TO COMPARE AND EVALUATE THE DEFLECTION PRODUCED ON VARIOUS ORTHODONTIC WIRES WHILE CRIMPING METAL STOPS WITH THE NOVEL CALIBRATED CRIMPING PLIER AND THE CONVENTIONAL CRIMPING TECHNIQUES

By

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Under the guidance of

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2019-2022

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled **"To compare and evaluate the deflection produced on various orthodontic wires while crimping metal stops with the novel calibrated crimping plier and the conventional crimping techniques"** is a bonafide and genuine research work carried out by me under the guidance of ***Prof. Dr Binnoy Kurian*** , Professor and Head of the Department of Orthodontics& Dentofacial Orthopaedics, St Gregorios Dental college ,Chelad, Kothamangalam

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ABSTRACT

Background/ objectives – Stops are crimpable orthodontic Auxillaries which have varied uses in orthodontic appliance system. Crimping stops often cause functional and microesthetic adverse effects. Presently there is no proper plier for crimping without producing deflection in archwire. The purpose of the study is to compare and evaluate the amount of deflection on various orthodontic archwires on crimping metal stops with a conventional and a novel calibrated plier.

Method – Two types of archwires - Cu NiTi and stainless steel, are chosen for the study. Four groups of archwires, Round Cu NiTi, Rectangular Cu NiTi, Round Stainless steel, Rectangular Stainless steel - 40 in number in each group are selected. Each group consists of four intra group wire sizes and 10 sets of wires in every sub group. A total of 160 wires, are selected for the study. Mean crimping force for each set calculated using a force resistor and arduino hardware. Two sets of the wires were crimped,one with the conventional crimping plier and other with a novel calibrated plier designed for the purpose. The crimping process was done by 10 experienced Orthodontists. Deflection produced was measured with a measuring electronic meter attached to a custom designed special jig.

Results and Interpretation – The results were verified and analysed. Test of significance was set as P< 0.05. Independent T test , two way ANOVA tests and Tukey's Post Hoc analysis were done to verify the results. Conventional plier produced noticeable deflections of the Archwires. Whereas novel cimping plier produced minimal or negligible deflection. The present study had limitations.

Keywords - Crimping, Load deflection rate, Frictional coefficient.

INTRODUCTION

Crimpable stops and hooks are orthodontic Auxiliaries which have varied uses in the Orthodontic appliance system. They are rectangular, cylindrical or tubular sleeve-like accessories crimped on to the archwires.They have routine uses as well as special purposes where they are utilized for planned orthodontic and movements.These versatile accessories can be used by a passionate orthodontist to achieve desirable treatment objectives or results.

In spite of having many advantages in regular orthodontic practice, the crimpable stops also have certain undesired effects which often goes unnoticed. Keeping in mind the negative effects of the stops, it could be used cautiously keeping the adverse effects to a minimum. Applying an ideal force with an apt plier in such a way to barely crimp or get a ‘friction-lock’ without slipping is the skill of clinician. If the force applied is less , the stops may not be crimped properly to the Archwire , causing it to slide on the wire. However an increased force may dent the archwire causing deflection of wire.

Usually stops are crimped to the orthodontic wires by the dental operator or orthodontist at chair side . Orthodontic pliers are used for this purpose .

The clinician cannot literally calculate and deliver the ideal force necessary to crimp the stops. The forces beyond the optimal range will dent the stops and deflect the arch wire.

The crimping force of the plier will compress the stops . This in turn will make a dent or bend and the two ends of archwire will be deflected at an angle . The degree of this angle will be determined by the amount of force applied and the type of plier used . Deformation is the result of structural changes occurring within the archwire . When a higher force is applied through a stop or directly on the wire, deformative changes may take place within the wire . The method used to control and measure the force applied during the crimping process of hooks on Archwires has been earlier advocated by Johal[9] et al. in 1999.

Stops are crimped with the crimping plier held parallel to the Archwire. The force applied may create a vertical deflection of archwire. The direction or angle at which the plier is held to deliver the crimping force in the oral cavity cannot always be consistent and parallel to the Archwire . It depends on the patients position and operator ergonomics. When the force could not be delivered as described above, first or third order deflective forces can be generated causing unwanted bends on the archwire. The angle at which the plier is held site of application of the force and the type of archwire are the determining factors in this process. The tip and torque of the teeth may be disturbed in this forces which need to be corrected later, costing extra effort and time.

Stops are crimped to the arch wire with the specially designed crimping pliers or with a worn–out heavy wire cutter. Crimpable stops are different for round wires and rectangular wires and could be crimped at any point on the arch wire as required. Unfortunately, they do not crimp well on small diameter arch wires like 014 NiTi, .014 SS,0.016 NiTi, 0.016 SS etc .

Crimpable hooks are similar to crimpable stops . They have a crimpable body which adapts to the archwire. and has a hook extension from the body. Stops and hooks are usually crimped with any of the handy pliers which could give pointed pressure areas. Mostly small sized bird beak pliers are preffered.

There are varied forms of pliers or their modifications which could be utilized to crimp the plier. There is no designated plier meant to crimp the stops. It is a common practice clinicians use certain pliers which couid be convenient serve the purpose of crimping. Some of the examples bird beak plier, weingardt plier , jarraback plier etc. Different modifications of these pliers are also available in the market. A typical modification of bird beak plier is one such example where there are three beaks , with two lateral square ones and an opposing centralized round beak with a pointed edge. While crimping with the plier there is less deformation of the wire but not predictable at the same time.

All these indicates a necessesity to develop a plier that optimally crimp the stops to the wire, without deflecting the Archwires. The force delivered through the beaks of plier should be a controlled one and should be optimised with proper calibration techniques.

The beaks of the plier should approximate to an extend to provide a ‘friction – lock’, which is ideal to crimp the stops. Such a plier should have the ability to control the force delivered through the beaks . The deflection of the wire then should be almost zero or nill.

In this study the ideal force to crimp a stop in an archwire is found out or measured. The innovative plier used in this study claims to deliver the optimal force necessary to crimp, the Archwires. It is calibrated or designed in such a way so that the above said ideal or the average force to crimp could be delivered consistently for any routine archwire size.

Several studies connected with the crimpable hooks are done earlier . Many pliers designated for crimping the hooks could be used for stops also. The literature found for both are similar.

The usage of stops is more relevant in self-ligating system but finds its applications in contemporary straight wire mechanics too. Round wires , mainly that of stainless steel and nitinol are the prime wires used in both system. They have the drawback of free sliding, especially in self-ligating system. Rectangular wires too do the same to an extend. Cu NiTi wires are more commonly used in self-ligating system. The study was done standard Archwire presently available in the market.

OBJECTIVES OF THE STUDY

1. To measure the mean crimping force applied on the wires by orthodontists.
2. To evaluate the deflection of the orthodontic wire after applying the mean crimping force.
3. To compare the deflection of orthodontic wire while crimping stops using the calibrated crimping plier.
4. To compare the deflection of orthodontic wire while crimping stops using the Novel calibrated crimping plier.
5. To evaluate the deflection of orthodontic wire in degrees which is measured using a special software application ..
6. To compare the deflection of the orthodontic wire between the two methods. (2 and 3)

BACKGROUND OF STUDY

The crimpable stops has been introduced as an auxiliary in the orthodontic appliance for quite a long period of time. Various authors and orthodontists have pointed out its uses as an adjunctive to the main appliance system. The application of crimpable stops has many demerits or undesirable side effects. Any Attempt to crimp the stops on the archwires at diferent locations of the archwire may have adverse effects on micro aesthetics of dentition . The crimping of stops, ideally is the result of the 'friction – lock' that comes to play between the stops and the archwire. The dimension of the wire , shape of the stops and its properties, the frictional coefficient of the archwire material , all have an effect on the crimping property. The force applied for bare crimping or getting resistance to slising has a direct effect on the operator, and his / hers force application. The crimping force most of the times is uncontrollable and may be excess which creates a deflection of the Archwire wire. This deflection of the wire could be minimised with suitably designed plier, that controls the deflective tendency. The plier needs to have a mechanism where the beaks approximates only to give a crimp or friction lock without advancing further transferring the extra force on to the Archwire.

REVIEW OF LITERATURE

- **Kapila S[1] et al 1989** has put up thorough review article which formulates all the clinical mechanical properties , and applications of stainless steel, chrome cobalt, beta titaninium and nitinol. Here the clinician working knowledge of orthodontic wires and their usage. The mechanical properties are depicted by their bending, torsional, and tensile behaviour. Though those tests do not provide the above charteristics they are are an indicator of their clinical behaviour. The desirable charectistics that are necessary for an orthodontic wire are springabilit, formability, resilience,low stiffnes, biocompatibility, high stored energy and environmental stability,low surface friction.weldabilty , sloderarability Etc stainless has advantages with high formability, low stiffness and better biocompatibility.cobalt chromium can be heat treated and maintained to a stage compatible with stainless steel.nitinol has ahifgh formability and springiness. But they are poor in welding and fusing together.multistranded wires have high spring back and low stiffness when compared to stainless steel. Materials are chosen according to the situation and need.

- **Hudgins JJ[2] et al , 1989** conducted a comparative a study to assess permanent deformation after long term deflection of nickel-titanium and beta titanium archwires it was concluded that all the nickel titanium archwires exhibited better spring back characteristics and permanent deformation than the beta titanium wire. The beta titanium wire but out performed the stainless steel wire. It was seen that the newer nickel titanium arch wires exhibited less permanent deformation than the original nitinol wire. There were no significant statistical differences between the deformation means of the newer nickel-titanium archwires ,except for the Orthonol wire.

  The nickel titanium wires exhibited less permanent deformation after a long term load and better spring back properties. Among the various forms of nickel titanium varities there is no much variation in deformation properties . But slight varitions exist among them, especially newer wires like Japanese nitinol and chineese nitinol which is negligible.

- **Kusy RP[3] et al, 1991** did a comparative study frictional coefficients for selected archwire-bracket slot combinations in relation to stainless steel and beta titanium archwires. The coefficient of friction of stainless steel wire is less compared to beta titanium archwires with any type of brackets, metal or ceramic. The static friction between Al_2O_3 and stainless steel is higher. The static friction for beta titanium in dry state is reduced to fifty percent when it is wet.

The study was aimed to find the differncre in friction between ceramic brackets and metal brackets with archwire during retraction force. The study showed that ceramic brackets induced greater friction than metal brackets.the metal surface of archwires were more scratched by ceramic brackets. The microscopic view of ceramic brackets revealed more porosity and roughness on ceramic brackets.
Among the different types of archwires Ni Ti forms the first levelling or initial archwire in the orthodontic appliance system.0.018 NiTi outperforms 0.012 SS and 0.018 Ni Ti outperform 0.014 SS wire. 0.021 x 0.025 and 0.017 x 0.025 Ni Ti wire has less stiffness and more strength and range than 0.016 SS wire.

- **Evans RD[4] et al 1991** had done a laboratory study done, and has come with an average value to ideally crimp a hook in 0.019x 0.025 stainless steel wire to be between 2.97 and 3.33 N. . Whilst the differences were attributed to the lesser physical strength associated with the female operator, nevertheless, the median values were in the order of 3 N. However, excessive force during crimping can cause both distortion of the wire and the introduction of unwanted force into the wire

  The newly designed crimping pliers for use with surgical ball hooks were laboratory tested against the old design. In the past hooks have been lost during the surgical procedure. The new pliers demonstrated an improved "friction lock" over the old design. However, it is still recommended for safety that a continuous ligature be used to tie with the final surgical arch wire to avoid the possibility of displacing hooks from the arch wire during surgical and postsurgical procedures.

- **Kusy RP[5] et al , 1997** has conducted a study and has written a review article about the characteristics of different materials used in the orthodontic appliance system. The materials developed in the metallurgy field and have been used or introduced in the field of orthodontics is quite a number. Several additions of metals are taken up the orthodontists as different alloys with good charecteristics have been introduced to the existing ones. New esthetic wires are preferred , like wires formed out of fibres, with characteristics similar to metal and less flaws. Better metal alloys are those having good formability, strength, stiffnes, soldering capacity, weldability etc. An ideal or better metal is not found yet but what the orthodontists could do is select the material which is apt for the situation or what is intendd to do.

- **Oltjen JM[6] et al 1997** determined clinically relevant deflections by selected different solid and multistranded nickel-titanium and stainless steel orthodontic wires. Twenty specimens of 24 different archwires were studied in both three-point contact and three-bracket bending modes. The unloading or withdrawing force deflection plot of each archwire was expressed by a polynomial regression from which wire stiffnesses or lack of springiness were obtained by mathematical differentiation. Graphs representing the functional relationship between stiffness and deflection are presented. The results of this investigation depicts that wire stiffness can be be made different by not only by changing the size, but also by varying the number of strands and the alloy composition. An equally important finding was the dependence of stiffness on deflection for most of the wires measured. Comparisons were also made between the stiffness values obtained in three-point bending and the three-bracket bending systems. It was concluded that the wire selections in clinical practice include considerations of the alloy type, wire cross-section , and the number of strands.

- **Nattrass C[7] et al , 1997** has conducted an experimental study which was intended to find the force necessary to move teeth in sliding mechanics using crimpable hooks. Three systems of force was delivered, namely- chain elastics, ligature tie with module, and open coil springs. The force through this application was checked with an universl instron machine. And they found the module with ligature tie produced greater force and the open coil springs delivered low force.

- **Griffin JT[8] et al 1998** has done a study was to ascertain the effect of addition of sandblasting and application of dental adhesive in crimpable hooks. Ninety crimpable hooks where paired in 6 groups. Certain groups where sandblasted, others where applied with metabond , panavka 21 and somon . Out of these those sandblasted had withstanding force from dislodging with heavy force

- **Johal A[9] et al, 1999** has conducted an experimental study was to measure the force delivered to attach crimpable hooks securely to rectangular stainless steel archwires, both in vitro and invivo . A specially designed electronic strain gauge or sensor was utilized to measure the force applied by each operator. To confirm ,in vitro testing of the attached hooks was carried out using an Instron Universal Testing Machine. Two operators involved in the study was asked to crimp a total of 80 TP Orthodontic crimpable hooks to 0·019 x 0·025-inch stainless steel archwires. There was a convincing difference between the intra- and extra-oral forces used to produce firmly attached crimpable hooks . However, force testing with instron machine demonstrated no statistically significant difference between the force levels required to displace or bend the crimped hooks for both operator. Better reliability or application of force with crimpable hooks may be achieved by placing them out of the mouth.

No previous study has investigated the magnitude of force used by clinicians to apply crimpable archwire hooks at the chairside. Evans and Jones (1991), in their laboratory study designed to evaluate AO hooks, reported a mean force of between 2·97 and 3·33 N for the two male operators, and 0·88 N for the female operator. Whilst the differences were attributed to the lesser physical strength associated with the different sex.

- **Johal A[10] et al 1999** had published a paper which summarizes important aspects of treatment in periodontaly compromised patients. There is increasing demand from adult patients for Orthodontic treatment, either purely for aesthetics, to improve aesthetics or function following previous disease, or to facilitate the stabilization, restoration or replacement of teeth. Orthodontics may have a major role in the rehabilitation of patients suffering the effects of advanced periodontal disease, but there are a number of important factors to be considered in the management of such patients if the optimal outcome is to be obtained.

The force system obtained through the 3D analysis of a two bracket set up involving a molar and an incisor bracket is significantly different from the previous 2D interpretation of the same.. The force system from a V-bend can be divided into three zones. Each zone represents a unique force system. In (1) no moment is created on the incisor. In (2) the vertical forces reverse direction but are very small in magnitude to be of any clinical relevance, the moments are opposite in direction.If the bend is placed to the incisor, the moment produced are similar and in the same direction.. Archwire bracket interactions involving torsional (third order) and bending (second order) moments created their own unique force systems at each bracket. The relative force system however remained constant across different arch wires with a repeatable pattern being observed as the bend was moved from the incisor to the molar bracket.

- **Johal A[11] et al 2001** The objective of this study was to measure the force applied to attach crimpable hooks securely to rectangular stainless steel archwires, both inside and outside the mouth. A specially designed strain gauge was utilized to measure the force applied by each operator. In vitro testing of the attached hooks was carried out using an Instron Universal Testing Machine. Two operators crimped a total of 80 TP Orthodontic crimpable hooks to 0·019 0·025-inch stainless steel archwires. For one operator there was a significant difference between the intra- and extra-oral forces used to produce firmly attached crimpable hooks (P0·03). However, in vitro testing demonstrated no statistically significant difference between the force levels required to displace the crimped hooks for either operator. The clinical significance of these findings is also discussed. Better reliability of crimpable hooks may be achieved by placing them out of the mouth

Clinicians produce more firmly attached crimpable hooks when they are
placed outside the mouth.
TP crimpable hooks show a wide variation in the force required to dislodge them.

- **Morley J[12] et al, 2001** has stated in thei article the combined effort to improve microesthetics by different specialities. The microesthetics of natural and smile improved dentitions must be combined with macroesthetic considerations. Smile design is a recently attracted new discipline in the area of cosmetic dentistry, and it involves several areas of evaluation and treatment planning. As mentioned earlier, macroesthetic principles are only part of the overall picture; gingival esthetics, facial esthetics and microesthetics are the other three essential components of effective smile design. In addition, occlusal and technical issues also may alter the smile design in both natural and restored dentitions and could influence the longevity of cosmetic treatment. Each patient under ones treatment is unique, representing a special blend of age characteristics and expectations, as well as sex and personality specificity. Macroesthetic concepts provide only guidelines and reference points for beginning esthetic evaluation, treatment planning and subsequent treatment. The artistic component of dentistry—and particularly of cosmetic dentistry—can be applied and perfected by dentists and orthodontists who understand the rules, tools and strategies of smile design

- **Yang WS[13] et al ,2001** evaluated the load deflection property of different wires like stainless steel, TMA and niclel titanium in a plain archwire compared with a multiloop edgewise arch wire (MEAW), its load deflection rate (LDR) incorporated wire. The interbracket span rate was 1:7.54 of the plain stainless steel wire, 1:1.76 of the NiTi, and 1:2.72 of TMA, were one represents the looped archwire. from the study it is relevant that stainless steel has high LDR next ot TMA and nitinol forms the least.

- **Wilkinson PD[14] et al, 2001** investigated the load-deflection characteristics of 7 different 0.016-in initial alignment archwires (Twistflex, NiTi, and 5 brands of heat-activated superelastic nickel-titanium [HASN]) with modified bending tests simulating a number of clinical conditions . Load-deflection tests were carried out on the archwires with 5 type of model designs . Data from selected points from the unloading phase of the generated graphs were statistically scrutinized. Wire deflection was carried out at 3 temperatures (22.0°C, 35.5°C, and 44.0°C) and to 4 deflection distances (1 mm, 2 mm, 3 mm, and 4 mm). Rankings were derived according to statistically significant differences in each test situation. From the study it was noted that the model, wire, and temperature variation were all statistically significant. Twistflex and the 5 HASN wires have similar or comparable results, and NiTi gave the highest unloading values. Model rankings indicated that self-ligating Twin-Lock brackets produced lower friction than regular edgewise brackets. The authors recommend using the gradings from the mechanical test simulations to use the archwires wisely according to the need.

- **Piyabongkarn D[15] et al, 2005** had done a study on Microelectromechanical systems (MEMS) gyroscopes utilising it to measure angular rotation and its applications. Microelectromechanical systems (MEMS) gyroscopes are typically designed to measure angular rate of rotation. A measurement of the angle itself is useful in many applications but cannot be obtained by integrating the angular rate due to the presence of bias errors which cause a drift. This paper presents an innovative design for a vibrating gyroscope that can directly measure both angle and angular rate. The design is based on the principle of measuring the angle of free vibration of a suspended mass with respect to the casing of the gyroscope. Several critical challenges have to be handled before the theoretical sensing concept can be converted into a reliable practical sensor. These include compensating for the presence of dissipative forces, mismatched springs, cross-axis stiffness and transmission of rotary torque. These challenges are addressed by the development of a composite nonlinear feedback control system that compensates for each of the above effects and ensures that the mass continues to behave as a freely vibrating structure. Theoretical analysis and simulation results presented in the paper show that the gyroscope can accurately measure angular rotation.

- **Hollinger A[16] et al 2006** has conducted a study to characterize the behavior of three commercial touch sensors and comment on ways to best use them in interface design with other gadgets. In order to select a touch sensor, the designer has to look to the application to choose which sensor is the most suitable for a given functionality. The FlexiForce showed the highest precision (i.e. the quality that characterizes the capability of a measuring instrument of giving the same reading when repetitively measuring the same quantity under the same prescribed conditions [6]) if compared to both the FSR and the PS3, but with higher noise than the other two.

Pressure and force touch sensors are pervasive in electronic musical instruments. While there are a variety of ways to sense pressures and forces, many instrument builders tend towards force-sensing resistors (FSR). These sensors are often implemented with only two design parameters in mind: their minimum and maximum resistances. While commercial FSRs are qualitative devices are not meant for accurate force measurement, if we want to design electronic musical instruments and interfaces which can compete in terms of expressivity with acoustic ones, care should be taken in choosing and implementing sensors properly.

- **O'Bannon SP[17] et al ,2006** conducted a study to compare the torsional dislodgable force tungsten-carbide coated split crimpable hooks with two other type of hooks. Under the conditions of this in-vitro study, tungsten-carbide coated split crimpable hooks required the same amount of force to torsionally dislodge from a rectangular archwire as soldered brass hooks. Ribbed split crimpable hooks were significantly easier to dislodge than coated split crimpable hooks and soldered brass hooks. The main advantage of coated split crimpable hooks over soldered brass hooks is that they can be applied to an archwire directly in the mouth without removing the archwire. A careful technique is still necessary so that the operator does not undercrimp the attachment (causing premature failure) or overcrimp, which can distort or place unwanted forces into the archwire. Further studies are needed.

- **Bartzela TN[18] et al 2007** has done an investigative study on few wires where selescted and tested for super elasticity.0.16, 0,16x 0,022, 0.018x 0.025 , 00.19 x0.025 niti are the different types of wires for study. Other than thsize these wires had the properties of true super elasticity, border line superelasticity and non superelastic properties.different combination of different wires are chosen these wires re tested for there load deflection property . Three point force brnding test with force has been avocated, the results show that when one clinician selelect the wires he should consider the load deflection of each wire.

- **Burrow SJ[19] et al**, **2009** conducted a study to ascertain the resistance of wire due to friction in self ligating brackets. In vitro studies show that in sliding mechanics with retraction there is notching and binding of archwire and the result of tooth movement is dependant on that. Invivo or in clinical studies the reality of friction affecting tooth movement is less while the notching and binding is the only causative factor in sliding tooth movement . So the outcome is, resistance to bodily tooth movement by sliding has little to do with friction but is largely a binding and release phenomenon that is about the same with conventional and self –ligating brackets . Hence the available data support the fact that there is no time lag with the type of bracket , only the binding phenomenon with the type of bracket is critical.

- **Kumar S[20] et al 2020** has written a review article related to the importance of smile enhancement with orthodontic treatment. Smile aesthetics has been one of the great concern in the modern day patients with great emphasis on smile esthetics . Patient expect smile enhancement after orthodontic treatment. Smile improvement enhances facial esthetics in turn. One most important feature of face attractiveness is improved smile. The emphasis had gone to such an importance of obtaining ideal smile feature after an orthodontic treatment. Smile atractiveness is improvement in macro , mini and micro esthetics of smile.

- **Motta AF[21] et al , 2012** conducted a study to assess how the changes in tip and torque influence the smile perception.Certain tooth characteristics that are usually seen in normal smile are perceived in different levels by different people. There are many unesthetic charecteristics like spacing, embrasure spaces and chipping of teeth. This study was conducted among dental graduate students using other photographs. Together with all other characteristics mentioned above the tilt or tip and the torque if gets worsened it damage the smile perception or beauty of smile.

- **Gomes NL[22] et al 2012** in a study vitro study evaluated the tensile force required to dislodge the cimpable hooks with and without spot welding the dislodging force pattern was different for different companies. A set of spot welding hooks and another group with crimping alone was created. Companies like moreilli, TPS , TP ortho with weld,TP – Tungsten,American orthodontics and American ortho with weld. Etc.the results showed that that AOs surgical and TP surgical ball hooks required reater amount of force to dislodge. The moreilli groupwas comparatively easy to dislodge.The best ball hooks for clinical application was TPs an AOs .

- **Pacheco MR[23] et al , 2012** friction force during sliding mechanics produced with the bracket archwire-ligature The resistance to sliding of archwires is multifactorial it depends on the materials related to it. It may be beneficial or worsen the activities. Friction controls the sliding activities in teeth movement. One such example of the biological problems is the food debris in the wire is one factor which affects the friction in the wire. The physical or mechanical properties which influence teeth movement also should be considered. The technical innovations and the improvement in material qualities has reduced related problems.

  Friction in orthodontic treatment does exist and is thought to reduce the efficiency of orthodontic appliances during sliding mechanics. During sliding mechanics, a friction force is produced at the bracket archwire-ligature unit which tends to counteract the applied force and in turn resists the desired movement. Different modified types of modules namely, superslick and synergyh helps reduce friction during sliding mechanics. For enmass retraction different modified modules could be used in the premolar region.

- **Da Silva, D L[24] et al**, 2013An investigative study by to estimate the loading and unloading properties of esthetic wires. The orthodontic esthetic wires of certin brands , ortho organisers, Trianiero where tested for their loading unloading properties with force . In the results it was found they have low loading and unloading property , low modulus of elasticity, modulus of resilience , and maximum deflection properties . The the coating thickness does not difer in the two types of wres. The study concludes, Reduction in the innercore thickness due to the difference in the external coating is one of the key factors.

- **Gatto E[25] et al , 2013** has done a study to find the superelastic charecteristics of two types of 0.014 and 0.016 wires.A set of these wires with different frictional properties are also choosen, which are normal super elastic wires and thermal niti wires. Three point bneding test was conducted the result showed that the thermal niti wires showed less resistance for a low wire deflection , the hysteresis platau was steep for normal superelastic wire. For a hih deflecton there wasa shallow plateau for the curve. Such difference for superelastic wires showed by martesite stress that is induced with higher deformation levels .

  Before using the elastic wires the mechanical properties of the typical wires used are verified.the frictional properties with the type of mechanics used in the sliding mechanism is used are also taken into consideration. Conventional bracket is used superelastic wire is the chice, while with in low friction bracket system thermal niti could be used because a continuous low force is received. In conventional brackets low force with superelastic wires will not overcome the resistance to wires.

- **Brandão RC[26] et al 2013** have posted a review article regarding microesthetics which could be controlled by an orthodontist. Microesthetics comprises treatment approaches that are more directly related to Orthodontics and other esthetic specialties enhancing smile. Its part of mastering the finishing esthetics in orthodontic treatment. The challenge is to use all the parameters available, making use of all the different specialties of Dentistry, and apply these concepts in each treated case. It is not a single detail that defines excellence, but the sum of many of them. This article aimed in defining the ideal dental proportions and dimensions, and their relation with the periodontium, which shall be considered by the orthodontist for treatment finishing. Many of these aspects are out of the scope of changes within the orthodontic appliance could provide and totally dependent on the intervention of periodontists and prosthetists.

- **Jee JH[27] et al 2014** has done a study with en mass retraction with crimpable soldered stops and preformed wires .In a study at korea a different enmass retraction system was introduced with the help of tads and wires sliding through crimpable stop tubes. Preformed wires with a stainless steel wire in posterior region from the tads. Superelastic niti in the anteriors . The end of niti wires sliding through a crimpable stop soldered to the stainless steel wire , where the hook has also an hook like extended part to give force in the direction of centre of resistance. There are no bracket attachments to the posterior teeth.

- **Gravina MA[28] et al , 2014** did a comparative study regarding surface roughness of normal NiTi and Cu NiTi with different brand of archwires .The results showed that NiTi wires presented Ni and Ti as the main elements of the alloy with certain other differences in their composition. The CuNiTi wires, however, presented Ni and Ti with a higher percentage of copper (Cu). The wires that presented the lowest wire-surface roughness were the superelastic ones by Masel and Morelli, while those that presented increased roughness were the

CuNiTi 27ºC and 35ºC ones by Ormco. That may be due to presence of microcavity formed as a result of removal of some NiTi particles. The fracture surfaces presented characteristics of ductile fracture, with presence of microcavities. The superelastic wires by GAC, CuNiTi 27ºC and the heat-activated niti by Unitek presented the smallest microcavities and the lowest wire-surface roughness at fracture site, while the CuNiTi 35ºC wires presented more wire-surface roughness in the fracture region.

- **Shenoy S[29] et al, 2014** introduced a new technique wherein a light cure adhesive composite is placed between the crimpable hook space which is usually used crimped on to the archwire. With the advent of pre-adjusted edgewise orthodontic bracket systems, archwire fabrication has been considerably simplified. Archwires that are devoid of any loops or customizing bends can be utilized. These include fabricated tie-back loops, soldered brass hooks, pre-posted archwires and crimpable archwire hooks. Soldering requires chairside or laboratory equipment, is time consuming and may lead to annealing of the archwire. Crimpable archwire attachment allows quick and simple placement of the attachment in any desired position along the archwire in or out of the mouth.The hook is then crimped to the arch wire with help of crimpable plier and adhesive composite is cured. Clinical application of this technique has shown positive results in preventing slippage of hooks.

- **Machado AW[30] et al, 2014** proposed few principles related to smile esthetics. They laid down the 10 commandments or the smile esthetics.

The search for esthetic treatment has evolved in the routine of dental professionals. Keeping this trend, dental patients have sought treatment with an imterest in improving smile esthetics. The aim of this article is to present a protocol to assess patient's smile: The 10 Commandments of smile esthetics.

The ten commandments suggested herein are as follows: 1st) Smile arc — Vertical position of maxillary incisors ; 2nd) Maxillary central incisors ratio and their symmetry; 3rd) Anterosuperior teeth ratio; 4th) Presence of anterosuperior space; 5th) Gingival design; 6th) Levels of gingival exposure; 7th) Buccal corridor; 8th) Midline and tooth angulation; 9th) Details — Tooth color and anatomical shape; 10th) Lip volume. Special attention is given to disposition of anterosuperior teeth (canine to canine or first premolar to first premolar) or the area known as esthetic zone where central incisors are known as key elements and characterize the term "dominance of central incisors". In short, central incisors must be highlighted as true protagonists of smile. Thus, commandments from 1 to 4 are directly related to "dominance of central incisors".

The 10 Commandments of smile esthetics may be considered a starting point for clinicians who aim at achieving maximum esthetic in dental treatment. Special attention should be given to the first four commandments associated with dominance of central incisors at smiling.

- **Sahu SK[31] et al, 2014** has described a simple ligature hook .Sometimes simple and technique like ligature wire hooks may be a great helpfor clinicians. Its always a handy tool which is time sving. As far as when you compare with the crimpable they are safer to use In situations where minor esthetics is crucial , and nynattempt which worsens it could be avoided.

- **Jyothikiran H[32] et al, 2014** has given an update on different orthodontic wires especially related to Copper Ni-Ti and normal nitinol. Cu NiTi is a new quaternary (nickel, titanium, copper and chromium) generates a more constant force over long activation span than other nickel titanium alloys and does so, on a consistent basis, from arch wire. These show a thermally induced super elastic effect. 25 Copper Ni-Ti wire consists of nickel, titanium, copper and chromium. The addition of copper to nickel titanium enhances the thermal-reactive properties of the wire, thereby enabling the clinician to provide optimal forces for consistent tooth movement.

  Differences between copper Ni-Ti and traditional Ni-Ti alloys Copper Ni-Ti is more resistant to permanent deformation and exhibits better spring back. Copper Ni-Ti demonstrates a smaller loading force for the same degree of deformation, making it possible to engage severely mal posed teeth with less patient discomfort and potential for root resorption. The decreased hysteresis and flatter unloading curve result in more consistent forces that are active longer within the optimal range for tooth movement. Copper Ni-Ti exhibits a more constant force/deformation relationship, providing superior consistency from arch wire to arch wire.
- **Prashant PS[33] et al 2015** Conventional wisdom suggests that resistance to sliding (RS) generated at the wire-bracket interface has a bearing on the force transmitted to the teeth. The relative importance of static and kinetic friction and also the effect of friction on anchorage has been a topic of debate. Lot of research work has been done to evaluate the various factors that affect friction and thus purportedly retards the rate of tooth movement. However, relevancy of these studies is questionable as the methodology used hardly simulates the oral conditions. Lately studies have concluded that more emphasis should

be laid on binding and notching of archwires as these are considered to be the primary factors involved in retarding the tooth movement. This article reviews the various components involved in RS and the factors affecting friction. Further, research work should be carried out to provide cost effective alternatives aimed at reducing friction.

Whether friction is really a bane to orthodontics is a subject open to debate. However, a clinician should look beyond friction and realize that it is just a small part of RS. The current methodologies employed to study the effects of friction on orthodontic biomechanics are inadequate and simulate oral conditions poorly. Only improved methodologies can shed more light on this subject.

- **Naik A[34] et al, 2016** has developed a new type of crimpable hooks. The anterior brackets like incisor, laterals doesn't have hooks attached to them, while premolar and molars have them. There are situations lke inter arch elastics , box elastics, class 2 elastics etc where you need hooks. The main types of hooks commercially available, kobayashi hook, hooks, crimpable hooks. Using the type of hook described here one could avoid debonding of brackets, less chair side time, economicaly cheap etc. A new type of hook developed by using braided ligature .
- **Giovanelli D[35] et al , 2016** conducted an experimental study on flexiblw force sensors ,its use and reliability . The low accuracy of single point sensors, the cost and complexity of sensor matrices, and issues related to measure body interface pressure are certainly some key factors for the relatively low diffusion of this technology for commercial devices. We performed some tests on a flexible force sensor made with Velostat: the repeatability has been found to be one of the major issues, in particular for long measurement. In fact if

random raw data is taken out from result set, up to around ±50% of error can be found.

- **Al Taki A**[36] **et al 2016** a Comparative Evaluation in Orthodontists, Dentists, and Laypersons People in eastern Arabia was ascertained for their smile perception. Dentists, orthodontists and lay men participated in the study. Different photographs where utilised. They had problems like diastema, gingival zenith variation, teeth proportions and variation . The general dentists and laymen couldnot find the diference in all the unesthetic features as unpleasing in fact theey found it pleasing. While the orthodontists found fault with large buccal corridor , smile arc not consonant with the smiling lips and any transveres smile aesthetic problems. Hence the perception varies , so the microesthetics should be seen by a practicing orthodontist.

- **Sadun AS**[37] **et al , 2016** has conducted a study with the low-cost Force Sensing Resistor (FSR) sensor related to active compliance control The results show that the FSR sensors are sufficient and reliable devices to measure and record the detected force. However, a proper design of sensor cover for both sensors is required to optimize contact force. This is particularly very important when dealing with different shape of objects so that the force is adequately measured. In conclusion, considering cheap and reliable force sensor, the FSR can be a suitable candidate to measure the force during interaction. It also can be used for a more complex and sophisticated system such as active compliance control for the robotic hand.

- **Sreejan A[38] et al in 2008** has put up a review article on applications of Flex Sensors. Even though it is widely used as a goniometer in rehabilitation research, its applications can be seen in different fields like, human machine interfaces, geology and musical instruments. In each application, the sensor identifies the flexure in terms of varying resistance that can be recorded digitally and the data is then used differently depending on application. With the advent of goniometer glove, measuring joint movements in rehabilitation research was simplified, which was earlier measured by mechanical goniometers. Later these gloves were used as human machine interfaces (HMI). Another type of HMI input device called a shape tape has been created to replicate shapes of real objects into CAD environment. In geology, the sensor was used to identify landslides remotely. Also flex sensor is used in creating a musical instrument that can be played by deforming and bending the instrument, to encourage experimentation to create interesting musical effects. Apart from these existing applications, this paper proposes another application to use the sensor to identify the dents on sheet metal panels, by recording flexure in two dimensions across the sheet.

- **Vasiljevic D[39] et al , 2017** has presented a paper regarding design, fabrication and characterization of force sensing resistors (FSRs) which can be used in many applicable devices in medicine, rehabilitation, robotics, dentistry, etc. They consist of printed interdigitated electrodes on flexible substrate, an adhesive spacer and a carbon based sensing layer. Four types of FSRs were fabricated with different designs of active area. Measurement setup for testing and characterization has been developed in laboratory conditions and represents a device for precise implementation of a controlled force on FSRs. The characteristics of FSRs - the resistance as a function of applied force and temperature as well as the voltage as a function of applied force are presented. The obtained resistances were in the range of tens of Ohms for a wide range of applied force (1 N – 65 N).

- **HENRIQUES JF[40] et al 2017** has conducted a study on the wire deflection properties with regard to steel ligature ties in different types of archwires are made in this study. Three types of ligature ties, namely , ring shaped elastomeric ligature (RSEL) figure of eight elastomeric ligature (8RSEL) metal ligature (ML) where done in different wires. The wires being, round nitinol, rectangulat nitnol, round stainless steel, rectangular stainless steel. Thee brackets with the wire ligature system are moved buccolingualy to imitate the deflection forces at 1mm 0.5mm at a constant speed of 2mm/min. the forces released by the wires are reccoreded. In imm deflection RSEL showed lighter forces .in shorter distance 0.5mm 8SEL showed higher forces . in 1mm the ML showed similar forces asin 8SEL.

  Thus the ligature system or any binding or clinging system as such could deliver deflective movements in arch wires.

- **Garro-Piña H[41] et al , 2017** has assessed the load deflection property of two dofferent wires , namely 0.16 round and 0.016 x 0.022 wires. Three point bending or force delivery system was used for this. A system set up with two sets of brackets on either side with the wire through the bracket easy setup where the force acts through the centre. Among the wires there was difference like coated and uncoated wires.

The results showed there is difference in loading and unloading between coated and uncoated round 0.016 wire with relation to the uncoated wires of the same company. There was no relavant difference between coated and uncoated wires of the same company. With regard to 0.016 x 0.022 rectangular wires there is no change in loading deflection but there is difference in unloading property. With permanent deformation had no difference among coated and uncoated wires.

- **Kallidass P[42] et al 2017**, has written review article on smile characteristics in orthodontics where they stress importance of smile in personal communication. An attractive, well-balanced smile can be a valuable asset . A pleasing smile is important in person to person communication and to enhance facial beauty. A persons dental and facial appearance is important not only in the role that attractiveness plays to others but also in one’s self-concept. Enhancement of facial beauty is one of the primary elective goals of patients seeking dental care. Facial appearance is important for an attractive and well-balanced smile. Enhancement of facial beauty is one of the primary valuable personal assets for a patient seeking dental care. The goal of orthodontic treatment should be the attainment of the best possible esthetic result, dentally and facially. The smile represents the first sign of human communicative ability appears early in life in young children. Something which give patient satisfaction at the end of orthodontic treatment is customers evaluation of facial esthetics. Facial appearance is important not only in the role that attractiveness pays but its important in one’s self-concept.

- **MATIAS M[43] et al, 2018** conducted a study to evaluate the deflection properties of diiferent coated archwires . Different types of Coated archwires and ceramic brackets is introduced to enhance facial esthetics during orthodontic treatment. Their mechanical properties has been different from metallic archwires and brackets. The aim of this study was to compare the deflection forces in coated nickel-titanium (NiTi) and esthetic archwires combined with ceramic brackets. Non-coated NiTi (NC), rhodium coated NiTi (RC), teflon coated NiTi (TC), epoxy coated NiTi (EC), fiberreinforced polymer (FRP), and the three different conventional brackets metal-insert polycrystalline ceramic (MI-PC), polycrystalline ceramic (PC) and monocrystalline ceramic (MC) were used. A clinical simulation device and evaluated in a Universal Testing Machine (Instron) to test the selected wires. An acrylic jig, representative of the right maxillary central incisor was buccolingually deflected and the unloading forces generated were recorded at 3, 2, 1 and 0.5 mm. The speed of the instron machine was 2 mm/ min. ANOVA and Tukey tests were used to compare the different archwires and brackets. Results: The different brackets presented the following decreasing force order : monocrystalline, polycrystalline and polycrystalline metal-insert. The decreasing force level of the archwires was: rhodium coated NiTi (RC), non-coated NiTi (NC), teflon coated NiTi (TC), epoxy coated NiTi (EC) and fiber-reinforced polymer (FRP). At 3 mm of unloading the FRP archwire had a plastic deformation . when deflected an extremely low force was produced in 2, 1 and 0.5 mm of unloading.

Combinations of the evaluated archwires and brackets will produce a force ranking depends mainly on the combination of their individual force rankings.

- **Changsiripun C[44] et al , 2018** This article described a method how to measure torque on the terminal end of an archwire with a standard, semicircular plastic protractor
- **Sab WF[45] et al, 2018** has explained fabrication of an economical Self-customized crimpable hook. There are different types of hooks that could be attached along with the appliance system either along with the archwire or attached to the brackets. Here a specialy designed hook planned to fit to the bracket . that could easily placed . Very economical and could be easily fabricated at chair side. They can be placed in dental arch in any position and could be removed with crimpable hook plier. Crimping of hooks , welding or soldering of hooks to the archwire creates distortion to the archwire.

- **Bhat FA[46] et al, 2015** conducted a comparative evaluation study showed that there is a huge difference in force-deflection properties between differewnt archwires. 0.016 inch round and 0.016 × 0.022 inch rectangular were selected because these are commonly marketed and these were selected because these archwires are commonly used clinically.

The aim of this study was to evaluate and compare the force acting and the deflection properties of different brands of NiTi wires available. From this data, a comparative evaluation shows that there is a huge difference in force-deflection properties of same dimension wire from different brands. The behaviour of wires is then unpredictable. With the same dimensions same wires of diiferent brands deflect differently. This is because they have different mechanical properties. some wires have shown less and some have shown more force.Wires of the same materials, dimensions, but from different manufacturers do not always have the same mechanical properties. There is a definite difference in the activation and deactivation forces among the different manufacturers of NiTi archwires.production methods have to be improved and should have proper standardisation. The NiTi wires provided to the orthodontists from different manufacturers should same quality.

- **Christou T[47] et al , 2019** has put up an article points out the outcome between the microesthetics of pre and post esthetic outcomes of an orthodontic treatment case . The diferent aspects that where checked are crown height ratio, connectors between upper anteriors, embrasure spaces, gingival zenith of maxillary lateral incisors and golden percentage of patients using plaster models and photographs of the patient. Adobe photoshop was used to measure golden percentage and vernier caliper for plaster model measure.statisticaly data was analysed for the pretreatment and posttreatment . The microesthetic parameters was very much improved for extraction cases. Microesthetics of the anterior teeth may worsen after extraction treatment . Carefull work need to be done especialy for extraction cases . The microesthetics is often compromised during treatment with any extra activity during treatment schedule.so such interventions in the appliance system will affect microesthetics, especialy in extraction cases. Hence treatment time prolong to complete the treatment.
- **Banker A[48] et al , 2019** The author and team had developed a technique for accurately measuring torque at the chair, using a smartphone and an attached plier. This is an easy method where the clinician can directly control the torque applied to the Archwire.

- **Alsabti N[49] et al 2020** has done a study on the static friction of different types of wires, TMA and stainless steel. Friction plays a major role in sliding mechanics. The different wires. 0.16 x 0.022 used are TMA low , TMA C , and stainless steel using an universal instron machine. In this study it revealed TMA low showed intermediate friction compared to the other two. But when the surface irregularity is checked with a non contact optical profilometer machine , TMAC showed maximum roughnes, followed by TMA low and Stainless steel. Then the roughness and frictional quality is under scrutiny. That property has to be reevaluated. The study concludes that the static friction resistance forces and surface roughness values of the TMA-Low arch wire are comparable to those of TMA-C but are marked inferior to those of the SS arch wire.

- **Schwenck A[50] et al** , 2021 has conducted a comparative study about MEMS sensors .Among the two production technologies for the fluidic sensor cell, the stacking of PCBs is more favorable than the MID technology, as only commonly available SMT is needed. This results in a shorter process chain. Additionally, the performance is better, and the measurement range is larger.

  The key findings of the benchmark are: the MEMS sensor ADXL355 has significantly better characteristic values compared to the MEMS sensors BMA280 and MPU6500. The fluidic sensors outperform the cheaper MEMS in every characterized category. Compared to the ADXL355 sensors especially, the PCB variant of the fluidic sensor performs equally well or even better in some categories.

- **Łuczak S[51] et al , 2021** has done a study on electrolytic liquid tilt sensors (inclinometers). It seems that the most significant feature of normal tilt sensors among the listed advantages is the capability of operation without electric supply. It is very important in the case of battery-supplied devices, which operate mostly in a sleeping mode, until they are triggered by some external mechanical stimulus that can be detected by a dedicated tilt switch. In this way, either their operation time can be considerably extended or the capacity of the battery decreased in a large measure, resulting in lower dimensions, smaller mass, and lower cost of the device. Despite being a very old solution, there are some applications, where the aforementioned advantages of tilt sensors employing free members, remain unchallenged. The same refers to electrolytic liquid tilt sensors (inclinometers)—many types of such sensors are still Sensors 2021, 21, 1097 18 of 20 manufactured, since they feature very high sensitivity, in the order of few arc seconds or even below arc second.

- **John G[52] et al, 2021** has attempted to measure the force deflection properties of NickelTitanium (NiTi) wires of four manufacturers, used in orthodontic treatment. They selected 480 NiTi wires with different cross-sections from four different manufacturers namely American Orthodontics (AO), 3M-Unitek (3M), Rabbit Force Orthodontics (RO) and Modern Orthodontics (MO). An experimental jig in acrylic with 5 different sets of lower anterior Libral brackets were fixed. Bending force was applied and force deflection measured in millimetres. Results showed 0.014” NiTi wire showed more mean deflection when compared to 0.016” NiTi wire. Comparing 0.016”×0.022” and 0.017”×0.025” NiTi wires mean deflection was almost the same for both the wires. When round and rectangular wires were compared it showed increased mean deflection in round wires. A significant difference (p-value <0.0001) was seen in the mean or average deflection values of MO and RO. Three way annova test concluded a significant difference (p-value <0.0001) for AO and 3M with other brands. Superelastic wires showed larger deflection as compared to conventional and heat activated NiTi. This can be attributed to the property of the wire. Stiffer the wire, less deflection was seen. Cost of the wire also played a role. Cost effective wires couldn’t consistently give the quality and standards of their counterparts.

- **Bukhary F[53]. et al , 2021** has made comparative study of how the tip and torque values is particularily important for any racial community in smile perception.Various racial communities where examined and compared with the Saudi people. There smile especially the anteriors have certain tip and torque values which is usually stndardised for a community. Here there was no much difference seen in tip and torque in the same community ie the Saudis. But off course there is difference in tip and torque among people in different geographical areas, especially, the the north American, the Italian , japenese or the indian and when compared with the Saudis. Whenyou know tht the tip and torque values which are important for any community then those factors that affect them should also be given due consideration in orthodontic treatments. The authors where trying to give a new prescription for Saudi community.

RATIONALE OF STUDY

During the process of crimping stops on Archwires ,there is always a chance of wire deformation and deflection due to uncontrolled forces. This changes the properties of the Archwire which may affect treatment results. The routine crimping process causes the first , second or third order of deflection of the archwire . The treatment time may be prolonged and sincere effort has to be put to correct the adverse effect A system for crimping stops with optimal force, necessary to lock the stops without deflection is relevant.

The rationale of this study is to compare and evaluate the effectiveness of a novel Stop Crimping Plier with the conventional crimping technique.

METHODOLOGY

RESEARCH QUESTION

Does crimping metal stops with the novel calibrated crimping plier cause deflection of the archwire ?

HYPOTHESIS

Definite deflection will occur on various orthodontic Archwires while crimping metal stops.

NULL HYPOTHESIS

There will not be any difference in deflection of orthodontic wires when crimped with conventional and a novel calibrated crimping plier .

AIM OF THE STUDY

To compare and evaluate the deflection produced on various orthodontic wires while crimping metal stops with the novel calibrated crimping plier and the conventional crimping techniques.

OBJECTIVES OF THE STUDY

1. To measure the mean crimping force applied on the wires by orthodontists.
2. To evaluate the deflection of the orthodontic wire after applying the mean crimping force.
3. To compare the deflection of orthodontic wire while crimping stops using the calibrated crimping plier and the conventional crimping plier.

4. To quantify the deflection of orthodontic wires in degrees when crimped with both the conventional plier and the novel crimping plier.
5. To compare the deflection of the orthodontic wire between the two methods. (2 and 3)

SAMPLING

- Sample size is calculated as 16
- 16 groups of different orthodontic wires used
- 10 numbers in each group thus having a total of 160 orthodontic wires

SAMPLE SIZE

$$n = \frac{(\frac{Z\alpha}{2}+Z\beta)^2}{d^2} \times SD^2$$

Z α/2 =Type 1 error (5%) = 1.96

Z β = Type1 error (80%) = 0.84

SD =Standard deviation =0.4 (From literature)

d =minimally detectable difference= 0.3

n= (1.96+0.84)2 ×0.42

(0.3)2

= 7.84 ×0.16 = 13.93≈ 16 (8per group)

0.09

RESEARCH DESIGN

In - vitro comparative study.

A comparative study with the data recorded the conventional crimping plier and the novel Crimping plier

RESEARCH SETTING

1. Department of Orthodontics and Dentofacial Orthopedics, St. Gregorios Dental College
2. STIC- Sophiscated testing and instrumentation centre, CUSAT
3. NPOL- Naval Physical and Oceanographic laboratory , Cochin
4. Mar Athanaseous engineering college, mechanical department Kothamangalam

An experimental setup designed at the department of Orthodontics and Dentofacial Orthodontics , St Gregorios Dental College simulating the patient head position in a dental chair. All the necessary gadgets, hardware and software settings necessary to support the study was set along with the jaw setup. The hardware and technical setup was designed by an external agency (GK technologies, Vytilla , cochin) under the guidance of Dept of electronics, Mar Athanasious Engineering College, Kothamangalam. The calibration and other technical support was given by the Sophisticated Testing and Instrumentation Centre (STIC) at CUSAT (Cochin University of Science and Technology).

STUDY DURATION

one year of duration

MATERIALS AND METHODS

No	Type of wire	Size	No of wires	Brand Name
1.	Round Cu Ni Ti Wire	0.013”	10 nos	Ormco
2.	Round Cu Ni Ti Wire	0.014”	10 nos	Ormco
3.	Round Cu Ni Ti Wire	0.016”	10 nos	Ormco
4.	Round Cu Ni Ti Wire	0.018	10 nos	Ormco
1.	Rectangular Cu Ni Ti Wire	0.014” x 0.022”	10 nos	Ormco
2.	Rectangular Cu Ni Ti Wire	0.016”x 0.025”	10 nos	Ormco
3.	Rectangular Cu Ni Ti Wire	0.017” x 0.025”	10 nos	American Orthodontics
4.	Rectangular Cu Ni Ti Wire	0.018” x 0.025”	10 nos	Ormco
1.	Round SS Wire	0.014”	10 nos	Ormco
2.	Round SS Wire	0.016”	10 nos	Ormco
3.	Round SS Wire	0.018”	10 nos	Ormco
4.	Round SS Wire	0.020”	10 nos	Ormco
1.	Rectangular SS Wire	0.016” x 0.022”	10 nos	Ormco
2.	Rectangular SS Wire	0.017” x 0.025”	10 nos	Ormco
3.	Rectangular SS Wire	0.018” x 0.025 “	10 nos	Ormco
4.	Rectangular SS Wire	0.019” x 0.025”	10 nos	Ormco

TABLE 1 – Different Archwires

ARCHWIRES AND GROUPS

a) Round copper niti wires
b) Rectangular copper niti wires
c) Round ss wire
d) Rectangular ss wire

Cu NITI WIRES (round)	Cu NITI WIRES (rectangular)
0.013” x 10 sets 0.014” x 10 sets 0.016” x 10 sets 0.018” x 10 sets	0.014” x0.025” x 10 sets 0.016” x 0.025” x 10 sets 0.017” x 0.025” x 10 sets 0.018” x 0.025” x 10 sets
Total 40 sets	Total 40 sets
STAINLESS STEEL WIRES (round)	STAINLESS STEEL WIRES (rectangular)
0.014” x 10 sets 0.016” x 10 sets 0.018” x 10 sets 0.020” x 10 sets	0.016” x 0.022” x 10 sets 0.017” x 0.025” x 10 sets 0.018” x 0.025” x 10 sets 0.019” x 0.025” x 10 sets
Total 40 sets	Total 40 sets
16 groups of wires **Total 16 x 10 = 160 wires**	

TABLE 2 –Archwires and groups

EQUIPMENT

1. A conventional crimping plier : type Bird beak Plier, Modern Ace Orthodontics
2. Novel Calibrated crimping plier.
3. A crimping plier with a force measuring system like force sensor, Arduino hardware, supported with a coding programme and a computer or a special display.
4. A special jig developed to hold the orthodontic wires simulating the orthodontic bracket system.
5. Deflection profile evaluation system - a modified software application to measure the angular change or deflection.
6. A jig to attach the software attached device for smooth tilting to focus the deflected wire.

PROCEDURE:

Force standardisation

A custom made plier assembly with a force measuring system attached to it was developed for this purpose. Five orthodontists with minimum five years of clinical experience was chosen to crimp the stops with the plier assembly. The forces are monitored and the mean value is calculated . A special plier assembly was developed for this purpose.

Evaluating mean crimping force

16 nos (one each from every group) of orthodontic wire selected were crimped with stops. A conventional plier with an electronic force sensor (force sensitivity resistor) attached to it was used in the study. The force sensor values were fed into a computer

through a programmable electronic circuit, Arduino using a special coding programme. The output, which is the force applied, was recorded in Newton - grams.

Method to study the deflection of Orthodontic wires

A custom jig was developed to hold the orthodontic wire, simulating the brackets and wires in the oral cavity. The mean crimping force was applied to crimp the metal stops on to different wires using the conventional crimping technique and the novel Calibrated plier. The deflection in the wires were recorded and evaluated . The resultant values were then statistically analysed.

Evaluating deflection of the archwires

Digital method was used to measure the amount of deflection, where the angle is measured in degrees or radians to the degree of one tenth of a degree.

A device with software application which detects the finer deflection of wires after crimping the stops was used for this purpose. Since the device was equipped with hardwares like gyroscope and accelerometer, it was equipped to measure even small angles and incliination.

Devising wire holding jigs

A special jig was designed and fabricated for the study, where the brackets are set in a horizontal plane. The crimping position of arch wires was standardised, marked in the wires and kept in the bracket holder.

Another jig to hold the device with the measuring equipment was placed. It had tilting mechanism to move the jig without jerking. This could facilitate to prcicely follow the amount of deflection that may occur in wire.

Similar applications are utilised in several other studies too. (C Changsiripun[44] et al **2018** and banker A[48] et al 2019)

Recording deflection : conventional crimping plier Vs novel calibrated plier

The required 2 sets of orthodontic wires were selected with crimpable stops in place. Each set of wires were crimped with regular conventional plier and the novel calibrated

Crimping plier. The force from the novel crimping plier is adjusted by calibrating the plier .

The deflection of the wires were separately recorded. Comparative study of deflection patterns with both pliers were done from the values recorded and statistically analysed.

EXPERIMENTAL SETUP – STUDY MODEL

Description of Study Setup

The panel of orthodontists who were to take part in the study was prepared. Their prior consent was obtained after they expressed their willingness. A detailed outline of every aspect of the study - the methodology, materials used, procedure and methods of data collection was explained before hand. The study setup was arranged at St, Gregorios Dental College , Kothamangalam, Ernakulam . Technical help was taken from other renowned institutions names are mentioned earlier.

The study setup was a three dimensional design layout in a horizontal platform with the phantom jaw simulator as the main focus of the operatory. The articulator with brackets bonded to the teeth represented the upper and lower dentition. The archwires were placed sequentially ligated with modules for crimping with the plier. The face mask was made of rubber material and represented the soft tissue coverage of the facial region.

Two orthodontic pliers , one the conventional bird beak crimping plier and the other, the novel crimping plier were placed besides the phantom jaw.

The plier design

There were two sets of pliers as stated earlier. The conventional plier which was used in this study was the No 139, bird beak plier. The other one the novel calibrated plier. It was basically a modified bird beak plier with a calibration mechanism at the beak. The required beak approximation is then calibrated by the adjustment in the plier beak. The beak of the pliers could get approximated or closed in such a way that the beaks adapts to the width of the stops in the wire in situ, which is the ideal position to crimp at every take of a specific wire configuration. The new plier had a technical adjustment that controlled the opening of the beaks and aids in calibrating the plier closure. The rotatory adjusting screws when winded clockwise will advance the screw between the plier beaks. Any advancement of the screw beyond the inner walls of the pliers will prevent the beaks from getting approximated.

Force sensing device and Force Resistor

The plier handle has a customised sensing sensing device attached to it . The sensing device is held between the plier handles and is connected to a digital display .a hardware circuit, namely Arduino uno, programmed with a software application which helps in converting the force or pressure to digital voltage signals . The voltage signals are displayed in force measuring units, Newton. When the plier handles are activated by applying pressure by the operator it is transferred to the sensor and the force calculated and displayed.

An FSR or force sensing resistor is a special electronic device which helps in detecting any pressure applied over it. These are flexible strips which changes its resistance with pressure application . In this study this sensor is attached to the plier designed to crimp the stops placed in between the handles with custom made fixatories or jig readily designed for the same.

The pressure applied to the plier through the palm pressure is delivered through the stops through a point at the beak end of the beak.Holding an archwire at the beak end opens up the jig handles which are always in close contact with the sensor. The sensor is held from the two arms of the jig through an adjustable button.The buttons are controlled with spiral rotatory advancement with screws having short interval flutes . The finer tuning adjustment with rotatable buttons are utilized every time when crimping force is evaluated. The pressure transferring button could be manually controlled where the load at the beak end and to the force sensor are same .

Calibrating the plier

The plier should be calibrated eveyrtime it is used. It should be calibrated for the change in size and shape of the wire. The rotatory adjustment that controls the close approximation of the plier beaks are used for this purpose.The archwire is first held between the plier beaks . The rotatory adjustments are advanced to a level that it barely touch the other opposing beak on closing. The rotatory adjustment is locked once it touches the opposing beak.

The stops are placed in the arch wire. The beaks are then used to hold the stops. The pressure is applied through the plier beaks. The plier beaks will advance to dent the stop. It will further advance to a limit set by the rotatory adjustment, preventing any further advancement. The limit is set initially by calibrating the plier. This will prevent the plier from transferring any excess force to the Archwire that may dent the wire. Thus the plier beak allow just to crimpthe Archwire or give a ‘ friction – lock’- adequate to retain the stops in the wire.

The Arduino Uno

The electronic hardware board , Arduino Uno is placed sidewise to the phantom jaw. Arduino is a circuit board with a microchip processor, interfaced with the force sensing resistor . The force sensing resistor (FSR) is placed between the handles of the novel plier. The force resistor is interfaced to the arduino through a half bridge resistor circuit. The FSR registers the palm pressure applied by the operator and transfers a change in voltage through the bridge circuit to the microchip. The microchip is programmed to give a digital output equivalent to the variation in pressure applied to the plier. The arduino is also calibrated to give the voltage variations in terms of force units which is Newton or gms. The resultant Force is displayed in a digital color display.

The inclinometer

The inclinometer is an instrument that could detect an angle of inclination of any surface, body or any appliance as such. This equipment has an inclination detecting sensor interfaced to an Arduino nano microchip controlled board. The sensor gives analogue output signals in voltage which is fed to arduino board. The arduino converts the analogue signals to digital voltage signals and a coding program fed to the arduino microcontroller helps doing this conversion. The digital output is displayed to a digital led display. The unit to which inclination could be displayed may be determined by the programmer. It could be either in angle or radians. The instrument may be programmed to get a calibration sensing changing to even a hundredth of a degree.

The inclinometer was designated to measure the deflection that occur in the archwire while crimping stops. An inclinometer or digital protractor with a visual display to measure the wire deflection was utilised in the study. A special setup with a tilting jig to follow the deflected wire is mounted on a horizontal table aligned parallel to the floor. The archwire is placed on the table in a standardised position . The stops are crimped to the archwire at a definite distance from the midline to standardise the crimping procedure.

The inclinometer is hinged to a zero positon with the horizontal table from the standard position from the midline.

Another jig deviced in this plane helps to tilt the plane of the inclinometer. The archwire that is crimped with is expected to deflect both arms. The long arm of the archwire which is expected to be deflected kept resting on the marking . The deflected wire is placed in a standardised position marked for the purpose . The midline point of the archwire and the crimping point in the archwire is noted by marking. The archwire is standardised to be positioned in the same parameters coinciding with the archwire which has the crimping and midline positons marked to it. The zero point or fulcrum will coincide with the crimped point in archwire. A needle pointer set at the basal level of the inclinometer is directed outward from the instrument. The needle pointer and the base of the inclinometer are both in the same horizontal plane. Any upward tilt of the inclinometer carries the pointer to the same level. The angle to which the pointer is raised is same as detected by the inclinometer. The inclinometer could be lifted with the jig as one corner as fulcrum point and the other corner moving high to reach the elevated small arm of the archwire. When the elevated inclinometer lifts parallel to the plane or comes tangent to the deflected wire, the horizontal needle will simultaneously touch the deflected wire which could be visualized .The angle of tilt of the inclinometer, together with the needle could be read from the display.

Different sets of wires after they are crimped with both the pliers are kept one by one in the horizontal platform. There are two segments for the crimped archwire since the stops are crimped at a certain length from the midpoint of archwire. The shorter arm from the crimped stop will have a higher deflection. The longer arm towards the distal will have a lesser deflection. The pointer from the inclinometer just crosses the deflected arm of archwire.

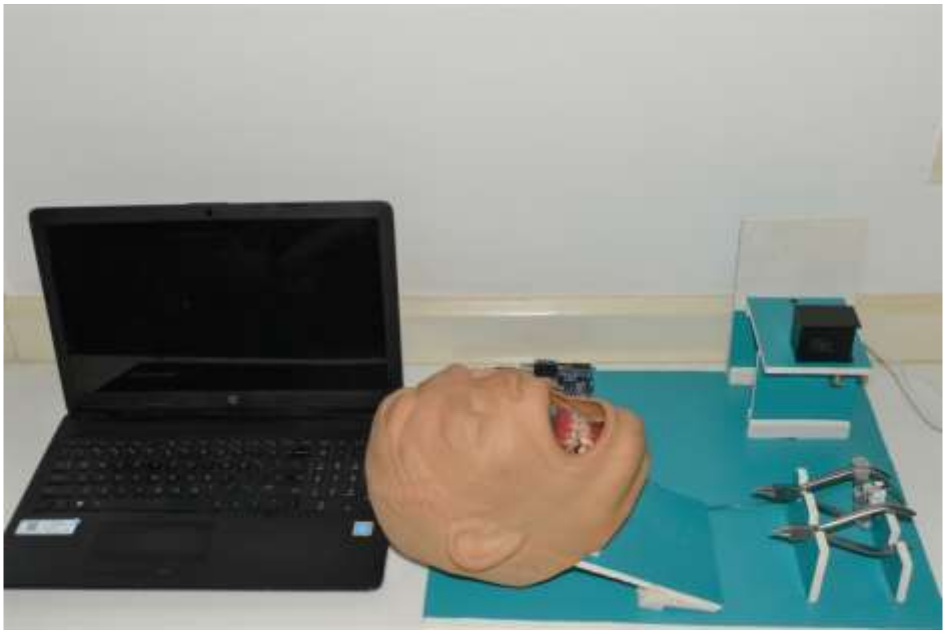
Force unit

The force is measured either in newtons or in grams. For the present study it is measured in grams. It could be obtained in either of the unit with the programme. The fraction of the value read could be made one hundredth or one tenth by calibrating the hardware . If force is recorded in newton it can be converted to gms with the formula below.

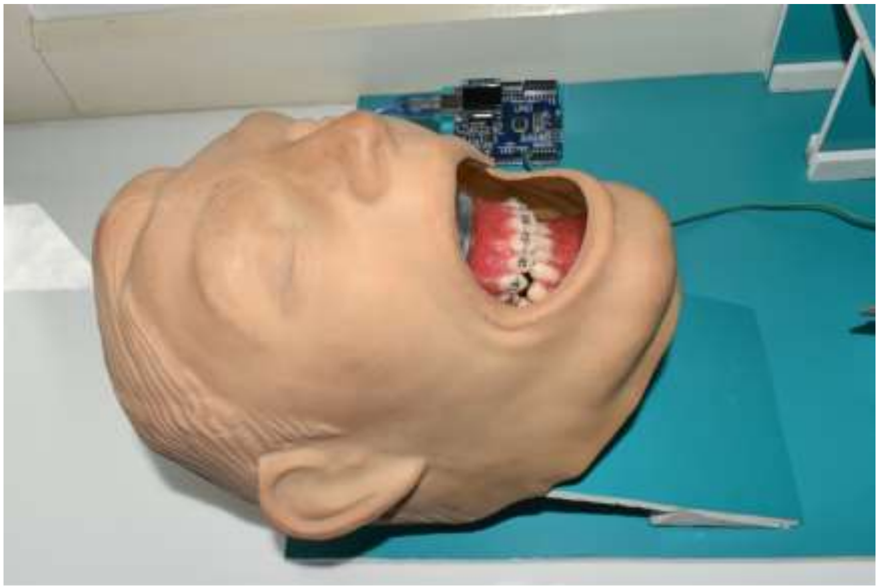
1Newton – 1/9.8 kg

- 1/ 9.8 x 1000 gms

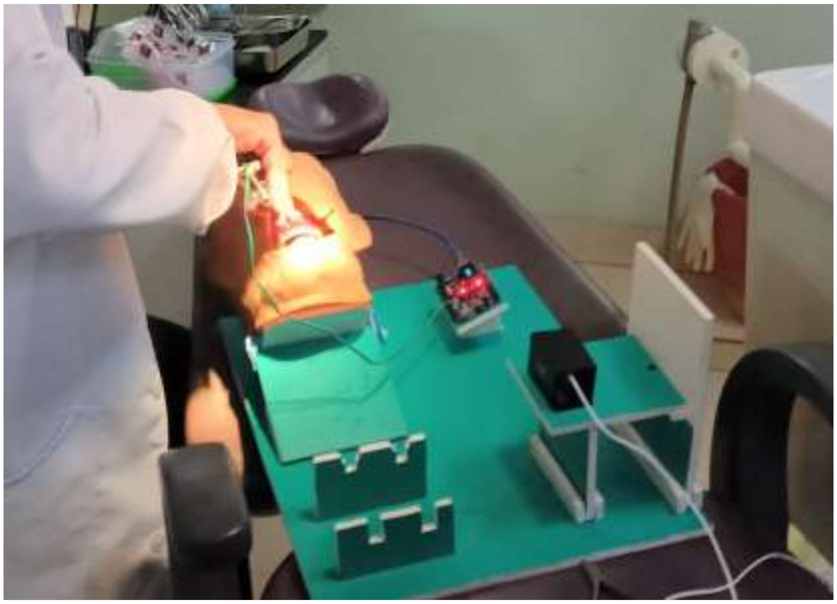
PHOTOS



EXPERIMENTAL SET UP



ORAL CAVITY SIMULATOR



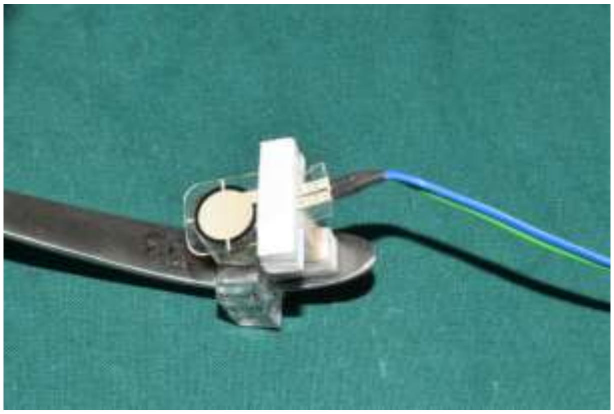
ORTHODONTISTS PERFORMING CRIMPING PROCEEDURE

ORTHODONTIS PERFORMING CRIMPING PROCEEDURE

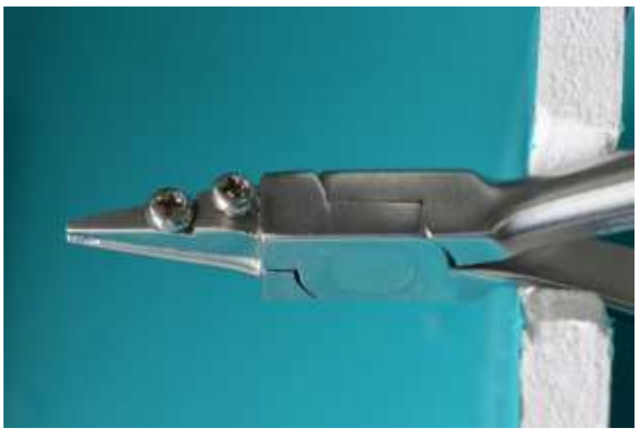
ARICULATOR WITH STOPS

NOVEL CALIBRATED PLIER AND CONVENTIONAL CRIMPING PLIER

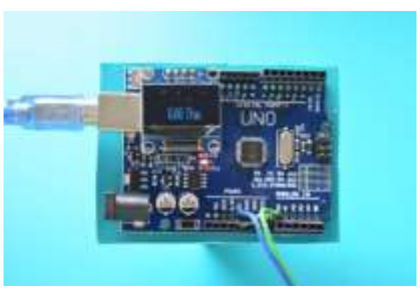
CRIMPING PLIER WITH FORCE SENSOR



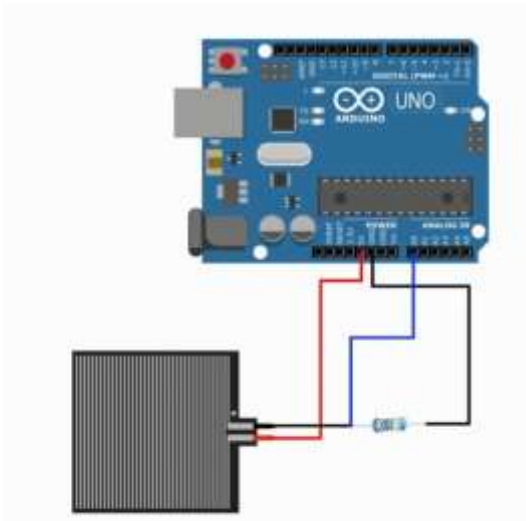
FS FORCE SENSOR SET UP



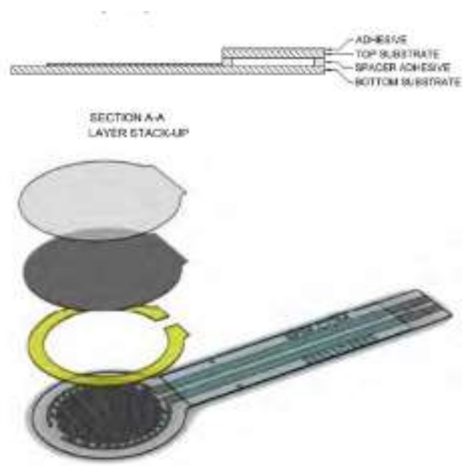
CALIBRATION SYSTEM IN PLIER



ARDUINO UNO MICROCHIP PROGRMMING HARDWARE



RESISTOR BRIDGING OF ARDUINO



FSR – FLEX SENSOR INNER CORE

INCLINOMETER

INCLINOMETER MEASURING ANGLE

Cu NiTi WIRES

STAINLESS STEEL WIRES

Cu nItI WIRES

STAINLESS STEEL WIRES

ETCHING SUSTEM

MODULES

LIGATIING INSTRUMENTS

RESULTS

There are four groups of archwires used in the present study namely

1) Round Cu NiTi

2) Rectangular Cu NiTi

3) Round Stainless steel

4) Rectangular Stainless steel. Every group had 4 intra groups . Each intra group has 10 number of the same wires.

The mean crimping force was evaluated first. Ten experienced orthodontists participated in the study.The deflection obtained by crimping stops using the mean crimping force were recorded. Equal set of wires were crimped with the conventional crimping plier and the novel Calibrated Crimping plier.

Deflection with conventional crimping plier

The results demonstrated that conventional plier produced definite deflection of archwires while the novel calibrated plier made only negligible deflections. All the four group of archwires showed deflection with the conventional plier. The intragroup measurements also showed deflection with variation among samples. Each sample from the ten nos recorded differences in deflection values.

Among the four different groups ,the small size Round Cu NiTi wire produced larger deflection, while the large sized Rectangular stainless steel wires exhibited least deflection . On comparing the Round Cu NiTi wires 0.018 Cu NiTi wires demonstrated least deflection . While all the other Round Cu NiTi wires exhibited similar deflection rates, which was more than 0.016 Cu NiTi wires. On comparing the Rectangular Cu NiTi wires , 0.018 x 0.025 Cu NiTi exhibited highest deflection rates whereas 0.017x 0.025 showed slightly less deflection.

On comparing Round Stainless steel wires , 0.016 stainless steel wires showed higher deflection rates while 0.020 stainless steel wire demonstrated the least. On comparing the Rectangular

Stainless steel wires . 0.017 x 0.025 stainless steel wires showed higher deflection rates when compared to 0.016 x 0.022 and 0.016 x 0.025 wires although they were not statistically significant.

The novel Calibrated Crimping plier had deflection in the range less than 1.5 ^{o} in all the groups.

STATISTICAL ANALYSIS

Data was analyzed using the statistical package SPSS 22.0 (SPSS Inc., Chicago, IL) and level of significance was set at $p<0.05$. Descriptive statistics was performed to assess the mean and standard deviation of the respective groups. Normality of the data was assessed using Shapiro Wilkinson test. Inferential statistics to find out the difference between the groups was done using INDEPENDENT T TEST (BETWEEN THE GROUPS) and One way ANOVA test (WITHIN THE GROUP) followed by Tukey's Post hoc analysis to find out the difference between any two groups.

CuNiti round wire		Deflection in degrees		T TEST	P VALUE (T TEST)
		Conventional crimping plier	Novel calibrated plier		
0.013		14.4±4.35	1.25±1.18	9.22	**0.0001***
0.014		14.2±3.32	1.2±1.03	9.01	**0.0001***
0.016		14.7±3.52	1±1.05	9.43	**0.0001***
0.018		10.5±2.01	0.45±0.64	15.13	**0.0001***
P VALUE (ONE WAY ANOVA)		**0.02***	0.27		
P VALUE (TUKEY'S HSD POSTHOC TEST)	**0.013 vs 0.014**	0.99	0.99		
	0.013 vs 0.016	0.99	0.94		
	0.013 vs 0.018	0.06	0.29		
	0.014 vs 0.016	0.98	0.96		
	0.014 vs 0.018	0.08	0.34		
	0.016 vs 0.018	**0.04***	0.60		

***P<0.05 IS STATISTICALLY SIGNIFICANT**

TABLE 1- Comparison of deflection of orthodontic wires – Conventional crimping plier & Novel calibrated plier- Cu NITI round wire

Cu NITI rectangular wire		Deflection in degrees		T TEST	P VALUE
		Conventional crimping plier	Novel calibrated plier		
0.014 x 0.025 (A)		6.9±3.91	0.57±0.43	5.11	**0.0001***
0.016 x 0.025 (B)		6.2±2.61	0.6±0.65	6.63	**0.0001***
0.017 x 0.025 (C)		5.2±2.09	0.3±0.42	7.24	**0.0001***
0.018 x 0.025 (D)		7.44±2.45	0.37±0.42	8.99	**0.0001***
P VALUE (ANOVA)		0.34	0.44		
P VALUE (TUKEY'S HSD POSTHOC TEST)	**A vs B**	0.94	0.99		
	A vs C	0.54	0.61		
	A vs D	0.97	0.79		
	B vs C	0.85	0.52		
	B vs D	0.78	0.72		
	C vs D	0.32	0.58		

***P<0.05 IS STATISTICALLY SIGNIFICANT**

TABLE 2- <u>Comparison of deflection of orthodontic wires – Conventional crimping plier & Novel calibrated plier-</u> Cu NITI rectangular wire

SS Round Wire		Deflection in degrees		T TEST	P VALUE
		Conventional crimping plier	Novel calibrated plier		
0.014		6.6±1.57	0.55±0.64	11.28	**0.0001***
0.016		7.2±3.11	0.45±0.35	6.85	**0.0001***
0.018		4.9±1.28	0.5±0.52	11.35	**0.0001***
0.020		4.5±1.51	0.3±0.42	8.55	**0.0001***
P VALUE (ANOVA)		**0.011***	0.70		
P VALUE (TUKEY'S HSD POSTHOC TEST)	**0.014 vs 0.016**	0.90	0.96		
	0.014 vs 0.018	0.20	0.99		
	0.014 vs 0.020	0.10	0.67		
	0.016 vs 0.018	0.06	0.99		
	0.016 vs 0.020	**0.02***	0.90		
	0.016 vs 0.020	0.96	0.80		

***P<0.05 IS STATISTICALLY SIGNIFICANT**

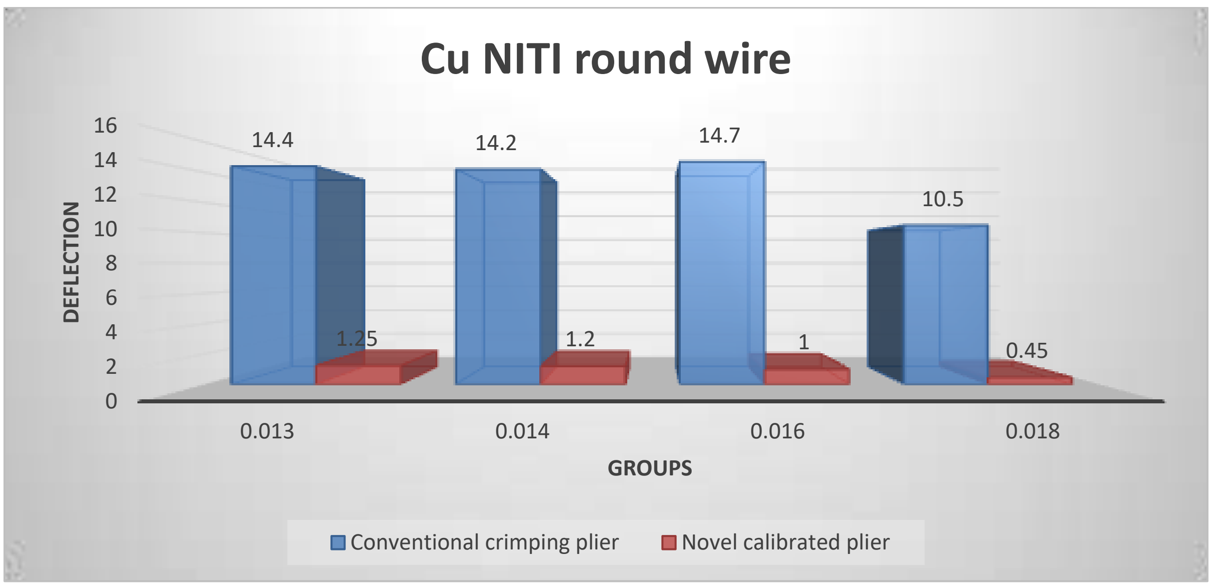
TABLE 3- Comparision of deflection of orthodontic wires – Conventional crimping plier & Novel calibrated plier- SS Round Wire

SS RECTANGULAR WIRE		Deflection in degrees		T TEST	P VALUE
		Conventional crimping plier	Novel calibrated plier		
0.016 x 0.022 (A)		2.8±0.78	0.6±0.61	7.02	**0.0001***
0.017 x 0.025 (B)		6.4±1.64	0.45±0.43	11.09	**0.0001***
0.018 x 0.025 (C)		4.6±1.83	0.15±0.24	7.62	**0.0001***
0.019 x 0.025 (D)		5.2±1.39	0.46±0.28	10.57	**0.0001***
P VALUE (ANOVA)		**0.0001***	0.12		
P VALUE (TUKEY'S HSD POSTHOC TEST)	**A vs B**	**0.0001***	0.85		
	A vs C	**0.04***	0.09		
	A vs D	**0.004***	0.87		
	B vs C	**0.04***	0.38		
	B vs D	0.27	0.99		
	C vs D	0.97	0.35		

***P<0.05 IS STATISTICALLY SIGNIFICANT**

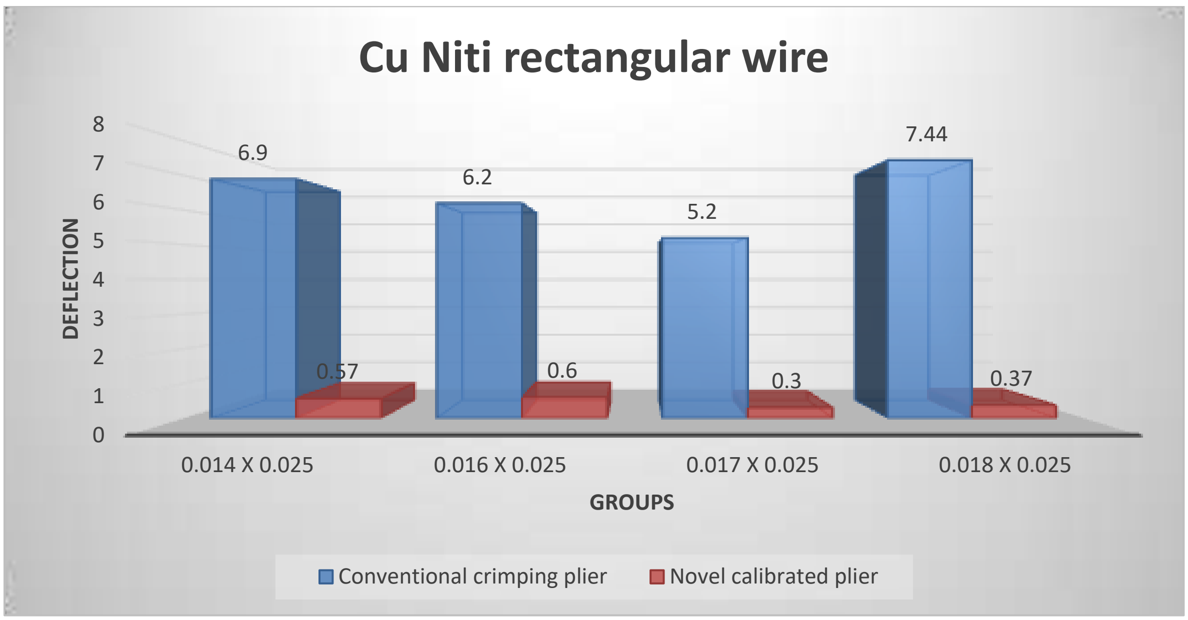
TABLE 4- **<u>Comparision of deflection of orthodontic wires – Conventional crimping plier & Novel calibrated plier-</u>** **SS RECTANGULAR WIRE**

GRAPHS



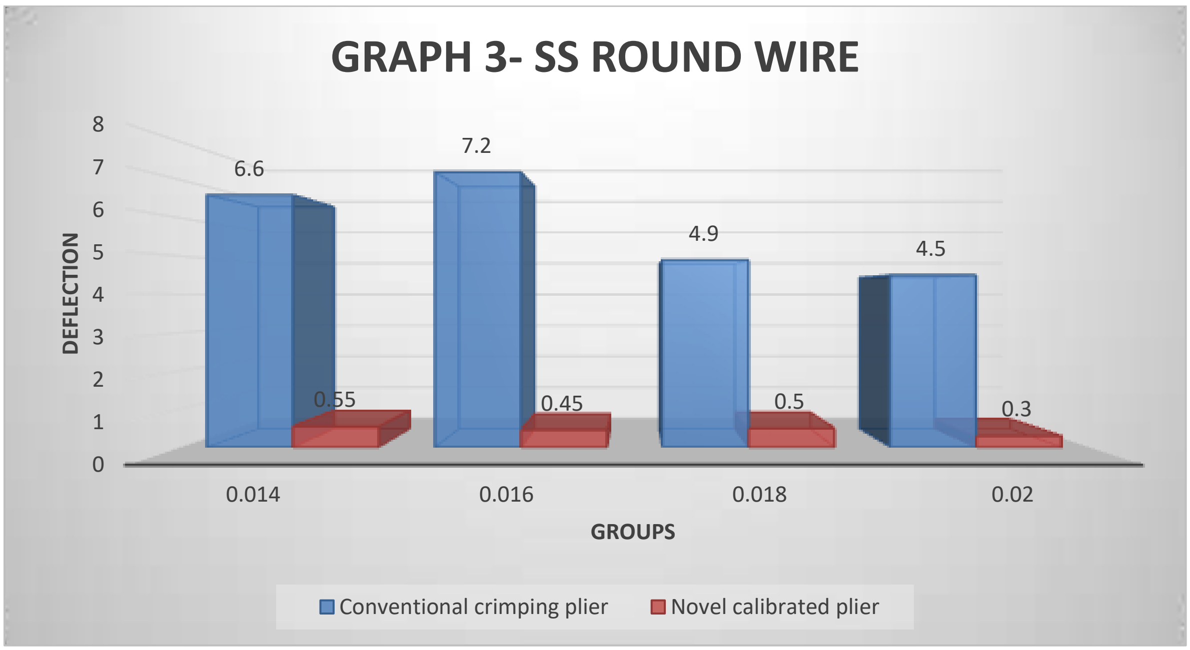
Graph -1 Comparision of deflection between Conventional crimping plier &

Novel calibrated crimping plier



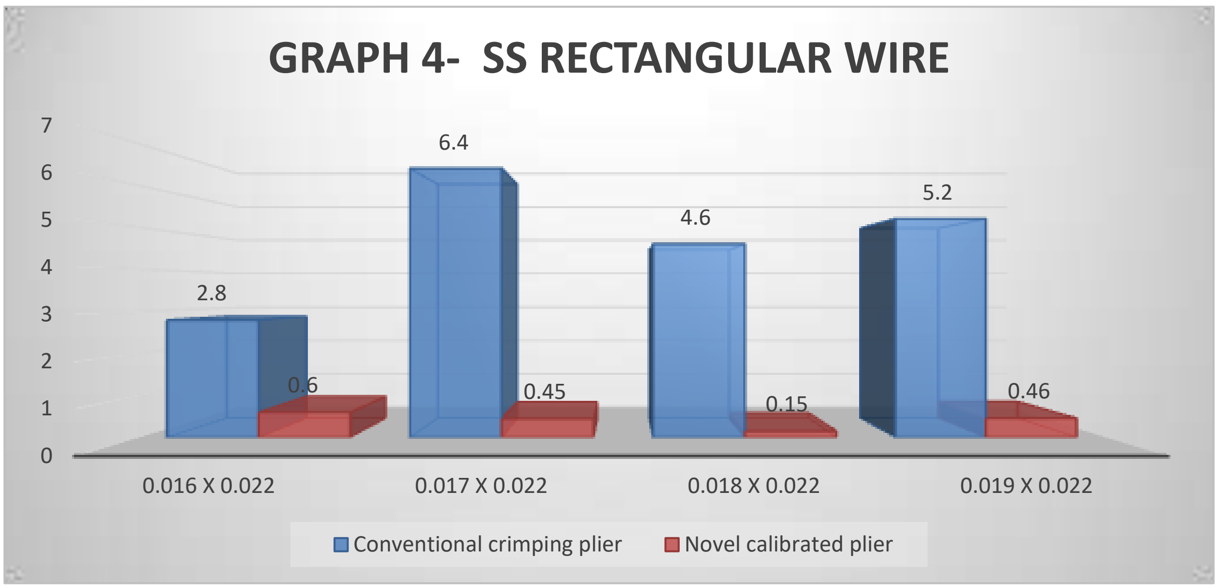
Graph -2 Comparision of deflection between Conventional crimping plier &

Novel calibrated crimping plier



Graph -3 Comparision of deflection between Conventional crimping plier &

Novel calibrated crimping plier



Graph -4 Comparision of deflection between Conventional crimping plier &

Novel calibrated crimping plier

DISCUSSION

The present study was aimed to evaluvate the comparative deflection properties of a set of selected wires from the orthodontic appliance system when crimped with metal stops. The crimpable stops are versatile orthodontic auxiliaries used in the fixed appliance system which have almost similar uses like the crimpable hooks. The study of the crimpable hooks and stops are always analysed with that of the archwire to which they are crimped.

The present study tries to analyse the force and its effect on the Archwire when applied to the crimpable stops through a crimping plier . Applying excess force may overdo the crimping and the wire inside the stops gets deformed. The wires have its own mechanical properties which give them the different deflective patterns. The optimal application of force through the stops is another criteria which needs a thorugh discussion. The thickness of the wires and the stops will also have an influence in the deflective properties. The dimension and shape of the stops are also critical factors. All the factors mentioned above in connection with the crimpable stops and the archwire are discussed with a historical background retrospective with their available literature.

Stops in orthodontic appliance system are used for different purposes

1. Stops are primarily used to prevent sliding or walking of archwire which may cause tissue injury .
2. They are commonly used in self-ligating system, as the sliding of archwires are frequent due to reduced friction within the bracket slots.
3. They can also be used to reinforce anchorage by preventing mesial or distal movement of anchor teeth.
4. De rotating single tooth especially cuspids
5. Unilateral relieving of crowded teeth
6. Modified stops in support with TADS to move teeth

Crimpable stops are mostly used in Self ligating appliance system where the initial thin wires are free to slide or walk through the brackets. This is because of the low friction between the slot and Archwire. The crimped stops prevent their sliding. In most cases stops can also along with initial thinner wires right from the start of treatment . Stops can also cause changes in the teeth position especially when they are combined with auxiliaries like open coil springs etc .

Instead of crimping hooks or stops they can be welded or soldered to archwire. The Lab establishment needed, the strain of work and the loss of quality of mechanical properties of archwire limits their use . Moreover the clinician is at ease to work comfortably at the chair side with crimpable stops. Hence crimpable stops suits better as an auxiliary in his armementarium.

With the advent of new technology new designs and of stops and hooks are available in the market. They are fabricated with CADcam and Laser technology.The thickness, shape and the material properties allows its easy clinging and firm snug fit to the arch wire forms. There are many claims of the design improvements for easy crimping of stops. Stops are rectangular and cylindrical in shape. Although there are different sizes, a few common sizes are used to crimp different sizes of wires. Few manufacturers design stops which adapts closely to that particular wire size. The properties of archwire material , shape and size also plays a role in crimping property.

In situations where stops could be avoided they could be replaced with some simple wire bending applications. The remedy is to place a STOP to prevent sliding of the arch wire. Conventionally the “STOP” mechanics in orthodontics utilized the following methods.

1. “Dimpled” NiTi arch wires - These dimples are fabricated in the middle of the arch wire to prevent sliding. There are larger dimple in the maxilla and smaller one in the mandible.
2. V – bends could be incorporated in the interbracket span in the archwire.
3. Bend back or Cinching of wires at the bare distal end of molar tube to prevent running of archwire.

But the desirable positive gains in using the stops mainly to derotate , decrowd gain space distalize or mesializing movements will be compromised with the cinching of wire. The freedom of movement will be compromised.

The seven principal keys to occlusion by Andrews state that the anterior and posterior teeth has their own tip, torque and interdigitation . There should be an ideal occlusal plane with ideal overjet and overbite . The disturbance in the intercuspal relation may open the bite, create interocclusal spaces and crossbites. The functional occlusion may also be disturbed. A chance of slight rotation by crimping stops could not be avoided and that may influence the minor aesthetics of teeth. Inter and intra variability among operators crimping the stops create a wide range of force variations which in turn may affect the properties of the archwire: thereby compromising the results.

Kumar S[20] and Prof. Ravindra Nanda has rightly stated about the influence of smile and smile perception by the patient . They have mentioned about the dynamic principles of smile and the influence and flattening of smile with orthodontic treatment. The orthodontic treatment influenced the smile aesthetics in three planes of face. Even a small percentage of change in smile corridor has a consequence which affect of the treatment outcome. The gingival display and the vertical maxillary excess could directly effect the smile aesthetics and it has influence on true smile perception of the patient. T Christou[47], et al in 2019 has described , the esthetic sway of orthodontic treatment .If the orthodontist in his earnest effort try to bring the best smile out of his treatment plan, there still could be nuances which creates finer disturbances in the aesthetics of smile. This may be corrected at the finishing stage of treatment with some active effort. All these indicates that the value of minor and micro aesthetics is very much important and that should be carefully preserved or taken care ,throughout the treatment schedule.

There are different materials for arch forms namely stainless steel, chrome cobolt, nickel titanium and beta titanium . However new materials also have been introduced.Materials which give light forces with super elastic or pseudo elastic property was accomplished with the introduction of nitinol .Even after a long term bending or deflection there will be no loss of shape the property is called shape memory . So selection of crimpable stops, crimping methods and materials which give lesser unwanted effects is important. The method or tool or plier for crimping this becomes all the more crucial.

The positon of crimping and the method or utility of the crimpable stops have gained attention recently. When stops are used along with coil springs for derotation there will be stress at the proximal teeth . When they are used to prevent distal or mesial movement of posterior teeth the deflective force combined with the force involved in space closure tooth movement produce undesirable movement of teeth. Added to that they create real cuspal or occlusal unrest in functional occlusion of the posterior teeth. The adverse effect depends on the type of application with the stops.

Peter D. Wilkinson[14] et al after testing a significant series of wires indicate low load deflection for certain nitinol wires. The practitioner should be aware of this property when using the crimpable stops or hooks.

The load deflection rate (LDR) of an orthodontic archwire is the mechanical property which influence the deflective characteristics of the wires with force as stated by Peter D Wilkinson et al, 2002. Wires with low load deflection rate gets deformed more with force , so Cu NiTi gets deflected more than stainless steel. When a stop is crimped to an archwire with any normal plier the crimpable stops will create a deflection in the archwire. Overdoing the crimp is a shortcoming which with the available crimping pliers in the market . The orthodontist always keeps his armamentarium minimum and uses any convenient plier like the bird beak plier or ligature cutter for the same. The nitinol and stainless steel wires has a notable difference in their frictional coefficients according to Bhushan Patil et al 2016. The orthodontists method of crimping is his or her intuitional response of force delivery.The amount of force he or she deliver will be dependant on the shape and thickness of archwire plus the characteristics and design of the stops.

Robert P kusy[5] is one of the pioneer in the studies with arch wire material properties. The series of notable studies with the wire material is accordable. According to him the properties like friction, flexibility, hardness , yield strength etc vary in different arch wire materials like, stainless steel and nitinol which are the primarily used orthodontic archwire materials. The springiness and flexibility of nitinol offers less permanent deformation than stainless steel wires. But they are flexible and yield to more deflection to ṣmall magnitude of force. Any permanent deformation is more stainless steel Archwires. Nitinol has less deformative property. A continuous force, force even if it is small, deforms the wire get permanently.

As for the frictional part, nitinol has greater friction than stainless steel. Any material which has more friction helps with more locking properties. The material with more friction has more binding nature. So stops crimp very easily in nitinol wires than in stainless steel wires . Prof Wilkinson et al states that the Load deflection produced in wires is more for nitinol preformed wires. The varied forms of nitinol like copper niti wires has variations in properties and then changes. Also the properties are different for round and rectangular wire and they vary depending on the thickness of wires.

The force necessary to crimp the stops is thus directly related to the frictional property between the arch wire material and the stop . The force delivered for the same could not be counted as the only key factor to crimp the. Moreover the thickness and shape of the wire material, properties related to mechanical characters such as frictional coefficient etc could also be considered as the crucial factors. Considering all factors force is still one of the key factors deciding the crimp with frictional property as the prime factor and still the shape and size of the archwire secondary factors.

The minimum force needed with a stop to get a 'friction-lock' with the archwire is the crimping force. The mean crimping force is first evaluated. The values obtained for crimping differs with different orthodontists. That can vary according to the operator, sex and even the age and experience of the clinician. The data shows a range of force varying from 2.87 N to 3.94 N , which is equivalent to 292.85 gms to 402 gms of force. The lowest values wwre obtained for female operators ; males recorded higher values in the study. The values obtained correlated well with the earlier studies done with the crimpable hooks. The mean crimping force from the study by Evans and Jones[4] et al 1991 and Johal A[11] et al 2001 for crimping hooks sets a similar range of force. The stops are similar in feature to the hooks. Hooks carry an additional vertical post to the basic structure of a stop. The 'friction-lock' mechanism may be considered almost similar for both the crimpable stops and the crimpable hooks.The materials added by the manufacturers to get a better grip may vary . The methods related to improve the 'friction-lock' in both auxillaries could be found in common literature .

The friction between the arch wire and the stops plays the major role in providing an efficicient crimp or adherence .The arch wire materials namely, nitinol, Cu NiTi, TMA and stainless steel has varied coefficient of friction. The different alloys and metals fabricating the crimpable stops crimpable stops also infuences the adhering property (Griffin and Ferracane ,1998). The size and design of the stops is also critical. The material and design of the stops could have different combinations , and they vary in shape and pattern . Material properties of different brands may also differ and there may be specifications for all these different products. Few of the manufacturers use adhesive material or may coat the inner adhering portion with grip providing materials.

There will be variation in the force application in relation to the position of a patient in the dental chair and the operators ergonomics. Sometimes it may be uncontrolled. The force delivery through the plier is operator specific and it is somewhat related to the mental calculation of the operator.

The mean or the average of different crimping forces obtained with a set of 10 wires would give a generalised or average crimping force . The mean crimping value obtained was taken as a reference value for crimping with both normal conventional and the novel calibrated plier mentioned in the study.

Interpretation of Result

There are four group of archwires namely, Round Cu NiTi , Round Stainless steel, Rectangular Cu NiTi, Rectangular Stainless steel. The deflections were recorded for both the conventional plier and the novel calibrated crimping plier. The different sets of wire in each of the four group are crimped with stops using the mean crimping force.

The results shows that all the sets of wires in the four groups have deflection of archwires with the conventional plier .The novel calibrated plier show only slight or negligible deflection. There is a wide variation seen in the deflection among different groups. The values obtained within each set of wires show variations among the different sizes of archwires. There are some unusual pattern of variation in the deflection among archwires. Certain intra group variations are not linear and not easily recognisable. Further study will be needed to substantiate the variations. The statistical analysis and scientific reasoning adds much relevance to this study.

The archwire properties could explain most of the variations seen among different wires. Thinner wires among the selected wires show more deflection with the force. Thinner wires are less stiff and so the range of deflection could be more. Among the thinner wires Cu NiTi Round wires showed more deflection. The load deflection rate (LDR) is more for Cu NiTi. LDR is the external loading needed for a unit deformation and in orthodontic literature it is the force generated by unit length of deformation. LDR is the minimum force required for a wire to come back to its normal state after it has been deflected. LDR is one way to explain the maximum amount of force that can be applied on a wire before permanent deformation. Thus LDR indirectly give the amount of force that is needed for certain amount of deflection. Cu NiTi wires has a higher deflection with a lesser force.

Round wires deflect more compared to rectangular wires. The rectangular cross section has low modulus of elasticity and high strength. CuNiTi wires has got less stiffness but increased range and strength. Rectangular Cu NiTi wires also show more strength and range. Robert kusy's 1991 study analyse the quality of different wire materials. Cu NiTi has increased coefficient of friction ,which indicates a higher friction with any other metal surface in contact. This property makes the stops easily adhere to the archwire. Cu NiTi wires need a lesser force to crimp the stops . The data obtained in the study substantiate this property.

When comparing same gauge of round Cu NiTi and Stainless steel wires , more deflection is for Cu NiTi. The load deflection property is low for Cu NiTi. The wires used are not exactly similar in both set of round wires. But the thicker round wires have low deflection for both Cu NiTi and Stainless steel. The deflection values for both the groups are almost similar. Cu NiTi round wires has slightly high deflection compared to Stainless steel in higher round wires.

Rectangular Cu NiTi wires have less deflection . The frictional property helps to lower the crimping force. The rectangular Stainless steel wires has more stiffness . So it is expected to have less deflection. The friction between the stop and the wire is less . The operator is tempted to deliver more force. This will create more deflection. Other than the frictional property, the binding nature of rectangular wires is more in stainless steel as stated by Jack Burrow et al 2009. So the deformation with the binding material will be more. Stainless steel stops should get more grip with the wires . But the frictional property may work well more than the binding property. The high frictional coefficient with rectangular Cu NiTi archwires will need only a lesser force to crimp the stops The higher rectangular Stainless steel wires has more tough surface which may reduce the crimping force transferred to the wire. This may produce less deflection when compared with the thicker Cu NiTi wires . Both Cu NiTi and Stainless steel wires have very less deflection when it comes to thicker wires.

Thinner and thicker wires have separate stops fabricated for their sizes. The stops have close adaptation with the Round wires . There is relatively a large surface area closely adapted to the stops. The stops have less relative adaptation with the rectangular wire . The crimping force may not be fully transferred through the rectangular type stops to the archwire. The deflection will be less for the rectangular wires compared to round wires. But thicker round wires should deflect more with this property.

The relative thickness of the stops are less compared to the total thickness of the archwire. But with a thinner wire the thickness of the stops is relatively high when compared to the total thickness of the archwire and the stops. The smaller the wire the stop thickness is significant. Smaller wires because of its low stiffness deflect more. With the thicker wires the thickness of the wire is significant than stop thickness. Thus it deflects less. The data shows more deflection for thinner wires when stops are crimped to the wire .

The deflection values with the novel crimping plier is not zero or null always. There will be slight deflection even with the rightly calibrated plier. Though the novel plier is good enough for crimbing to give a bare ‘friction – lock’ there are limitations. The study shows very slight deflection with the calibrated plier. So there should be some further modification or proper calibrating system to be evolved which gives zero deflection of the archwire when used for crimbing.

First group Round Cu NiTi has two sub groups , Conventional crimping plier & Novel calibrated plier group. The results shows the deflection after the application of force in the two groups (Conventional crimping plier & Novel calibrated plier) among Cu NITI round wire group. Conventional crimping plier group has significantly higher deflection of wires (0.013/ 0.014/ 0.016 & 0.018) compared to the Novel calibrated pliers. The deflection found in the two sub groups may be due to the low load deflection property .The deflection of the first group shows more deflection that indicate conventional plier cannot deliver consistent force.

Second group shows the deflection after the application of force in two groups (Conventional crimping plier & Novel calibrated plier) among Cu NITI rectangular wire group. Conventional crimping plier group has significantly higher deflection of wires (0.014 x 0.025/0.016 x 0.025/0.017 x 0.025/0.018 x 0.025) compared to the Novel calibrated pliers. The deflection of the first sub group shows more deflection that indicate conventional plier cannot deliver consistent force. There is more deflection on thinner rectangular wires namely 0.014 x 0.025/0.016 x 0.025 because of low stiffness and increased flexibility of thinner wires .

Third group shows the deflection after the application of force in two groups (Conventional crimping plier & Novel calibrated plier) among Stainless steel round wire group. Conventional crimping plier group has significantly higher deflection of wires (0.014/ 0.016/ 0.018 & 0.020) compared to the Novel calibrated pliers. The deflection of the first sub group shows more deflection that indicate conventional plier cannot deliver consistent force. There is more deflection on thinner round wires namely 0.014/0.016 because of low stiffness with thinner wires, flexibility and range of force .

Group four shows the deflection after the application of force in two groups (Conventional crimping plier & Novel calibrated plier) among Stainless steel rectangular wire group. Conventional crimping plier group has significantly higher deflection of wires (0.016 x 0.022/ 0.017 x 0.025/ 0.018 x 0.025/ 0.019 x 0.025) compared to the

Novel calibrated pliers. That may be due to the extra force delivered through the conventional plier. The thicker Rectangular wires has less deflection and that could be due to the increased stiffness.

Within group (Conventional crimping plier) analysis for Round Cu NITI reported significant result between different wires of first group .The significant difference existed only between 0.016 and 0.018 wires. The difference in deflection may be due to the greater difference in thickness, where 0.018 wire is 1.25 times thicker than 0.016. whereas the the other combinations or pairs does not differ much in thickness.

In the second group Rectangular Cu NITI, the inner sub groups (Conventional crimping plier) values using did not report any significant result between different wires. The wires in this group are rectangular , where the breadth of wire is more which increased area of contact. These wires may also get a ‘friction- lock’ easily since they are nitinol wires. The width of the wire is same and may experience same ‘friction- lock’ and the binding nature may be almost similar. Thus all the wires in the group have similar deflection property.

Among the third group Round Stainless steel wires (Conventional crimping plier) the values reported significant result between different wires. Significant difference existed only between 0.016 and 0.020 Stainless steel wires. The difference in deflection between the 0.016 and 0.020 wires may be due to the greater difference in the thickeness in the wires. All other wires have less difference in thickness.

The subgroups of the fourth Rectangular Stainless steel group (Conventional crimping plier) also showed significant result between different wires. Significant difference existed between 0.016 x 0.022 vs 0.019 x 0.025 wires. No significant difference existed between 0.017 x 0.025 vs 0.019 x 0.025 and 0.018 x 0.025 vs 0.019 x 0.025. The width of wire is common. As the thickness of wire increases the gap between the stop and wire decreases. As the gap decreases the close adaptation of stop and wire transfers the force through the stops easily. The thicker wires may have an decreased deflection. The last two subgroups with 0.018 x 0.025 and 0.019 x 0.025 are comparatively thicker with increased stiffness increase and hence there will be less deflection. 0.018 x 0.025 has less deflection compared to 0.017 x 0.025 and 0.019 x 0.025. That maybe because of more close adaptation of stop with the larger breadth of the wire and increased stiffness.

The subgroups of all the Four groups (Novel calibrated plier analysis) did not report any significant result between different wires within the groups.

Among the four groups (Novel crimping plier) there is no significant difference in deflection between the wires . Any change in deflection could have been due to the properties of archwire or the lack of performance of the novel crimping plier. The property of the wires are not significant in this result, since the deflection of wires are negligible and are almost similar for every group of wire. Then the mild deflection of the wires could be because of the slight inaccuracy of the plier itself.

It was found that among the rectangular wiresthe higher size wires showed more deflection than their lesser counterpart, although they were not statistically significant.

This may be attribuited to the properties of the stops which is made of soft steel which absorbs the forces to some extend . Further studies and investigation may be required to get aclarity on this phenomenon.

From the study it is relevant that the novel calibrated crimbing plier has got much advantage over the conventional crimping plier. The plier does not produce much wire deflection when metal stops are crimped to archwires. The deflection produced is minimum and that could be overcome with further refinement of the plier.

CONCLUSION

Archwires behave differently to crimping forces depending on its shape, size and material property. Several authors have confirmed this through their earlier studies. In the orthodontic appliance system, force is the chief biomechanical tool which influences all treatment plans. Force is utilised for positive or desirable changes or movements. The negative effect controlled with suitable measures.

Crimpable metal stops are passionately and creatively used by many clinicians as an orthodontic auxiliary. Its critical use as an auxiliary is just a technique to stop walking of wires, especially in the self- ligating orthodontic system. Crimping stops need force application through suitable pliers and overdoing it may affect the mechanical properties of the Archwires influencing treatment results.

The present study verifies the reliability of a novel Calibrated Crimping plier over the conventional plier. Findings of the study can be concluded as below.

1. While using conventional crimping pliers ,the forces are uncontrolled which may cause deflections in the Archwire.
2. The use of new calibrated crimping plier delivered consistant force for crimping which could be customised according to wire sizes.
3. Cu NiTi wires have more deflection with crimping force compared to Stainless steel wires. Cu NiTi round thinner wires should be carefully managed while crimping for varied uses.
4. Rectangular Cu NiTi has less deflection than rectangular stainless steel wires especially in thinner gauges with crimping.
5. Customised stop-sizes and shapes are ideal for a good crimp.
6. Select the stops with ideal specifications for suitable use and wire selection.
7. Use crimpable stops judicialy with suitable wires and apply force that minimise the side effect
8. New advantages or indigineous use with stops are being explored. The benefits surpass the limitations

The novel plier is verified through this present study and there is a minimum or negligible deflection produced while with crimping with this plier. The plier need to be modified with better calibration method for final refinement for an optimal crimp.

Limitations of the this study -

- This was an in vitro study and had its limitations. The study result may vary in the intra oral in oral environment.
- In vivo oral musculature may interfere the proper crimping of stops. The present study is in vitro which cannot fully simulate the oral structures.
- The intra oral force application in crimping may vary. In this study although an oral jig simulation was set up, values of deflection may vary in intra-oral conditions.
- The size and shape and friction property of the crimpable stops are are not included in the study.
- Various patterns of modified crimping pliers were not available at the time of the present study.

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ANNEXURES

MATERIALS AND METHODS

a) Round copper niti wires
b) Rectangular copper niti wires
c) Round ss wire
d) Rectangular ss wire

Cu NITI WIRES (round)	Cu NITI WIRES (rectangular)
0.013" x 10 sets 0.014" x 10 sets 0.016" x 10 sets 0.018" x 10 sets	0.014" x0.025" x 10 sets 0.016" x 0.025" x 10 sets 0.017" x 0.025" x 10 sets 0.018" x 0.025" x 10 sets
Total 40 sets	Total 40 sets
STAINLESS STEEL WIRES (round)	STAINLESS STEEL WIRES (rectangular)
0.014" x 10 sets 0.016" x 10 sets 0.018" x 10 sets 0.020" x 10 sets	0.016" x 0.022" x 10 sets 0.017" x 0.025" x 10 sets 0.018" x 0.025" x 10 sets 0.019" x 0.025" x 10 sets
Total 40 sets	Total 40 sets
16 groups of wires Total 16 x 10 = 160 wires	

TABLE 3 - Materials , different Archwires

PROFORMA FOR DATA COLLECTION

Different orthodontic wires from each group	Conventional crimping plier, force in newton meter , N	Force in gms F in N X 1000 9.8	Mean force - Grams
1 0.013 CuNiTi	3.4	346.9	
2 0.014 CuNiTi	3.74	381.63	
3 0.016 CuNiTi	3.4	346.9	
4 0.016 SS	3.6	367.34	
5 0.018 SS	2.8	294.89	
6 0.016 x 0.022 CuNiTi	3.3	338.73	350.89
7 0.014 x 0.025 CuNiTi	3.45	352	
8 0.017 x 0.025 CuNiTi	2.9	295.91	
9 0.018 x 0.025 SS	3.8	387.75	
10 0.019 x 0.025 SS	3.89	396.93	

TABLE 4 – Mean crimping force with conventional crimping plier

Comparision of deflection of orthodontic wires – Conventional crimping plier & Novel calibrated plier

0.013 CuNiti round wire	Conventional crimping plier		Novel calibrated plier	
	Mean force using sensor	Deflection in degrees	Mean force using sensor	Deflection in degrees
1		19		8
2		20		3
3		9		1
4		12		0.5
5		19		0
6	350.89	18	350.89	2
7		10		3
8		14		0
9		14		0
10		9		1

TABLE 5A - Deflection between conventional crimping plier and Novel calibrated crimping plier

0.014 CuNiti round wire	Conventional crimping plier		Novel calibrated plier	
	Mean force using sensor	Deflection in degrees	Mean force using sensor	Deflection in degrees
1		14		3
2		12		2
3		21		0
4		14		0
5		15		1
6	350.89	12	350.89	2
7		10		0
8		15		2
9		18		1
10		11		1

TABLE 5B - Deflection between conventional crimping plier and Novel calibrated crimping plier

0.016 CuNiti round wire	Conventional crimping plier		Novel calibrated plier	
	Mean force using sensor	Deflection in degrees	Mean force using sensor	Deflection in degrees
1		9		3
2		15		2
3		15		1
4		22		0
5		14		0
6	350.89	12	350.89	0
7		15		2
8		18		1
9		15		1
10		12		0

TABLE 5C - Deflection between conventional crimping plier and Novel calibrated crimping plier

0.018 CuNiti round wire	Conventional crimping plier		Novel calibrated plier	
	Mean force using sensor	Deflection in degrees	Mean force using sensor	Deflection in degrees
1		15		1
2		12		0.5
3		10		0.5
4		12		0
5		9		0
6	350.89	9	350.89	0
7		10		0.5
8		8		2
9		10		0
10		10		0

TABLE 5D - Deflection between conventional crimping plier and Novel calibrated crimping plier

0.014 x 0.025 Cu Niti rectangular wire	Conventional crimping plier		Novel calibrated plier	
	Mean force using sensor	Deflection in degrees	Mean force using sensor	Deflection in degrees
1		16		0
2		3		0
3		7		0.5
4		10		1
5		5		1
6	350.89	6	350.89	1
7		7		0.5
8		8		0
9		3		0.7
10		4		1

TABLE 6A - Deflection between conventional crimping plier and Novel calibrated crimping plier

0.016 x 0.025 CuNiti rectangular wire	Conventional crimping plier		Novel calibrated plier	
	Mean force using sensor	Deflection in degrees	Mean force using sensor	Deflection in degrees
1		9		1
2		7		1
3		12		2
4		5		0.5
5		6		0
6	350.89	5	350.89	1
7		6		0.5
8		3		0
9		4		0
10		5		0

TABLE 6B - Deflection between conventional crimping plier and Novel calibrated crimping plier

0.017 x 0.025 CuNiti rectangular wire	Conventional crimping plier		Novel calibrated plier	
	Mean force using sensor	Deflection in degrees	Mean force using sensor	Deflection in degrees
1		7		0.5
2		8		0
3		4		0
4		3		0
5		8		1
6	350.89	4	350.89	0.5
7		5		0
8		7		0
9		3		0
10		3		1

TABLE 6C - Deflection between conventional crimping plier and Novel calibrated crimping plier

0.018 x 0.025 CuNiti rectangular wire	Conventional crimping plier		Novel calibrated plier	
	Mean force using sensor	Deflection in degrees	Mean force using sensor	Deflection in degrees
1		11		0
2		9		1
3		9		0.5
4		6		0.7
5		9		0
6	350.89	5	350.89	0.5
7		7		0
8		3		1
9		8		0
10				0

TABLE 6D - Deflection between conventional crimping plier and Novel calibrated crimping plier

0.014 SS round wire	Conventional crimping plier		Novel calibrated plier	
	Mean force using sensor	Deflection in degrees	Mean force using sensor	Deflection in degrees
1		7		0.5
2		7		0.5
3		10		1
4		6		0
5		7		0
6	350.89	6	350.89	0
7		4		0.5
8		7		1
9		5		2
10		7		0

TABLE 7A - Deflection between conventional crimping plier and Novel calibrated crimping plier

0.016 SS round wire	Conventional crimping plier		Novel calibrated plier	
	Mean force using sensor	Deflection in degrees	Mean force using sensor	Deflection in degrees
1		9		0
2		10		0.5
3		13		0.5
4		9		1
5		7		0
6	350.89	4	350.89	0
7		6		0
8		7		1
9		3		0.5
10		4		1

TABLE 7B - Deflection between conventional crimping plier and Novel calibrated crimping plier

0.018 SS round wire	Conventional crimping plier		Novel calibrated plier	
	Mean force using sensor	Deflection in degrees	Mean force using sensor	Deflection in degrees
1		5		0
2		4		1
3		7		0
4		3		0
5		4		1
6	350.89	4	350.89	1
7		5		0
8		5		0
9		7		1
10		5		1

TABLE 7C - Deflection between conventional crimping plier and Novel calibrated crimping plier

0.020 SS round wire	Conventional crimping plier		Novel calibrated plier	
	Mean force using sensor	Deflection in degrees	Mean force using sensor	Deflection in degrees
1		4		0.5
2		5		0.5
3		8		0
4		3		0
5		5		1
6	350.89	5	350.89	1
7		4		0
8		3		0
9		5		0
10		3		0

TABLE 7D - Deflection between conventional crimping plier and Novel calibrated crimping plier

0.016 x 0.022 SS rectangular wire	Conventional crimping plier		Novel calibrated plier	
	Mean force using sensor	Deflection in degrees	Mean force using sensor	Deflection in degrees
1		3		2
2		3		1
3		3		0.5
4		4		0.5
5		2		0.5
6	350.89	2	350.89	0
7		2		0.5
8		4		1
9		3		0
10		2		0

TABLE 8A - Deflection between conventional crimping plier and Novel calibrated crimping plier

0.017 x 0.025 SS rectangular wire	Conventional crimping plier		Novel calibrated plier	
	Mean force using sensor	Deflection in degrees	Mean force using sensor	Deflection in degrees
1		4		0
2		8		0
3		6		0
4		10		0.5
5		6		1
6	350.89	5	350.89	0.5
7		6		1
8		7		1
9		6		0.5
10		6		0

TABLE 8B - Deflection between conventional crimping plier and Novel calibrated crimping pli

0.018 x 0.025 SS rectangular wire	Conventional crimping plier		Novel calibrated plier	
	Mean force using sensor	Deflection in degrees	Mean force using sensor	Deflection in degrees
1		2		0
2		4		0
3		6		0.5
4		8		0.5
5		4		0
6	350.89	4	350.89	0
7		2		0.5
8		5		0
9		6		0
10		5		0

TABLE 8C - Deflection between conventional crimping plier and Novel calibrated crimping plier

0.019 x 0.025 round rectangular wire	Conventional crimping plier		Novel calibrated plier	
	Mean force using sensor	Deflection in degrees	Mean force using sensor	Deflection in degrees
1		8		1
2		4		0.5
3		6		0.5
4		5		0.5
5		6		0
6	350.89	5	350.89	0.5
7		4		0.5
8		3		0.6
9		5		0.5
10		6		0

TABLE 8D – Deflection between conventional crimping plier and Novel calibrated crimping plier s

ST. GREGORIOS DENTAL COLLEGE

UNDER THE MANAGEMENT OF MJSCE TRUST, PUTHENCRUZ

CHELAD , KOTHAMANGALAM, ERNAKULAM DIST, KERALA - 686681

SGDC/152/2019/3730

15/11/2019

ETHICAL CLEARANCE CERTIFICATE

To,

Dr.Jose Nelson
St.Gregorios Dental College
Chelad,Kothamangalam

Dear Dr.Jose Nelson

Subject: Ethics Committee Clearance Reg.

Protocol: A study on the effect of crimping metal stops on various arch-wires.

After the Institutional Ethics Committee (IEC) held on 15th of November 2019, this study was examined and discussed. After theconsideration, the committee had decided to approve and grant clearance for the aforementioned study.

The members who attended the meeting at which the protocol was discussed were:

1) Dr.C.K.K Nair - Former BARC Scientist.
2) Dr.Cinu Thomas A - Scientist, Senior lecturer, Department of Pharmaceutical Sciences Centre for Professional and Advanced Studies.
3) Dr.Lissy Jose-Former member Women's Welfare Association.
4) Adv.Jose Aranjani - Advocate.
5) Dr.Sauganth Paul- Reader, Department of Biochemistry, St.Gregorios Dental College.
6) Dr.Eapen Cherian - Secretary.
7) Dr.Jain Mathew - Principal and Head of the Department, Department of Conservative Dentistry and Endodontics.
8) Dr.George Francis - Head of the Department, Department of Prosthodontics and Crown& Bridge.
9) Dr.Binoy Kurian - Head of the Department, Department of Orthodontics & Dentofacial Orthopaedics.

Dr. C.K.K Nair
Chairman Institutional Ethics Committee
St.Gregorios Dental College, Chelad

Dr.Eapen Cherian
Secretary

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