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Review Article

Pain perception and patient discomfort between various dimensional initial nickel-titanium wires – A review

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ABSTRACT

The key to a successful orthodontic therapy depends not only on manual skills and knowledge about treatment steps but also on knowledge and choice of materials used. One of the major components of fixed orthodontic therapy is the choice of wires. Orthodontic wires are defined as devices consisting of a wire conforming to the alveolar or dental arch, used as an anchorage in correcting irregularities in the position of the teeth. The history of these materials is as old as that of fixed orthodontic treatments and they present different features. With proper general knowledge, doctors can differentiate between wires and use the sufficient wire sequence suitable for each patient. This can increase the quality of treatment. Therefore, the aim of the present review is to assess the pain perception and patient discomfort between various dimensional nickel-titanium wires as well as the sequence of leveling wire selection according to the treatment plan.

KEY WORDS: Alignment, Orthodontic wires, Sequence preference

INTRODUCTION

Fixed orthodontic appliance treatment uses archwires to exert force on teeth.

Treatment is carried out in stages and selection of appropriate archwires contributes to the treatment success.[1] There is no one archwire ideal for all stages of fixed appliance treatment. The initial archwire is the first archwire to be inserted into the fixed appliance at the beginning of the treatment and is used mainly for correcting crowding and tooth rotations. This usually takes about 10 weeks but can be up to 20 weeks where teeth are very irregular. There is general agreement that light, continuous forces (also known as optimal forces) are the most desirable to achieve controlled and predictable tooth movement with minimum harm to the teeth and supporting tissues.[2-4]

The initial discomfort experienced during orthodontic treatment for the first couple of days after force application is generally accepted as inevitable. Most orthodontic appliances deliver a relatively complicated set of forces and moments that are indeterminate and not quantitatively predictable.[5] Many factors have been assumed to affect the perception of pain, namely the intensity and duration of applied forces, age and gender, degree of crowding, structure of wires, patient's psychological background, and past experiences. There is a traditional belief of the existence of a relationship between the amount of force applied to the tooth and the degree of pain experience. Existing literature has indicated that patients may feel tension, pressure, soreness of teeth, and pain as a result of orthodontic treatment.[6,7] The prevalence of experiencing at least some degree of pain among subjects ranges from 70 to 95%.[8]

The forces delivered by the archwires depend largely on the physical properties of the wire material and dimension of the wire. The initial archwires must be biocompatible and ideally have as follows:

1. Low stiffness to deliver light forces on activation;
2. Good range to be able to maximize activations so there is elastic behavior over weeks to months;
3. High strength and resistance to permanent deformation;
4. Ease of engagement within fixed appliance attachments within a reasonable time scale;
5. Low cost.[9]

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Precious metal alloys (e.g., gold) were historically used for the fabrication of initial archwires for many years but high material costs limited their use and they are now virtually obsolete in orthodontics.[10] Stainless steel replaced gold, offering comparatively good strength and springiness, corrosion resistance, and low cost. Stainless steel archwires can be bent to almost any desired shape without breaking. Increasing the length of wire using loops increases the flexibility of the archwire to enable use as an initial aligning archwire. This can be time consuming as each wire must be customized, by the orthodontist, for the individual patient.[11] Another method of increasing the flexibility of stainless steel archwires was the development of a multistrand wire. Multistrand wires are generated by twisting two or more strands of a small diameter wire (≤0.01 inch), therefore, turning a springy wire into a cable. Among stainless steel wires, multistrand wires offer an impressive combination of strength and spring qualities. The properties of multistrand wires depend both on the characteristics of the individual wire strands and on how tightly they have been woven together during their manufacture.[12]

Nickel-titanium (NiTi) alloys have been widely used in orthodontics, especially at the beginning of orthodontic treatment. This is mainly due to their good mechanical properties, biocompatibility and ductility, resistance to corrosion, lower elastic modulus, superelasticity, and shape memory effect. The superelasticity is the property of NiTi alloy to deflect on loading without plastic deformation and return to its preformed shape after unloading.[13] The alloy can be deformed up to 8% strain, which is useful in leveling severely misaligned teeth.[14] Shape memory heat-activated NiTi archwires can return to their original shape, recovering from large strains throughout heating. While superelasticity is induced by stress, shape memory is initiated when the alloy in martensite phase is warmed and transformed to stable austenite phase in the specific range of temperature transformation.[15] The deflection of heat activated alloy can generate locally stress-induced martensite, which is unstable at oral temperature and undergoes reverse transformation to austenite as soon as the stress from misaligned teeth is relieved.[16]

Wire is very pliable in the areas of crowded teeth exerting continuous force until the teeth move into a new position and reduction in deflection occurs.[17]

Thus, the aim of this review is to assess the effects of initial NiTi archwires for the alignment of teeth with fixed orthodontic braces in terms of the rate of tooth alignment, amount of root resorption accompanying tooth movement, and intensity of pain experienced by patients during the initial alignment stage of treatment.

Pain Perception among Patients

Pain and discomfort are commonplace after insertion of an initial archwire during orthodontics and are reported at some stage during treatment by 91% of patients and following each appointment by 39%.[18] The level of pain reported after archwire placement is believed to be greater and more prolonged than that following extraction of teeth. Discomfort peaks on the morning after placement of an archwire remained at this level for 2–3 days before abating at 5–6 days.[19] The fear of potential pain related to treatment affects the uptake of orthodontic care.[20] Furthermore, treatment discontinuation and poor compliance have been attributed to discomfort experienced in the early stages of appliance therapy.

Pain may be elicited by heavy pressure placed on the tooth with an instrument or by normal mastication, or it may arise spontaneously;[21] pain is known to be influenced by psychological, sociocultural, and environmental factors, making objective evaluation difficult. The experience of pain is measured indirectly, and the visual analog scale (VAS) is the most reliable method of measuring pain perception.[22] The variations in individual responses to insertion of orthodontic archwires have led several groups of investigators to look for factors that could be helpful in predicting which patients will experience the most pain. Discomfort may be influenced by a number of factors including the force generated by the archwire, the ligation technique, soft tissue ulceration, or difficulties with mastication.[23] Burstone[24] identified an immediate pain response related to the periodontal ligament (PDL) being compressed immediately after archwires placement, and a latter response – hyperalgesia, related to changes in the blood flow and correlated with the presence of prostaglandins, substance P, and other substances.

Non-linear relationships have been shown between pain experienced after initial archwire placement and archwire material and age; social class; degree of force applied; dental arch relationships; and dental crowding.[25] It is not surprising that the use of preemptive and post-operative analgesia has been shown to reduce pain scores.[26]

NiTi Archwires

Fixed orthodontic appliances include a wide variety of archwires as means of delivering forces on teeth. Light and continuous forces are desirable to achieve physiologic tooth movement with minimum pathological effect on the teeth and their surrounding structures.[15]

Such force reduces the potential for patient discomfort, tissue hyalinization, and undermining resorption. When force is applied, the archwire should behave elastically over a period of weeks to months.

It has been suggested that superelastic NiTi archwires are capable of producing light continuous forces capable of achieving fast tooth movement with minimal patient discomfort and tissue trauma.[27] However, this theoretical advantage of superelastic NiTi wires over other archwires is based solely on *in vitro* testing, and to be validated; this should be assessed clinically. Few studies evaluated the pain intensity experienced by patients during the initial alignment stage of treatment with different archwires.[13,14] Bearing these studies in mind, there are no definite conclusions as to which archwire is associated with the least pain.

Therefore, this review aims to evaluate the pain experience during the initial aligning phase of orthodontic treatment with three types of NiTi wires:

Superelastic NiTi, thermoplastic NiTi, and Nitinol aligning archwires. Further aims were to examine any possible associations between age, gender, and degree of crowding/teeth irregularity and the pain intensity.

DISCUSSION

A study by Marković *et al*.[28] was performed on a sample of 189 orthodontic patients who were given the modified McGill Pain Questionnaire with VAS to assess the quality and intensity of pain after insertion of initial NiTi orthodontic wire as a part of fixed appliances. It is well known that correct measurement of pain is an essential part of its evaluation and adaptation of methods to control it. Following insertion and ligation of six different NiTi wires, subjects perceived pain. In the study, 0.014 inch diameter wires were used for leveling in the first phase of orthodontic treatment to produce light forces even in cases with the most severe crowding. No differences in pain perception between patients with 0.014 and 0.016 inch NiTi archwires were found. The difference in pain response was not found when superelastic NiTi wires, conventional NiTi wires, and stainless steel wires were compared. The quality and intensity of pain was not in correlation to the degree of dental crowding as well as the type of archwire. Since the pain during orthodontic treatment is mostly associated with the level of compression of the PDL, it may be hypothesized that both superelastic and heat-activated NiTi archwires generate equal response of the PDL and blood vessels initiating the similar type of pain perception.

The mechanisms by which pain arises when orthodontic force is applied are not completely understood. It has been suggested that pain perceptions are due to blood flow changes in the PDL.

Other studies have indicated the presence of prostaglandins, substance P, and other substances to be associated with discomfort. Two types of pain have been described in the past literature including the immediate and delayed pain responses to orthodontic treatment.[29] Immediate response can be explained by the initial compression of the PDL. The delayed response is due to the partial compression of the PDL that still allows blood flow and overtime results in hyperalgesia of the PDL which lowers the patient's pain tolerance. This type of pain develops a few hours after appliance placement and is caused by an increased sensitivity to prostaglandins, histamines, and substance P.[30]

It has been previously reported that the magnitude of the force applied to teeth corresponds to the experienced pain.[17] Two previous studies that attempted to compare pain intensities associated with application of different force magnitudes using a split-mouth design found that higher forces were associated with stronger pain.[20,21] Therefore, the use of lighter forces has been recommended to reduce pain. However, other studies have found no relationship between the applied force and associated pain,[27] and the controversy on whether or not light forces will decrease the degree of pain during tooth movement remains unanswered.

In vitro studies revealed that superelastic NiTi wire demonstrates more superior properties than conventional NiTi alloy archwires.[8] Lombardo *et al*.[31] stated that copper NiTi showed significantly lighter forces and longer plateau, which corresponds to continuous force than conventional NiTi of the same diameter. This has led to enhanced use of copper NiTi archwires compared with conventional NiTi in anticipation of providing the light, constant, and continuous force required for physiological tooth movement, along with the absence of tissue hyalinization and reduced patient discomfort. Superelastic NiTi wires are recommended in terms of reduced tissue trauma, minimal patient discomfort, and rapid tooth movement by applying light continuous forces.

Fernandes *et al*.[18] evaluated pain/discomfort during the 7-day period following initial placement of conventional and superelastic NiTi and did not find any significant difference between the groups. In the conventional NiTi group, significantly lower pain levels could be found at 4 h. He also argued that nitinol, a superelastic light force delivering archwire, induces higher pain levels than Sentalloy.

Similarly, Chen *et al*.[19] stated that they could observe no significant difference in recorded pain between multistranded stainless steel and superelastic NiTi archwires during the leveling and alignment stage of orthodontic treatment.

In another study, Abdelrahman *et al*.[32] assessed the pain/discomfort experience in three different types of

NiTi aligning archwires (superelastic, thermoelastic, and conventional) for the first 7-day period after bonding and found no statistically significant difference among groups.

This meta-analysis revealed that superelastic NiTi archwires are not more efficient compared with conventional NiTi archwires in the alignment stages of tooth movement. Regarding sequences of archwires, there is no difference in terms of effectiveness between the heat-activated NiTi archwire sequence and the conventional NiTi archwire sequence. However, the use of a heat-activated NiTi archwire sequence was associated with greater pain intensity at 4 h as well as 1 day after insertion of each archwire.[24]

In a randomized controlled trial, pain perception following the first orthodontic archwire placement was compared between heat-activated and superelastic nickel-titanium aligning archwires. This trial concluded that heat-activated nickel-titanium usage caused less pain. This result can be turned into an advantage during clinical practices comprising highly sensitive patients.[22,23]

In summary, pain recognition has a complex background related to sex, age, force application, ligation technique, soft tissue acceptance, etc. Therefore, the relation of archwire materials and dimensions with pain is still unclear and need further research.

CONCLUSION

Dimensions of archwires can be both advantageous and disadvantageous at the same time. In those with small dimensions, the contact point and friction are less; this has a positive effect on tooth movement and results in a decrease in pain. On the other hand, when the clearance between the wire and bracket sloth increases, the tooth movement control decreases. The same situation allows the clinician to include teeth to the treatment earlier even when they are in crowded and difficult-to-reach positions. Adding these teeth into the treatment during those phases result in movement of more teeth that may increase the pain.[25]

Having a proper knowledge about wire features is mandatory to be a good orthodontist. Thus, doctors can differentiate among wires and use a sufficient wire sequence suitable for each patient. This can increase the quality of treatment. According to literature reviewed, there are still some points that have not been clarified in the existing studies. There is a necessity to conduct further and broader studies on initial archwire preferences and the sequence that should be used.

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