILIZATIONS ON LOAD DEFLECTION CHARACTERISTICS, TENSILE PROPERTIES OF COPPER NITI WIRES- AN INVITRO STUDY

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ABSTRACT: Copper NiTi wires were introduced by Sachdev a R and Miyasaki S in 1994. This latest innovation in the evolutionary scale gives us the opportunity of choosing the force level by choosing the temperature at which the wires will deliver its optimum force level. With so many advantages and their ability to return to their original form coupled with the high cost of copper NiTi many clinicians started reusing the wire. This raises concern about disinfecting/sterilizing the wire before using in another patient for prevention of cross infection. Hence, various sterilization procedures like cold sterilization using 2% acidic glutaraldehyde, dry heat sterilization and autoclaving were used to prevent this cross infection. Aim: The main aim of this study is used to evaluate the effects of different kinds of sterilization on load characteristics and tensile properties of copper Ni Ti wire.

Materials and Methods: In the present study, selected mechanical properties like load deflection characteristics, ultimate tensile strength of the 0.016 copper NiTi wires were studied before and after sterilization procedure. Three point bending test was performed to evaluate the load deflection characteristics and tensile test were evaluated to determine other mechanical properties. Pretreatment and post treatment values were statistically analyzed by one way ANOVA test.

Results: On the load deflection characteristics, even though there was an increase in the loading and unloading forces, statistically significant changes in the forces are seen only when the wires were subjected to two cycles of sterilization with autoclave and dry heat. No detrimental changes were detected in tensile properties of copper NiTi were after single cycle of sterilization with any of the stated sterilants. Very minimal non significant changes occurred during the second cycle of sterilization procedure.

Conclusion: Pronounced changes in load deflection characteristics have been found in the wires which have undergone two cycles of sterilization with either dry heat or autoclave implying that there was loss in pseudoplastic and pseudoelastic properties of wires and increase in stiffness of wires.

KEYWORDS: Copper NiTi, sterilization, load deflection, Tensile properties

INTRODUCTION

Orthodontic therapy is a force management procedure largely based on the use of metal wires for storing and distributing therapeutic forces. Archwires are an important constituent of modern orthodontic appliances, as they directly determine the characteristics of force generation and consequentially, of the tooth movement. In orthodontic mechanotherapy, the requirements of the wire changes from the initial phase of treatment to the finishing stage. In earlier periods, Gold and Stainless steel were used and this was effected by altering the cross section of the wire i.e., from small to large, and its geometry i.e., round, square and rectangular. This strategy of wire selection and usage is called “Variable cross-section Orthodontics”.

Two new arch wire materials with a major component of titanium became available in the 1970’s The first Nickel titanium (NiTi) orthodontic alloy, introduced by ANDREASEN, was known as Nitinol (NiTi - Nickel Titanium; NOL - Naval ordinance laboratory) were based on the original research of BUEHLER who developed special NiTi alloy having two remarkable properties that were unique in dentistry-“shape memory and super elasticity.” In the nineties nickel titanium archwires like copper NiTi and Neosentalloy, that are superelastic and thermodynamic were introduced. By taking advantage of the body temperature and setting the alloy transformation temperature (Af) for the martensitic transformation, precise control of the memory phenomenon can be effected. This is called “Varying transformation temperature Orthodontics”.

Copper NiTi alloy wires, a quaternary alloy of Copper, Nickel, Titanium and chromium is a recent introduction in the family of NiTi alloy wires with active austenitic grains. They were introduced by ROHIT SACHDEVA AND SUCHIO MIYASAKI in 1994 and have distinct advantage over Nickel-Titanium alloys.
The copper NiTi are more resistant to permanent deformation and generate a more constant force over longer activation spans than NiTi alloy wires, and also a nearly constant force for very small activations. Incorporation of a smaller ratio of copper combined with more sophisticated manufacturing and thermal treatment processes made it possible, for the fabrication of different copper NiTi archwires with precise and constant transformation temperatures at 150, 270, 350 and 400°C. This along with its low deflection rates has made copper NiTi the best among the contemporary aligning archwires.

As a consequence of both the cost factor and need for retention of elastic properties after clinical usage, it has prompted some clinicians to reuse these archwires. This raises the concerns about the treatment of wires between patients for prevention of cross-infection. Few studies exist concerning the reuse of the copper- NiTi wires following treatment with currently accepted sterilization techniques.

**Aim of the study**

The aim of this study was to compare and evaluate the load deflection characteristic changes, tensile properties of round 0.016 copper NiTi arch wires before and after three different types of sterilization procedures viz. Cold sterilization by immersing the wire in undiluted 2% glutaraldehyde solution, autoclaving the wire at 121°C, Dry heat sterilization at 160°C, for the purpose of subsequent clinical reuse.

**Materials and Methods**

The study was designed to evaluate the effects of three different types of sterilization procedures on load deflection characteristics, Tensile properties of Copper NiTi wires (ORMCO) (Fig.1, Fig.2).

**Experimental design:**

For each test, 56, 51mm wire segments each obtained from the manufacturer were used. Out of these 8, wires were removed and kept as control group and the remaining 48 wires of each were divided randomly into two groups.

- **Group I** - Consist of 24 wires out of which
  - 8 wires receive 2% glutaraldehyde – 10 hrs without dilution
  - 8 wires receive dry heat sterilization – 1 hrs 160°C
  - 8 wires receive steam auto clave – 121°C, 15-20psi for 20 minutes.
- **Group II** - consists of 24 wires out of which
  - 8 wires receive 2% glutaraldehyde – 20 hrs without dilution
  - 8 wires receive dry heat sterilization – 2 hrs 160°C
  - 8 wires receive steam auto clave – 121°C, 15-20 psi for 40 minutes.

Base line data was obtained on control wires. Control wires did not receive any sterilization treatment. Group I and Group II were tested after one and two sterilization cycles and were compared with control group.

**Test Methods:**

Three point bending tests, tensile tests (using Instron Universal Testing Machine Co. Mass) were conducted on copper NiTi wires before and after sterilization.

**Load deflection changes:** The load deflection changes in wires tested, were determined by the use of a three point bending jig (Fig.3) similar to the one proposed by Miura et al. The procedure involved the three point bending of a wire across a 14mm span and tested on an Instron Universal Testing Machine, having a load cell capacity of 100 Kg, and a full scale sensitivity of 0 to 500 gms.

**Three point bending test:** The jig consisted of an upper member with two steel poles and a lower member with one steel pole. The steel poles were of 5mm diameter. Two 0.022 inch standard edgewise stainless steel medium twin brackets were bonded with super glue (Sun Medical Co. Japan) to the steel poles on the upper member and the distance between the poles adjusted such that the mid axis of the two brackets were 14mm apart. The upper member was then attached to the load cell, while the lower member was attached to the cross head of the testing machine (Instron-4487 Universal Testing Machine Co. Mass) such that the single pole of the lower member was midway between and just above the level of the two brackets(Fig.4). A straight buccal segment of each wire was ligated to the two brackets with elastic modules (Elastiks, Unitek Corp, Calif). The crosshead of the testing machine was activated such that, the lower member of the jig moved downwards at a rate of 1mm/min, deflecting the wire as it moved for a total distance of 1.5mm. The cross head was reversed, maintaining the same speed as the wire was unloaded. The readings were noted at intervals of 0.3mm, from 0 mm to 1.5mm during loading, and from 1.5mm to 0mm during unloading. Mean loads were plotted against deflection on an X-Y recorder. After each run, the wire was removed, a new wire was ligated to the bracket, and the procedure repeated.

**Tensile properties:** Tensile tests were done using the Instron- 4487, with an intercross head distance of 100mm and cross head speed of 3mm/min. The test was performed at room temperature. As the wire diameter was small, the wire slipped from mechanical grips of Instron machine during testing. Thus the grip was changed from mechanical to pneumatic grip. The specimen was slowly loaded along it long axis.
All the data obtained was statistically analyzed by using one way ANOVA test. In addition, Scheffe ‘F’ test was done to provide information on the differences in the load deflection characteristics of the wires between any two time points at a predetermined confidence level of 95%.

Results
Load deflection changes: (Table I and II) (Fig.5 to Fig.11) Control copper NiTi wires demonstrated a unique nonlinear loading and unloading curve, reflected by the relatively straight segment of load deflection curve. The above mentioned sterilization procedures produced loading and unloading forces which are different from that of control group. Group II autoclave i.e., the wires which were subjected to two cycles of the sterilization procedures, showed significant increase in loading forces from that of the control group. The p value being 0.0001 (p < 0.05) showed that, there was significant difference in the loading force between the groups. Loading forces of control group differed from that of Group II dry heat with Group II dry heat recording higher loading forces for same amount of deflection. The p value between the groups being 0.0010 (p > 0.05) showed that, it was significant. Further more, comparison between Group I and Group II loading forces showed only one significant result i.e., between Group I autoclave and Group II autoclave (p = 0.004). Unloading forces also showed the same trend, when the wires were subjected to sterilization procedures showing increase in the force amount for same amount of deflection. But of all these groups, the group showing significant increase in unloading force levels were Group II - Autoclave & Group II – Dry heat. Comparison between control group with Group II – Dry heat showed p value of 0.0495 (p < 0.05) and with Group II - Autoclave showed p value of 0.0410 (p < 0.05). Comparison between Group I and Group II did not reveal any significant difference of unloading forces at any given deflection.

Ultimate Tensile Strength: (Tables. III) (Fig.12) The ultimate tensile strength of 0.016 copper NiTi control group, when compared with that of first cycle of 2% Glutaraldehyde, autoclave and dry heat showed a change of 0.2%, 0.4% and 0% respectively, but with second cycle the values changed to - 0.5%, - 3.0% and - 4.8% respectively, indicating higher values for experimental groups during record cycle. But, the p value between these groups and control group was 0.3025 (p < 0.05) indicating that these changes were of not any statistical significance.

Discussion
Orthodontic therapy is a force management procedure largely based on the use of metal wires for storing and distributing therapeutic forces. The mechanical properties
of arch wires are important considerations in the construction of an orthodontic appliance.

The new alloy copper NiTi, developed by Rohit Sachdeva and Sachio Miyasaki\(^4\) has an added advantage over Nitinol alloy wire. The new alloy copper NiTi, does not exhibit any hysteresis, thus providing equal loading (engaging) and unloading (tooth driving) forces. This makes it easier to insert large sized rectangular as well as round wires without patient discomfort. It also generates more consistent tooth movement as the wire is active longer in optimal force range. Copper NiTi develops approximately 20% less loading force, hence creates less trauma and patient discomfort. Around the rest position, however, the decrease of force generated in copper NiTi is less than that of nickel titanium alloys. This explains the clinical efficiency of copper NiTi to continue working even as teeth near their intended position.

Numerous physical and mechanical properties can be used to describe orthodontic wires. The intent of any such list is to characterize clinically significant parameters. Therefore, load deflection changes, ultimate tensile strength, yield strength, percent elongation, modulus of elasticity, and surface topography are important, not only because they are basic material properties which can be measured with standardized laboratory procedures, but also, because they are closely associated with appliance property. The present study was undertaken to evaluate the effects of three different types of commercially available sterilants on selected mechanical properties of copper NiTi wires. The mechanical properties evaluated were load deflection changes, modulus of elasticity, 0.2% yield strength, percent elongation, ultimate tensile strength and surface topography.

Three point bending test as described by Miura et al and modified by Kapila\(^5\) was used to determine the load deflection characteristics and tensile loading test was used to determine other mechanical properties of orthodontic wires. The bending and tension test were conducted primarily to determine the fundamental stiffness and inherent strength. The stiffness and strength are necessary to calculate elastic property ratio on basis of following relationship

\[
\text{Strength} = \text{stiffness} \times \text{range.}
\]

Only if the strength and stiffness changes after treatment will the elastic property ratio change, thereby indicating a change in clinically important wire mechanical properties. The scanning electron microscopic picture of surface topography before and after storage or treatment provide a picture of any onset of tarnish or corrosion because of recycling.

The stress-strain curves in bending can be obtained by following cantilever bending test as with a Tinius Olsen stiffness Tester or a torquemeter, or by the three point bend test as designed by MIURA\(^4\) or by the four point bending test as proposed by KUSY\(^6\) or by five point bending test as suggested by NIKOLA\(^7\). Out of these, here we used three point bending test proposed by MIURA as this method of testing is claimed to have the following characteristics:

- The results are reproducible and repeatability is maintained.
- It accurately differentiates between wires possessing super elastic features.
- It actually simulates the application of wire pressure on the tooth in the oral cavity.

NIKOLA\(^7\) states that the three point bending test is in essence a pair of mirror imaged modified cantilever test as specified in ADA specification no: 32. In the present study, the three point bending test involved the use of Instron universal testing machine at a cross head speed of 1mm/min. The loading and unloading forces were registered by the load cell and plotted against displacement on X-Y recorder for each specimen. These values were recorded at intervals of 0.3 mm, from 0 mm to 1.5mm during loading, and from 1.5mm to 0mm during unloading. This was a slight deviation from what was earlier done by Kapila S\(^5\), wherein they recorded the values at 0.2mm intervals, this was done only for better convenience. Mean loads were plotted against deflection for all samples. Loading and unloading characteristics were analyzed separately for the wires, since these two characteristics represent the potential clinical behaviour of the wire during activation and deactivation respectively. Such a distinction in analysis of these two characteristics helped to simplify the interpretation of findings and in relating the findings to the changes expected in the clinical performance of the wire.

Tensile bending test was also performed with an Instron Universal Testing Machine. The specimen was slowly loaded along its long axis and the load was plotted as a function of specimen extension. From the load deflection data, modulus of elasticity, 0.2% Yield strength and percent elongation. Ultimate strength were calculated. The wire sample tested in the present study were of diameter 0.016 inch copper NiTi (ORMCO corp. California). 

Load deflection changes: The three point bending test used in the present study provides information on clinically pertinent characteristics of the wire. When a wire is deflected to place it in a bracket on a malaligned tooth, it is subjected to loading. The inherent tendency of the wire on loading is to try to return to its original shape or to unload, provided that its elastic limit is not exceeded during loading. This unloading of the wire represents its spring back and provides the force required to cause biologic tissue response, which tends to move the tooth into alignment. The loading portion of the graphs obtained from three point bending test in the present study
stimulates the activation of the wire, whereas the unloading segment of the graph provides some information on the forces associated with the wire as it undergoes deactivation. Therefore, the unloading forces associated with the wire provide some indication of its potential clinical behaviour. The basic requisites of elastic wires are stiffness, strength, range, formability, frictional resistance, joinability, bio-compatibility, environmental stability and esthetics.

**Stiffness:** This is a force / distance ratio, i.e., a measure of resistance to deformation. It is a measure of the force required to bend or deform the material through a definite distance. Stiffness is proportional to the slope of the elastic portion of load deflection curve (modulus of stiffness) or stress-strain curve (modulus elasticity/young's modulus). The more horizontal the curve, the stiffer the wire. A low stiffness is desirable as it provides: The ability to apply lower forces. More constant force over time as the appliance experiences de-activation. Greater ease and accuracy in applying a given force.

**Strength:** It is a force value that is a measure of the maximum possible load, the greatest force that the wire or the arch arrangement can sustain/deliver, if it is loaded to the limit of the material. Three different parts on the stress-strain diagrams can be taken as representative of the strength of a material. Each represents in a somewhat different way, the maximum load that the material can resist i.e. the proportional limit, yield strength and ultimate tensile strength. The mechanical properties of the wire can be determined by utilizing either the tensile or the bending mode of loading. The latter mode is preferred, since it is considered to be more representative of clinical
### Table 1: Summary Of Load Deflection Change (mgm) at Different Deflection Points In Different Study Groups (Loading changes)

<table>
<thead>
<tr>
<th>Study Group</th>
<th>Deflection points</th>
<th>0.3</th>
<th>0.6</th>
<th>0.9</th>
<th>1.2</th>
<th>1.5</th>
</tr>
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<tbody>
<tr>
<td>Control Group</td>
<td></td>
<td>51.15 ± 4.677</td>
<td>104.56±10.990</td>
<td>129.86±10.104</td>
<td>147.25±8.679</td>
<td>165.68±3.393</td>
</tr>
<tr>
<td>Group I- 2% Glutaraldehyde</td>
<td></td>
<td>55.58 ± 0.764</td>
<td>117.74±1.043</td>
<td>134.73±0.942</td>
<td>154.01±1.013</td>
<td>172.28±1.732</td>
</tr>
<tr>
<td>Group I- AutoClave</td>
<td></td>
<td>57.24 ±2.340</td>
<td>107.73±3.479</td>
<td>136.10±7.606</td>
<td>152.68±6.353</td>
<td>170.51±6.331</td>
</tr>
<tr>
<td>Group II- AutoClave</td>
<td></td>
<td>75.54 ±7.457</td>
<td>137.39±10.155</td>
<td>166.03±10.247</td>
<td>186.11±10.750</td>
<td>204.09±16.922</td>
</tr>
<tr>
<td>Group II- DryHeat</td>
<td></td>
<td>66.48 ±6.172</td>
<td>131.45±12.263</td>
<td>172.00±15.392</td>
<td>191.55±20.088</td>
<td>203.08±18.510</td>
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</table>

**ANOVA Result for comparing load deflection change (mgm) between study groups**

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean sum of squares</th>
<th>F value</th>
<th>p_value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Due to deflection</td>
<td>4</td>
<td>515501.723</td>
<td>128875.43</td>
<td>1137.23</td>
<td>0.0001</td>
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<tr>
<td>Due to groups</td>
<td>6</td>
<td>43286.678</td>
<td>7214.44</td>
<td>66.36</td>
<td>0.0001</td>
</tr>
<tr>
<td>Error</td>
<td>269</td>
<td>30484.245</td>
<td>113.324</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>279</td>
<td>589272.646</td>
<td></td>
<td></td>
<td></td>
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</table>

### Table 2: Summary Of Load Deflection Change (mgm) at Different Deflection Points In Different Study Groups. (Unloading changes)

<table>
<thead>
<tr>
<th>Study Group</th>
<th>Deflection points</th>
<th>0.3</th>
<th>0.6</th>
<th>0.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group</td>
<td></td>
<td>2.25 ± 0.129</td>
<td>18.61 ± 5.281</td>
<td>41.15 ± 4.784</td>
</tr>
<tr>
<td>Group I— 2% Glutaraldehyde</td>
<td></td>
<td>2.45 ±0.919</td>
<td>21.68 ± 6.139</td>
<td>43.21 ± 5.38</td>
</tr>
<tr>
<td>Group I— AutoClave</td>
<td></td>
<td>5.68 ±2.377</td>
<td>26.51 ± 7.348</td>
<td>45.26 ± 8.255</td>
</tr>
<tr>
<td>Group I— Dry Heat</td>
<td></td>
<td>6.51 ± 2.621</td>
<td>40.73 ± 14.655</td>
<td>55.00 ± 12.103</td>
</tr>
<tr>
<td>Group II— 2% Glutaraldehyde</td>
<td></td>
<td>8.23 ±2.811</td>
<td>24.14 ± 6.260</td>
<td>44.06 ± 6.548</td>
</tr>
<tr>
<td>Group II— AutoClave</td>
<td></td>
<td>15.43 ±7.226</td>
<td>41.44±14.419</td>
<td>57.29±13.924</td>
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<tr>
<td>Group II— DryHeat</td>
<td></td>
<td>9.17 ±6.932</td>
<td>43.46 ±18.269</td>
<td>57.53±13.381</td>
</tr>
</tbody>
</table>

**ANOVA Result for comparing load deflection change (mgm) between study groups**

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean sum of squares</th>
<th>F value</th>
<th>p_value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Due to deflection</td>
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<td>144632.184</td>
<td>48210.73</td>
<td>572.96</td>
<td>0.0001</td>
</tr>
<tr>
<td>Due to groups</td>
<td>6</td>
<td>9123.99</td>
<td>1520.665</td>
<td>18.07</td>
<td>0.0001</td>
</tr>
<tr>
<td>Error</td>
<td>198</td>
<td>16660.38</td>
<td>84.1433</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>207</td>
<td>170416.55</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
orthodontic use than the uniaxial loading conventionally used. However, it is considered impossible to measure the true modulus of elasticity in bending because bending deformation is considered as having both elastic and plastic components.

Range: It is described as the maximum flexibility, range of activation, range of deflection, working range and is a measure as to how far the wire can be deformed without exceeding the limits of the material. The factors effecting range are wire size and shape, modulus of elasticity of the material, design of the orthodontic appliance, elastic limit. The control copper NiTi wires exhibited a unique non linear loading and unloading curves reflected by relatively straight segment of load-deflection curve. This unique behaviour of copper NiTi wires signifies that these arch wires exert fairly constant forces, whether deflected relatively small or large distances during activation and deactivation. This characteristic of the wire has often been referred to as “Superelasticity” in orthodontic literature, but is commonly known in metallurgic texts as “pseudoplasticity” during loading and “pseudoelasticity” during unloading.

Although the load deflection data from the tests performed on copper NiTi after one and two cycles of sterilization procedures, showed changes from that of the control group (p = 0.0001), the statistically significant change is seen only between the Group II autoclave and Group II Dry heat when compared to control group. On comparison between control groups with Group I wires i.e., wires which had undergone one cycle of sterilization procedure showed a marginal increase of loading and unloading forces. But this marginal increase was not statistically significant. For example, in group I wires, the maximum increase in forces during loading occurred between control group and wires subjected to Dry heat at 1.5mm and amounted to 11.08gms (6.6%), and maximal increase in forces during unloading amounted 9.08gms (12%) at 1.2mm. These statistically insignificant differences may have arisen because of small variability in each sub-sample of sterilized wires. The clinical significance of such modest changes in load deflection characteristics of these wires is therefore open to question.

Copper NiTi wires, which were subjected to two cycles of sterilization procedures, demonstrated significant increases in force levels on loading and unloading. Most of the changes in load deflection characteristic were observed from 0.6mm to 1.5mm on loading and 1.5 mm to 0.6mm on unloading, with the maximum change at 1.5mm in loading and 1.2mm in unloading. Even though, the wires which were subjected to two cycles of 2% Glutaraldehyde sterilization procedures showed an increase of both loading and unloading forces, but these forces, when compared to control group were not statistically significant with p values of 0.1521 (p < 0.05) for loading and 0.8206 (p<0.05) for unloading. These findings reflect similar findings found by Kapila which states that cold sterilization by 2% glutaraldehyde had no effect on the load deflection characteristics even after two cycles of sterilization. There is a significant increase of loading forces, when wires were subjected to second cycle of autoclave, with a maximum increase of 38.41gms (23.1 %) at 1.5mm. In this case, the unloading forces showed an increase of 17.88gms (24.1%) at 1.2mm. The p value for loading and unloading forces of wires subjected to two cycles of autoclave when compared to control group showed 0.0007 (p< 0.05) and 0.0410 (p<0.05) which was statistically significant. The loading and unloading forces of the wires subjected to two cycles sterilization with dryheat showed a significant increase on comparison with control group wires. P values for loading and unloading on comparison in above groups showed 0.0010 (p< 0.05) and 0.0495 (p< 0.05) This confirms the earlier investigation done by Kapila in which he stated that NiTi wires subjected to dryheat sterilization showed statistically significant increase in loading and unloading forces.

On comparison of the control with clinically recycled copper NiTi most of changes observed in the load deflection characteristics occurred after second cycle of sterilization, where as substantially smaller changes were observed between 1st cycle and 2nd cycle. There is a general tendency of increased loading and unloading forces in copper NiTi wires after recycling. In addition, there appeared to be loss in pseudoplasticity and pseudoelasticity, and an increase in stiffness of the wires as indicated by an increased slope of the loading and unloading curves (Fig.5 to11). The findings of the previous studies together with those of the present investigation, suggests that alterations in load-deflection characteristics of copper NiTi wires occurs largely after 2nd cycle of sterilization with autoclave and dry heat.

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Table 3. Mean values of Ultimate Tensile Strength for the Studied groups

<table>
<thead>
<tr>
<th>Study Group</th>
<th>Mean ± SD</th>
<th>p_value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.2227 ± 0.01056</td>
<td>.3025</td>
</tr>
<tr>
<td>Group I — 2% Glutaraldehyde</td>
<td>0.2231 ± 0.0096</td>
<td></td>
</tr>
<tr>
<td>Group I—Auto Clave</td>
<td>0.2227 ± 0.0040</td>
<td></td>
</tr>
<tr>
<td>Group I — Dry Heat</td>
<td>0.2237 ± 0.0085</td>
<td></td>
</tr>
<tr>
<td>Group II — 2% Glutaraldehyde</td>
<td>0.2248 ± 0.02100</td>
<td></td>
</tr>
<tr>
<td>Group II—Auto Clave</td>
<td>0.2308 ± 0.00718</td>
<td></td>
</tr>
<tr>
<td>Group II— Dry Heat</td>
<td>0.2345 ± 0.01201</td>
<td></td>
</tr>
</tbody>
</table>
Ultimate Tensile Strength: (Tables I and II, Fig.12)

This is one of the mechanical properties of the arch wire which is clinically significant and is determined using a tensile test. In clinical practice, force levels such as those obtained at UTS is seldom reached because it is obviously un-biological. Nevertheless, it is an indication of the total force that can be delivered before the wire itself becomes misshapen from the form in which the orthodontist has placed it in the brackets.

In the present study, tensile property determination for copper NiTi controls had a range of UTS from 0.212 to 0.238 Msi. After any sterilization procedure the ultimate tensile strength resulted in mean values that fell within the range of control values, except for wires undergoing 2nd cycle of sterilization having a range of 0.196-0.248 Msi. The ‘F’ test or Analysis of variance is done to determine the statistical significance of any change in the property. The ‘F’ probability value for UTS by one way ANOVA is (0.3025) (p>0.05), indicating that it is not significant.

CONCLUSION

The perceived relative high cost of NiTi wires and their ability to return to their original form has led to their reuse. Finally the following conclusions can be drawn from the present study,

- There was an increase in loading and unloading forces exhibited by the wires, treated by any of the above sterilization procedures as the number of cycles subjected to increases.
- No statistically significant changes seen in loading and unloading forces after 1st cycle of sterilization procedures.
- Cold sterilization with 2% acidic glutaraldehyde showed no changes in load deflection characteristics and tensile properties of these copper NiTi wires even after undergoing two cycles of sterilization.
- Pronounced changes in load deflection characteristics have been found in the wires which have undergone two cycles of sterilization with either dry heat or autoclave implying that there was loss in pseudoplastic and pseudelastic properties of wires and increase in stiffness of wires.
- Dry heat sterilization and autoclaving have been found to have very minimal changes on the tensile properties of these wires after one or two cycles of sterilization procedures, but not statistically significant.
- Results support the use of these sterilization procedures as part of infection control process, if the clinician select to reuse these wires for one time only. However, of late, since there is easy availability and modest cost of these wires it is recommended to use new wires which are supplied sealed sterilized packs for each patient to comply with present admissible standard of hygiene and sterilization.

References


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Vol. - III Issue 3 Jul – Sep 2011 35