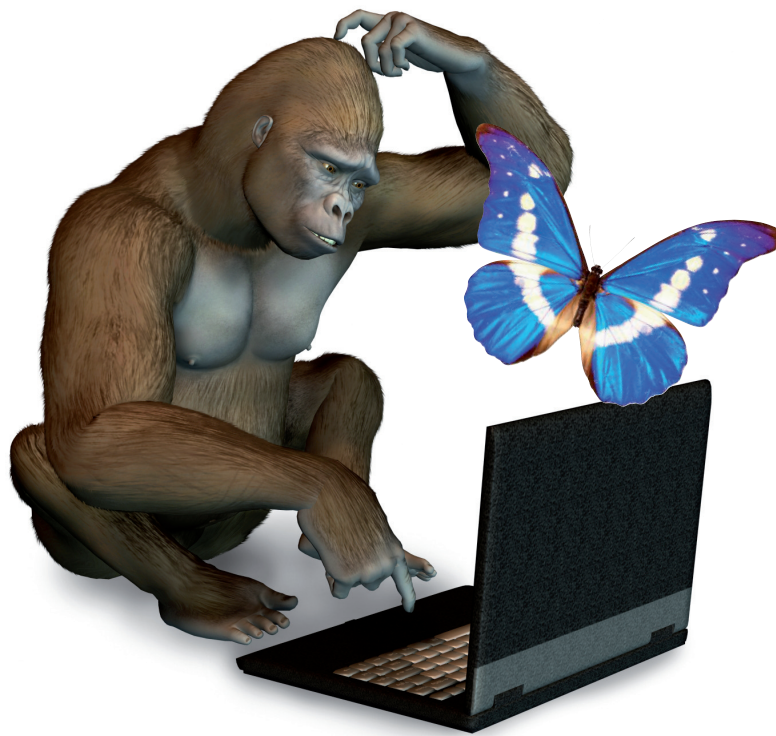


Australian Society  
of Orthodontists



University of Sydney



## Evolution of Aesthetic Orthodontic Appliances

*Creating **Brighter** Futures*

# Evolution of Aesthetic Orthodontic Appliances



Fig. 1. Etruscan statue with "braces"

Man has long sought to enhance his appearance. Evidence of orthodontic treatment dates back some 3,000 years. Archaeologists have discovered mummified remains with crude metal bands wrapped around individual teeth with catgut thought to have been used to apply forces. Later, in 400-500 BC, Hippocrates and Aristotle both considered ways to straighten teeth. The Etruscans were using appliances to maintain space and prevent collapse of the dentition; while in a Roman tomb in Egypt, a researcher found a number of teeth bound with a gold wire - the original ligature wire! At the time of Christ, Aurelius Cornelius Celsus first recorded the treatment of malaligned teeth using finger pressure.<sup>(1)</sup>

Despite all this evidence and experimentation, until the 1700s the most aesthetic - though not effective - appliance remained the finger!

The French surgeon, Pierre Fauchard – the "Founder of Modern Dentistry" – described procedures for aligning the teeth, including: filing them, manipulating them with forceps, and then tying them with thread to a silver or gold "bandeau".<sup>(1)</sup>

A contemporary of Fauchard, Etienne Bourdet, dentist to the King of France, went a step further and recommended the extraction of first premolars to maintain symmetry of the jaws. He also used the first and more aesthetic lingual appliances.<sup>(2)</sup>

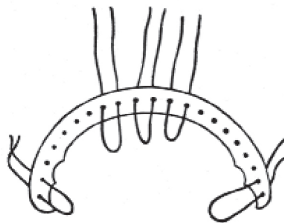


Fig. 2. Fauchard's "Bandeau"

By the 1840s materials generally used were cotton or silk ligatures, metallic wedged

arches and wooden wedges. The discovery of vulcanite, when combined with gold wire springs and screws, allowed the use of removable appliances to induce individual tooth movement.<sup>(1)</sup> By 1937, the discovery of acrylic had allowed translucent acrylic plates to replace black vulcanite.<sup>(3)</sup>

Edward H. Angle (1855-1930), the "Father of Modern Orthodontics" developed the first widely adopted system for correcting malocclusions using brackets soldered to the labial of metal bands.<sup>(2)</sup> The Edgewise system was born.<sup>(3)</sup>

## Brackets and Bands



Fig. 3. Gold & Stainless Steel Banded Teeth

Until the early 20th century, 14-18 carat gold was the principle metal used for constructing orthodontic brackets and bands. However, with the metallurgical developments of World Wars I and II appropriate forms of stainless steel became available.

The introduction of stainless steel allowed the development of progressively smaller appliances. The road to smaller appliances had begun and it was significantly accelerated with Buonocore's 1955 direct bonding of resin to enamel<sup>(4)</sup> and Newman's use of epoxy resin in 1965 to directly bond brackets to the labial surface of teeth.<sup>(5)</sup>

**Plastic brackets**, initially made from acrylic and later from injection moulded poly-carbonate, were introduced in the 1970s. They promised significantly enhanced aesthetics; unfortunately, problems of staining, odour, time-dependent creep, and breakage soon became apparent. Permanent deformation, or creep, occurs when a material is subjected to a constant load over an extended period. It is particularly important for thermoplastic materials such as polycarbonate and polyurethane resins. Compensation for the lack of strength and rigidity is reinforcement with ceramic or fibreglass fillers and/or metal slots. This has improved their popularity.<sup>(6)</sup>

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### FLUORIDES IN AUSTRALIA

Last issue, Section A of the Fluoride Guidelines (ADJ 2006; 51(2):195-199) on Community Water Fluoridation was summarised. Section B of the Fluoride Guidelines concerns Self-use Fluoride Products. This includes Fluoridated Toothpaste, Fluoride Supplements and Fluoride Mouthrinses. There are **8** Guidelines arising from these 3 areas:

There are three age-related guidelines for the use of Fluoridated Toothpaste. **1.** From the time the teeth erupt to 17 months, children's teeth should be cleaned by an adult but not with toothpaste. **2.** From 18 months to five years teeth should be cleaned twice daily using a pea-sized amount of low fluoride toothpaste (400-550ppm) and with adult supervision. **3.** For people over six years, teeth should be cleaned at least twice daily using standard fluoride toothpaste (1000ppm). When tooth brushing with fluoridated toothpaste people of all ages should spit out, not swallow and not rinse.

The next two guidelines address variations from the above. **4.** Children who do not consume fluoridated water, or have an elevated caries risk may, with dental professional advice, use fluoridated toothpaste more frequently. They may also begin using toothpaste at a younger age or change earlier to standard (1000ppm) toothpaste. **5.** For teenagers and adults with an elevated caries risk the use of a high fluoride toothpaste (>1000ppm) should be considered on dental professional advice.

With regard to Fluoride Supplements the guidelines are clear and specific. **6.** Fluoride supplements in the form of drops or tablets **should not be used**.

Two guidelines relate to Fluoride Mouthrinses. **7.** Children below six years **should not use** fluoride mouthrinses as ingestion poses a fluorosis risk. **8.** Fluoride mouthrinses for people over 6 years should be used at a time of day when toothpaste is not used and should not be a substitute for brushing with fluoride toothpaste. Mouthrinse should be spat out and not swallowed.





Fig. 4. Self-ligating Bracket

**Self-ligating brackets** were first popularised in the 1980s, one of the earliest being the SPEED system. They are more aesthetic as they have a much smaller labial "footprint" than other stainless steel brackets of the day and no longer require the use of either steel or elastomeric ligature ties.

Stainless steel self-ligating brackets have been shown, in vitro, to have the lowest static and kinetic frictional forces. Polycarbonate self-ligating brackets generate significantly greater static and kinetic frictional forces than stainless steel self-ligating brackets but are comparable to conventional stainless steel brackets.<sup>(7)</sup> Other manufacturers have more recently introduced aesthetic ceramic variants of self-ligating brackets including the 3M Unitek's Smartclip™.<sup>(8)</sup>

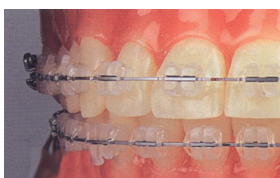


Fig. 5. Ceramic brackets

**Ceramic brackets** were first introduced in the 1980s. There are two basic forms: monocrystalline, which is almost transparent; and, polycrystalline, which is tooth coloured. Offering better aesthetics than either stainless steel or polycarbonate, they also exhibit

good resistance to wear and deformation, as well as colour stability. However, they have problems when compared to stainless steel brackets including greater frictional resistance, bracket breakage, iatrogenic enamel damage, and difficulty in debonding the brackets.<sup>(6)</sup> These problems are being overcome and the brackets now offer quite an aesthetic alternative to stainless steel.



Fig. 6. Lingual brackets

**Lingual brackets** are arguably the most aesthetic appliance of all as they are placed on the lingual aspect of the teeth. Despite being made of stainless steel they are virtually invisible to the casual observer. Unfortunately, these appliances are generally considered to be more time

consuming to both place and adjust and therefore attract a significant premium in cost over conventional labial brackets and are initially more uncomfortable than labial brackets. Consequently fewer patients are attracted to them.

## Archwires

By the 1960s, gold as an archwire had largely been replaced. It gave way to thinner, more resilient stainless steel wires such as Wilcox's Australian wire.<sup>(3)</sup> However, in 1974 Unitek patented its **Nitinol** (Nickel Titanium Naval Ordnance Laboratory) wire having the lowest modulus of elasticity and most extensive deactivation range of any equivalent cross sectional wire of the time. This allowed the application of light forces over a protracted range. By 1986 "superelastic" alloy wires that undergo stress induced change in their crystal form had been developed. These offered significant advantages over Nitinol.

The range of wires available to orthodontists has been further extended by the addition of various other elements including Cobalt Chromium, Beta Titanium and, in 1994, Copper. Copper NiTi changes its crystal form at a specific temperature. Most recently, a nickel-free wire – titanium-niobium



Fig. 7. Looped Stainless Steel Archwire and Metal Bands (used mainly prior to the introduction of bonded brackets and NiTi archwires)



Fig. 8. Alignment commencing with NiTi archwires.

– has been introduced.<sup>(3)</sup> With these new wires, especially the superelastic wires, it is no longer necessary to incorporate multiple loops, significantly enhancing aesthetics as well as comfort.

A number of manufacturers now offer NiTi and stainless steel archwires coated with tooth

coloured materials to enhance their aesthetics, especially when combined with ceramic brackets. Unfortunately, these coatings tend to wear away with time; however, further research should see this resolved.



Fig. 9. Coated archwires in ceramic brackets

The search for improved aesthetics is leading us down the road of fibre reinforced composites. These materials are not yet clinically useful as arch wires; however, they have been incorporated into bis-GMA ribbons and bonded, as strips, to multiple teeth, to provide retention and also anchorage, reducing the number of conventional brackets required.<sup>(9)</sup>

## Auxiliaries

Brass wire was initially used to ligate the arch wire to the band/bracket combination. However, by the 1960s the thinner and more aesthetic stainless steel had replaced it as the ligature tie of choice. The advent of polyurethane materials has seen the introduction of aesthetic coloured elastomeric modules to ligate the archwire to the bracket. While offering good aesthetics when initially placed these modules are prone to discolouration and breakdown over time and so must be regularly replaced. They also tend to increase the friction between the bracket and the archwire. Nevertheless, their ease of placement and appeal to younger patients has ensured their general use.

## Clear Plastic Aligners



Fig. 10. Clear Plastic Aligner

The latest innovation to the orthodontist's aesthetic armamentarium is the sequential clear plastic aligner. The principles of this process were actually developed by Kesling in 1945.<sup>(10)</sup> However, it did not achieve more widespread use until Invisalign™ combined the technique with 3D computer graphics and CAD/CAM technology to allow phased movement of multiple teeth to correct mild to moderate malocclusions. Since Invisalign™ appeared a number of other companies have released similar products, including an Australian company, ClearSmile™.

Unfortunately, these appliances are not suitable for treating all malocclusions. Those with significant crowding or spacing, and/or inter-arch discrepancies (such as Class II and III relationships) often cannot be treated properly with these systems alone. Similarly, individuals with very short crowns and younger adolescents where teeth are not fully erupted are generally not suitable. Although some extraction treatments are being carried out they are not normally as suitable as non-extraction cases. Precise alignment and finishing with these systems can be more difficult compared to traditional fixed appliances so that a compromise result may need to be accepted. Further, they are still somewhat visible on the labial surface and over the incisal edges. However, clear aligners are considerably more aesthetic than traditional braces.





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Oral hygiene is also much easier with these appliances and they are more comfortable than traditional fixed appliances. While psychologically they are attractive because they can be removed by the patient when they feel so inclined, the practitioner needs to reinforce the importance of self discipline if the aligners are to be effective. Patients who lack the necessary discipline will find their treatment takes a lot longer, the result is not as good, additional aligners may be required at additional cost, and in some cases fixed appliances are indicated to complete the treatment.

Nevertheless, clear plastic aligners have become an attractive and popular alternative, especially for adult patients.

## Conclusion

Metal appliances – steel or gold – as unattractive as they may be, have been the mainstay of the orthodontic armamentarium for centuries. The superior aesthetics of ceramic and polycarbonate brackets when compared to conventional stainless steel are not only well accepted by patients - particularly adults - but are positively sought after. Many clinicians, however, have been less willing to accept them due to their perceived unfavourable clinical characteristics. Nevertheless, they are effective and reliable at correcting malocclusions.

The technological revolution, which is all around us, continues apace so that there are now viable aesthetic appliance alternatives that don't necessarily require compromise in either the patient's or practitioner's treatment goals. Modification of the arch wire slot, advances in bracket base design and refined manufacturing processes have tackled the problems of friction, strength and force control. Further development and research will ultimately result in aesthetic brackets that perform clinically in a manner truly comparable to the current "Gold Standard" stainless steel bracket.

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