Torsional Properties of Commercial Chinese-made Nickel Titanium Wires During Deactivation

Vachara Phetcharakupt, Sirawish Sathapana*, Chaturaporn Junsuriyapong, Naphasorn Kributra, Suphakarn Romrasri, Tiwat Traijakvanich and Wanlapar Wichaisakul

Faculty of dentistry, Rangsit university, Patumthani 12000, Thailand
*Corresponding author, E-mail: sirawish.s@rsu.ac.th

Abstracts

Deactivated torsional property of the commercial Chinese-made nickel-titanium (NiTi) wires two different wire sizes was studied, which were 0.016x0.022 inch and 0.017x0.025 inch at the twisted degree of 21, 18, 15, 12, 9, 6 and 3 respectively. The two Chinese made NiTi wires, Unnamed Chinese1 [UC-1] and Unnamed Chinese2 [UC-2]), which are available and generally using were chosen. Two standard branded NiTi wires (3M-Unitek and Ormco) were used as reference wires. Ni-Ti (Ormco), Nitinol SE (3M-Unitek), UC-1, and UC-2, which were different in cross-sectional area, were compared by dividing them into 8 subgroups (two groups for each brand). Each group had 10 wires. This study was conducted on a maxillary model by using Lyoyd Universal Testing Machine to test the activated and deactivated forces of each wire. The differences in the different torsional moments were compared by the t-test and ANOVA. The results show that UC-2 wire had the highest deactivated torque when comparing with the other three groups. While UC-1, on the contrary, had shown the lowest deactivated torque in both 0.016x0.022 inch and 0.017x0.025 inch groups in all the degrees of testing. Most of the deactivated torque obtained in Nitinol SE(3M-Unitek) and Ni-Ti (Ormco) were in between those in UC-2 and UC-1. In conclusion, Chinese made NiTi had various torqueing moment that gave higher and lower torque that commonly used NiTi wire manufacturing from America but Chinese-made NiTi in some degree exhibit force in the optimal torqueing moment of 1-2 Ncm.

Keywords: *Orthodontic wire, Deactivated torsional property, Chinese made NiTi*

บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาแรงบิดขณะคืนกลับของลวดนิกเกิลไทเทเนียมที่ผลิตในจีน 2 ขนาด คือ 0.016x0.022 นิ้วและ 0.017x0.025 นิ้ว ที่บิด ณ 21, 18, 15, 12, 9, 6 และ 3 องศา ด้วยเหตุผลที่ลวดนิกเกิลไทเทเนียมที่ผลิตในจีน 2 ยี่ห้อ คือ Unnamed Chinese 1 (UC-1) และ Unnamed Chinese 2 (UC-2) ซึ่งเป็นลวดที่หาซื้อได้ง่ายและใช้ทั่วไป กับลวดมาตรฐานนิกเกิลไทเทเนียม 2 ยี่ห้อ คือ Ni-Ti (Ormco) และ Nitinol SE (3M-Unitek) เพื่อใช้อ้างอิงในการเปรียบเทียบ อย่างละ 2 ขนาด 0.016x0.022 นิ้วและ0.017x0.025 นิ้ว ดังนั้นจึงสามารถจำแนกกลุ่มตัวอย่างทดลองได้ 8 กลุ่ม โดยแต่ละกลุ่มจะใช้ลวดนิกเกิลไทเทเนียมอย่างละ 10 เส้น ซึ่งศึกษาแรงบิดขณะดึงและขณะคืนกลับของลวดนิกเกิลไทเทเนียมด้วยเครื่อง Lloyd Universal Machine ในห้องปฏิบัติการ และเปรียบเทียบความแตกต่างด้วย T-test และ ANOVA ผลการศึกษาพบว่าลวดนิกเกิลไทเทเนียมที่ผลิตในจีน ยี่ห้อ UC-2 ให้มีแรงคืนกลับสูงที่สุดเมื่อเปรียบเทียบกับลวดอื่นอีก 3 ยี่ห้อ แต่ในทางตรงข้ามยี่ห้อ UC-1 มีแรงคืนกลับต่ำที่สุดในลวดทั้งสองขนาด 0.016x0.022 นิ้วและ0.017x0.025 นิ้วในทุกองศา โดยพบว่าแรงคืนกลับของลวดยี่ห้อ 3M-Unitek และ Ormco โดยส่วนใหญ่ ยังคงอยู่ระหว่างในช่วงแรงคืนกลับของลวด นิกเกิลไทเทเนียมที่ผลิตจากจีนทั้ง 2 ยี่ห้อ ลวดนิกเกิลไทเทเนียมที่ผลิตจากประเทศจีนยังมีการให้แรงที่ต่างกัน โดยมีทั้งชนิดที่ให้แรงมากกว่าและน้อยกว่า ลวดในไทที่ผลิตจาก ประเทศอเมริกา แต่ทั้งนี้นั้นลวดที่ผลิตจากประเทศจีนในบางองศาก็ยังให้แรงที่อยู่ในช่วงแรงบิดที่เหมาะสมในการเคลื่อนฟัน1-2 นิวตัน เซนติเมตร

คำสำคัญ: *ลวดจัดฟัน ผลิตจากประเทศจีน แรงบิดขณะคืนกลับ*

1. Introduction

Nowadays, orthodontics plays an important role in the society because people's appearances tend to become more powerful factors for people who work in many careers. Today's treatment of choice for malocclusion is orthodontic treatment. Tooth movement can occur when the applied forces adequately overcome the friction at the bracket slot-arch wire interface (Hirai et al., 2012; Queiroz, Rino Neto, De Paiva, Rossi, & Ballester, 2012). High levels of frictional force between the bracket slot and the arch wire which might cause binding between the two components (Monteiro, Silva, Elias, & Vilella Ode, 2014). The clinician can choose from a large variety of different bracket systems and also from a wide range of alloys including selection of an arch wire for straight wire mechanics (Wichelhaus, Geserick, Hibst, & Sander, 2005). Orthodontics helps to correct the malalignment teeth (improve function) and also improves the patient esthetic and the orthodontic wires is one of the important components to move the teeth into the proper position (Archambault et al., 2010).

In dentistry, Nickel titanium (NiTi) wire is widely used for dental orthodontic applications because of its high-quality mechanics (Ren, Bai, Wang, Zheng, & Li, 2008). There are many types of dental wires in orthodontic treatment which play a significant role to improve efficiency without teeth in tissue damaging (Monteiro et al., 2014). There are many countries that have developed a dental wire including Chinese-made NiTi. Chinese-made NiTi wire began to play a role in Thailand. From the researcher survey, it was found that the advantage of NiTi made in China is economic because it is cheaper than others. But the quality of wire was questionable because they do not reveal the manufacturers identity so it is difficult to decide which brand is suitable for orthodontic treatment. The purpose of this research is to study the torqueing moment during deactivation of the wires, making it easier for the dentist to make a decision.

NiTi wires are commonly used in orthodontics (Ren et al., 2008); China-made NiTi would become more well-known and more popular in the near future. However, some researches mentioned that the research on Chinese NiTi wires is hardly found and there are not many researchers studying about NiTi. So, this research would like to provide more information on NiTi made in China. Researchers are expecting that Chinese made NiTi wires would be widely recognized not only for a specialist but general dentists also.

2. Objective

To study the deactivated torsional property of the commercial Chinese made nickel-titanium (NiTi) wires in two different wire sizes which are 0.016x0.022 inch and 0.017x0.025 inch at the twisted degree of 21, 18, 15, 12, 9, 6 and 3 respectively.

3. Materials and methods

3.1 Sample collection

Experimental analysis of torque characteristics of orthodontic wires and torsional properties of commercial nickel titanium wires during activation and deactivation were performed according to Partowi et al. (2010) and Gurgel et al. (2001) respectively. From this study they used 10 samples groups (Partowi et al., 2010) and 5 samples groups (Gurgel et al., 2001). For this experiment, 12 samples of each NiTi wire were used, ignoring the highest and the lowest torque moments measured. A sample of the remaining 10 samples were taken for analysis and evaluation.

3.2 Material and instruments

Tooth 21 was taken off from dentoform and 0.018 inch archwire brackets (Standard zero) were attached to the remaining tooth. Then custom leveling arm was made by attaching 0.018 inches bracket at tip of 3-inch length stainless steel to represent tooth 21. The instrument was set-up with Lloyd universal testing machine to measure the value of NiTi wire.

3.3 Data analysis

ANOVA was used for detecting the difference of deactivated torque within the group for both 0.016x0.022 inch and 0.017x0.025 inch wire sizes. T-test was then applied to compare between the two of each sample which came out to the total of 168 pairs.

4. Results

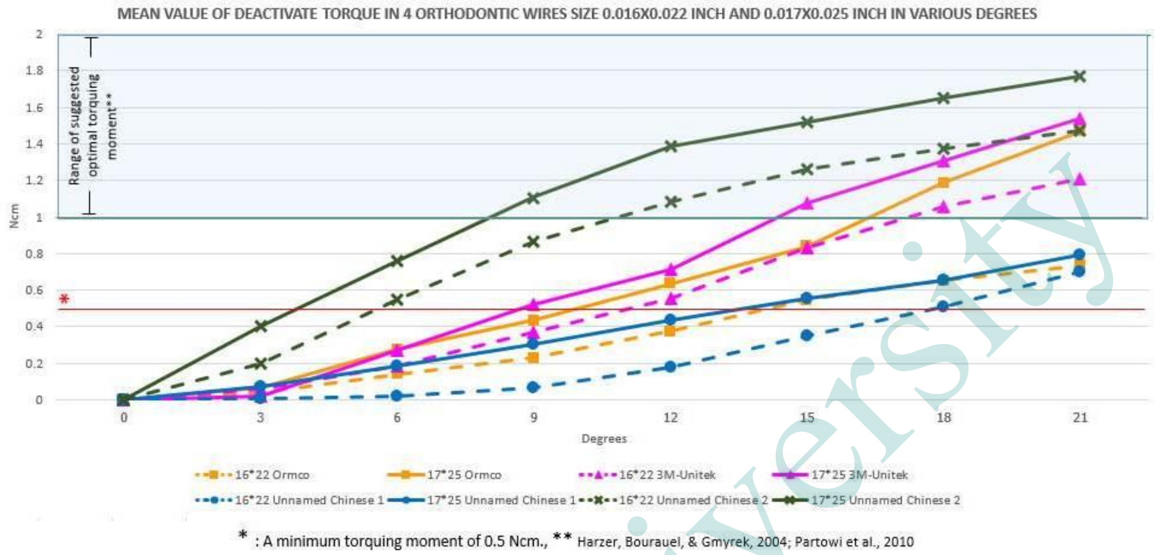

Figure 1 Mean value of deactivate torque in 4 orthodontic wires sizes 0.016x0.22 inch and 0.017x0.025 inch in various degrees

UC-2 wire showed the highest deactivated torque when comparing with the other three groups. While UC-1, on the contrary, had shown the lowest deactivated torque in both 0.016x0.022 inch and 0.017x0.025 inch groups for all tested degrees.

Most of the deactivated torque obtained in Nitinol SE (3M-Unitek) and Ni-Ti (Ormco) were in between those in UC-2 and UC-1. Nitinol SE (3M-Unitek) and Ni-Ti (Ormco) wires size 0.017x0.025 inch had presented no significant different in deactivated torque in the tested degrees of 21, 12, 9, and 6. Nitinol SE (3M-Unitek) wire size 0.016x0.022 inch had significantly higher deactivated torque than Ni-Ti (Ormco) in the same size except only in tested degree of 6 and 3. At the highest tested degree, UC-2 wire size 0.016x0.022 inch had shown no significant difference in deactivated torque to Ni-Ti (Ormco) and Nitinol SE (3M-Unitek) size 0.017x0.025 inch. At the tested degree of 3, most of the wires showed no difference in deactivated torque except in UC-2. The standard deviations of Nitinol SE (3M-Unitek), Ni-Ti (Ormco), UC-1, and UC-2 at degree of 21 were 0.076 0.060, 0.089, and 0.144 respectively. (Figure 1)

5. Discussion

5.1 Torque Testing Machine

Many studies used torsiometer to measure torqueing moment of the wires (Gurgel et al., 2001; Hirai et al., 2012; Partowi et al., 2010). Some studies have simulated the palatal root torque of the teeth by setting up the dentoforms and measure the torqueing moment occurred on the bracket (Bolender et al., 2010; Filleul & Constant, 1999).

The major drawbacks from using torsiometer are the setting that may not represent the real situation on the teeth and the wire tested can only be in straight-line form.

Our study had set up the dentoforms to simulate the torqueing moment on the teeth use the pre-curved arch form that is generally used orthodontically.

5.2 Temperature Control

Many in vitro studies had shown attempts to simulate the oral cavity environment. Temperature is one of the factors that affect the property of the wires. Bolender et al. (2010) and Filleul and Constant (1999) controlled the testing temperature at 37°C by using thermostat water-bath. Gurgel et al, 2001 used the oven to control the temperature at 35°C while Partowi et al. (2010**)** used acrylic glass hood and a regulated heating system maintained a constant temperature at 37°C.

For our study, the temperature control system was somehow similar to Partowi et al. (2010) but making it more convenient and more affordable. We have applied the idea of "hatching incubator" in which the acrylic glass box was customized and the hatching heat generator was then used to maintain a constant temperature of 37°C. The accuracy of this incubator was claimed to be ±0.5°C. However, the disadvantage of using this system is the waiting time to warm the temperature up to the setting temperature.

Another benefit for our designed system is that the tested wire can be changed effortlessly when compare with the other closed systems.

5.3 Wire types and sizes

In our study, we have chosen Nitinol SE (3M-Unitek) and Ni-Ti (Ormco) wires for their worldwide acceptance and they are commonly used in most of the wire studies. For the commercial Chinese-made NiTi, since there was no actual brand of these wires, we have named them as Unnamed Chinese 1 (UC-1) and Unnamed Chinese 2 (UC-2). Both of them are the wires that are commercially available in Thailand and generally used in orthodontic clinic. The wire size of 0.016x0.022 inch and 0.017x0.025 inch were chosen for the reason of their popularity in clinically used.

5.4 Deactivated Torque

The result of our study for 0.017x0.025 inch for Nitinol SE has demonstrated the average of torqueing moment at 1.54 Ncm, which are comparable to the results studied by Bolender et al. **(**2010). In contrast to the result for 0.016x0.22 inch for Nitinol SE has shown a much higher torqueing moment than the results studied by Meling and Odegaard (1998). The assumption for the difference could be due to the different settings where Meling and Odegaard used the torsiometer while our study used the dentoforms setting.

In regards to the torque value measured in our study, Reitan (1964) suggested the minimal torqueing moment for root torqueing movement is at 0.5 Ncm. In addition, the optimal torqueing range was hypothesized to be at 1-2 Ncm. (Burstone, 1966).

Our study revealed that UC-2 0.017x0.025 inch, UC-2 0.016x0.022 inch, 3M 0.017x0.025 inch, Ormco 0.017x0.025 inch, and 3M 0.016x0.022 inch had started to reach the optimal range at the tested degree of 9, 12, 15, 18, and 18 consequently. While UC-1 0.016x0.022 inch, UC-1 0.017x0.025 inch, and Ormco 0.016x0.022 inch had not reached the optimal range even in the highest tested degree.

Although UC-2 had shown the highest deactivated torque in most tested degree, it may result in an unnecessary pain to the patient.

5.5 Suggestion for future research

As the result of commercial Chinese-made NiTi wire has shown the wide variations of deactivated torque, this may suggest more types of Chinese-made NiTi wire should be included in the study.

In our study, the efforts had been made to maintain the same environment in each experiment. However, due to the sensitivity of the testing machine, the error was sometimes unavoidable and can possibly be seen as the wide variation between the wire types. Therefore, this may suggest that all the wires should be either tested all at once or all types of wire should be equally tested in each experiment.

6. Conclusion

Solid conclusion still cannot be drawn regarding the deactivated torsional property of Chinese-made NiTi since the results have shown a large variation, both higher and lower than the reference NiTi wires. However, Chinese NiTi wires, at some tested degree, have shown the torque values that were within the suggested optimal range (the optimal torqueing range was at 1-2 Ncm). Therefore, this study could give orthodontists some suggestions regarding Chinese-made NiTi wires as follows:

1) The Chinese NiTi wires could be unexceptionally used in some degrees of torsional movement. As the results of Chinese-made NiTi wires demonstrated wide variations of deactivated torque, more types of Chinese-made NiTi wires should be studied in further studies. In our study, all efforts have been made to maintain the same environment for each experiment. However, due to the sensitivity of the testing machine, some errors were unavoidable and can possibly because of variations among the wire types.

2) The manufacturers have played an important role and could be the key factor in determining the property.

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