Micro-Orthodontics: An Ambition for the Future

One orthodontist asks the orthodontic industry to think smaller when it comes to brackets

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Micro-orthodontics is a novel technique in the field of orthodontics which advocates using miniature bonded attachments during comprehensive treatment.

The miniature attachments presented in this article possess an edgewise slot, a vertical slot, and the unique feature of not having any tie wings. This configuration allows for the construction of a bracket that has a narrow width (1.3 mm) and minimal occluso-gingival height (1.4 mm). The bracket is laser welded to a mesh pad and archwires are secured within the edgewise slot via ligation through the vertical passage using Teflon coated steel ties (Figure 1).

Historically, the first micro-orthodontic brackets were manufactured in 2003 using CNC precision-milling (American Orthodontics). The appliance was limited to the upper anterior sextant and was named NanoArch (Figure 2).

This micro-orthodontic system was employed sporadically in my practice over a period of 10 years, mainly for cases with severe crowding requiring extraction of premolars. I would not characterize these brackets as user friendly, but nonetheless, placement of the appliance using direct bonding was adequate and controlled tooth movement via sliding mechanics was routinely accomplished.

The present article will discuss the advantages and explore the biomechanical challenges experienced using the NanoArch appliance in patients. Here, I also wish to encourage the orthodontic community to think smaller in terms of brackets and invite manufacturers to develop and promote newer, more sophisticated miniaturized attachments.

Advancing the art of micro-orthodontics is desirable as it will offer patients therapeutic modalities that are superior in comfort, hygiene, versatility and aesthetics compared to conventional appliances.

Figure 1: A prototype maxillary central incisor micro-orthodontic bracket compared to the corresponding mini-twin bracket. Due to its extremely small size, this attachment is referred to as Nano bracket.

Advantages

Aesthetic benefits:

The most obvious advantage is the fact that micro-orthodontic systems are more aesthetic than conventional fixed appliances. When used in conjunction with tooth colored, coated archwires, the appliance is quite inconspicuous (Figure 3, page 28). It is hypothesized that a ceramic version of this appliance would not be noticeable from a short distance. Ceramic Nano brackets would actually be smaller in size than some of the virtual composite attachments used in the Invisalign® system.

Biologic advantages:

Studies comparing the incidence of white spot lesions in treated patients to untreated controls demonstrate that post-treatment decalcifications are iatrogenic in nature.[1,2] It has been shown that the incidence of white spot lesions on the maxillary canines increases 11 times after a 2-year orthodontic

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treatment compared to untreated controls.[1] The maxillary anterior segment is an area prone to develop white spots with the maxillary lateral incisors presenting the highest overall incidence.[1,2] Furthermore, decalcification on the maxillary anterior segment is most disturbing, because this area is readily visible when smiling or talking.

A logical but yet untested assumption is that miniature brackets can decrease the incidence and/or the size and severity of white spot formation. The possible mechanisms of action are facilitated dental hygiene around the micro-orthodontic appliance and greater access to salivary flow (Figure 4, page 28).

Light forces:

In bending, the stiffness of an archwire is inversely proportional to the cube of the span of unsupported wire length.[3] In other words, if the interbracket distance is doubled, the deactivation force of an archwire will be eight times lower. Micro-orthodontic attachments create greater inter-bracket distance, due to their reduced mesio-distal width. This is useful in situations of ectopically erupted maxillary canines, where lowering the intrusive reaction forces to the adjacent laterals is important to avoid root resorption[4-8] (Figure 5, page 28).

Increased comfort:

Another clinical advantage associated with the use of wingless miniature brackets can be appreciated when correcting anterior crossbites accompanied by a deep overbite. In these cases, it is often impossible to bond a conventional twin bracket on the maxillary incisor in crossbite without adding a bite plate; otherwise the vertical overlap between the upper and lower incisors risks dislodging the attachment. On the contrary, a bite plate is usually not required when bonding a Nano bracket on a maxillary incisor in crossbite, because its compact size and absence of tie wings reduce the likelihood of an occlusal interference with the attachment (Figures 6 and 7, page 29).

Biochemical and Clinical Considerations

Bond strength:

Because the base area of the Nano brackets is decreased, a reduction in bond strength is anticipated when compared to normal sized twin brackets. In an in vitro study evaluating the relationship between bond strength and bracket base surface area, MacColl et al demonstrated that orthodontic brackets with base surface areas inferior to 6.82 mm² were significantly less retentive.[9] The bracket base with the smallest surface area (only 2.38 mm²) recorded a mean shear bond strength of 8.93 KgF compared to 11.7 KgF for orthodontic brackets with base surface areas ranging

Figure 2: A micro-orthodontic preadjusted appliance (.018-edgewise slots with Roth prescription on upper incisors and .022" slots on upper posterior teeth).

Figure 3: Miniature wingless brackets bonded to the maxillary incisors and canines engaged with a coated nickel titanium archwire.

Figure 4: Standard size twin brackets were removed from the upper incisors and replaced with Nano brackets in order to expose the previously decalcified zones and facilitate plaque removal.

Figure 5: Top, initial engagement of a .012" nickel titanium archwire in a patient with highly erupted maxillary canines using wingless miniature brackets. Bottom, the same patient 8 months into treatment.

from 6.82 mm² to 12.35 mm². The same study showed that when the 2.38 mm² base was sandblasted, the shear bond strength increased to 10.51 KgF. This is one reason why I recommend sandblasting the Nano brackets prior to bonding. The maximum biting forces on the posterior teeth during chewing vary from 5 kg (12 pounds) for children to 13.5 kg (30 pounds) for adults.[10] Obviously, the upper anterior teeth, where the NanoArch appliance is bonded, are subjected to weaker displacement forces.

Although controlled studies are needed to evaluate the bond strength of micro-orthodontic brackets, my observation was that the bond failure rate with the NanoArch appliance is similar to that of normal twin-sized brackets when bonded to the upper anterior sextant.

Rotational control:

As is often the case with single edgewise brackets, dental rotations are difficult to resolve with a micro-orthodontic system. This is particularly true for the maxillary central incisors; the larger a tooth is mesio-distally, the more difficult it is to control dental rotations with a 1.3 mm wide bracket. When this occurs, it is recommended to bond two identical miniature brackets on the same maxillary central incisor. This can be accomplished by using a special bracket-jig assembly ("twin-jig") that holds the two brackets parallel to each other in both mesio-distal and bucco-lingual directions and also keeps the edgewise slots lined up with the arch curvature (Figure 8).

In essence, this approach allows the creation of "twin" micro-orthodontic brackets for the maxillary central incisors and gives the operator the freedom to decide what the mesio-distal width of the "Siamese" bracket will be (Figure 9).

Torque control:

Incisor retraction is negatively impacted when using micro-orthodontic brackets because the stiffness of an archwire in torsion is theoretically inversely proportional to the interbracket distance between the incisors and canines.[11] Accordingly, micro-orthodontic attachments having a 1.3 mm mesio-distal width will allow more tipping of the incisors during retraction compared to conventional twin brackets which can measure from 2.6 mm to 4.3 mm in width. This is true even with full-size archwire engagement of the anterior brackets.[12,13] It was found that Gianelly's bidimensional technique did not systematically produce bodily incisor retraction when filling the slot of the Nano brackets with a flat .018 x .022 SS archwire. Additional labial crown torque was routinely bent into the anterior segment of the archwire.

Recently, I described the Split-Edgewise technique[14] and advocated bonding .019-slot brackets to the upper and lower incisors, .022 x .028 slot attachments on the posterior teeth and using a .019 x .025 SS wire to perform incisor retraction. Since the torsional stiffness of a .019 x .025 SS wire is estimated to be 35% to 40% greater compared to a .018 x .022 SS wire,[11] perhaps the new Split-Edgewise format would be warranted when using micro-orthodontic brackets.

Future Directions for Micro-Orthodontic Techniques

In my experience, micro-orthodontic appliances can be used to successfully treat severe malocclusions. However, there is no question that chair time is increased and finishing is more difficult compared to traditional appliances. This is one reason why the NanoArch system

Figure 6: Correction of the maxillary left lateral incisor crossbite using miniature wingless brackets. A bite plate was not necessary to disclude the anterior teeth.

Figure 7: Same patient 6 months into treatment. Note the auxiliary pin inserted through the vertical slot of the maxillary left canine bracket. The "T" pin can serve as a pair of tie wings on the bracket.

was never marketed for widespread distribution. Also, due to the increasing demand for aesthetic orthodontic appliances, it was assessed that only translucent micro-orthodontic brackets could gain commercial success. With the advent of ceramic injection moulding, miniaturization of ceramic brackets is now feasible.

Finally, I expect that the shortcomings of the Nano brackets during finishing will be resolved with the use of digital intraoral scanning and in-house 3D printing. These new technologies will empower clinicians with the option to remove micro-orthodontic appliances toward the end of treatment and expedite final detailing with five or six customized aligners printed near chair side.

Treatment strategies using ceramic micro-orthodontic appliances in conjunction with in-office aligners will soon undergo testing at McGill University's new Craniofacial Orthodontic program. **OP**

References available with our online edition.

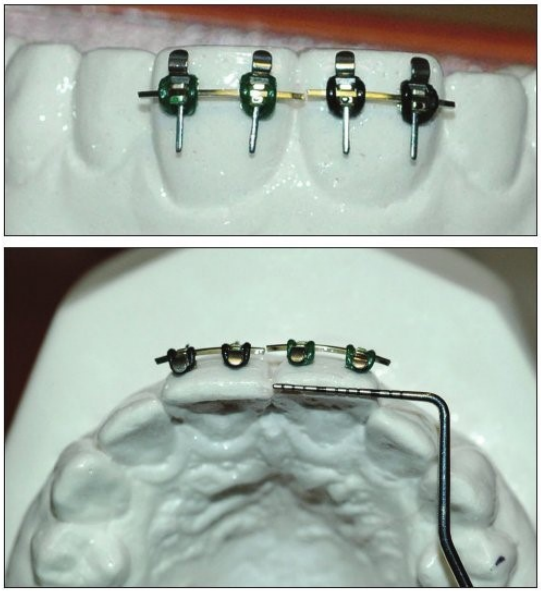

Figure 8: A prototype "twin-jig." The device allows two Nano brackets to be bonded with identical torque and tip on the same tooth. The mesio-distal span between the two brackets is adjustable by sliding the brackets on the arch bar of the "twin-jig" that completely fills the edgewise slot.

Figure 9: "Twin" Nano brackets bonded on wide maxillary central incisors allow for good rotational control.