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Extended Project Report

How significant have been the developments in
dental braces since the 1960's?

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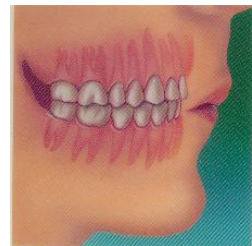
How significant have been the developments in dental braces since the 1960's?

Since the 1960's, dental braces have seen a revolution of advancements inevitably resulting in a new multitude of benefits. However, many problems continue to persist whilst other developments have not completely replaced the former, inferior braces in many parts of the world. This report aims to evaluate the relative significance of the recent advancements by assessing their benefits along with the limitations and even the disadvantages that the developments may incur. Afterwards, I shall review the limitations of braces as a whole and use a holistic approach to identify factors that cause the developments to fail to be significant. 'Clinical Complications' will highlight how despite the developments and their subsequent advantages, braces continue to be imperfect. Once this has all been evaluated, the conclusion will finally assess and surmise exactly how significant the developments have actually been.

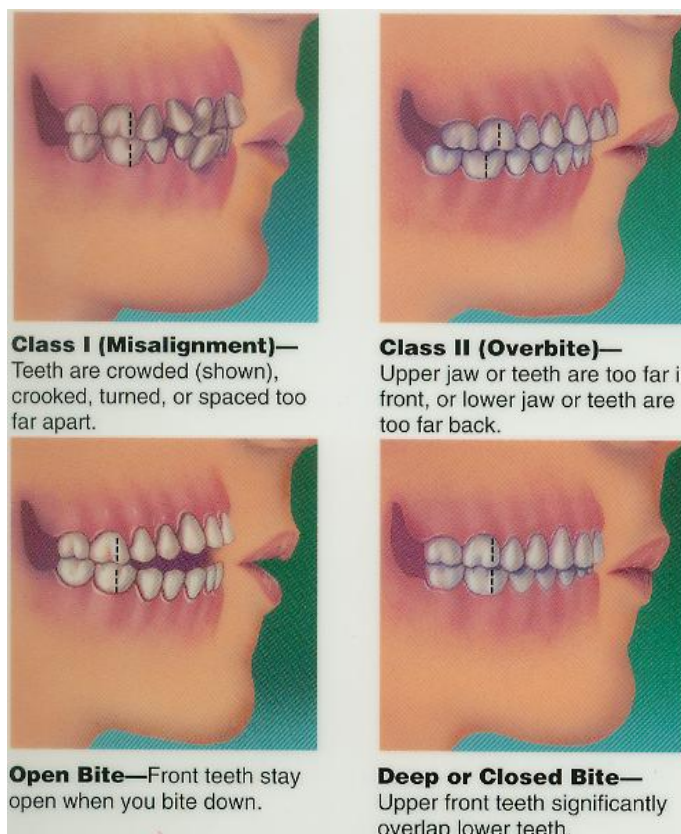
1. Introduction

"We live in a very image-conscious society and impressions are made within a few seconds. Straightening teeth makes a difference and can ultimately make or break your chances of getting certain opportunities." — Mark Montano, host of TLC's, 10 Years Younger

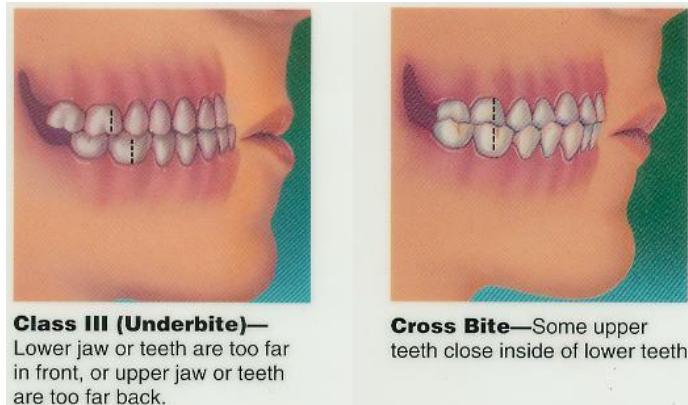
In layman's terms, braces are dental appliances which are fitted onto teeth to move them into the correct position by applying a steady pressure, generally over a long period of time. This is normally conducted by the orthodontist, a dentist who has specialised in malocclusions or improper bites. However, the form of the appliance varies drastically depending on the type of braces chosen with each type carrying different benefits to meet the different needs of the individual. The brace moves the teeth into their correct alignment, as can be seen in the diagram opposite, in order to give the correct bite:



Incorrect bites that need to be treated include:



2



The immediate function of braces is primarily to correct malocclusions which are improper bites as shown above, or misalignments of the teeth that could be detrimental to oral health. Malocclusions, if uncorrected, can cause wearing of the tooth enamel, tooth decay and gum disease to name as well as other harmful effects.¹

However, as a result of a growing self-conscious society, braces are becoming frequently desired and used by adults and children alike in order to have the ‘perfect smile.’ This medical vs. cosmetic needs for braces has resulted in a flurry of developments in order to cater for these different needs, resulting in a wide variety of different braces with their own corresponding benefits. If asked, orthodontists would describe improving oral health and “bad bites” as the most important function of braces, nevertheless, much of the advancements made in braces have been centred on improving their cosmetic appeal such as the development of the transparent brace Invisalign™ and on improving patient care. The main types of braces that have been developed and this essay will consequently analyse are:

- Braces involving Nitinol arch wire
- Lingual Braces
- Invisalign

The advantages of these braces will be primarily evaluated and compared to the formerly common stainless steel archwire braces, and their limitations will also be thoroughly considered in order to assess the relative significance of these new developments. Braces have been existent in primitive forms such as gold wires for over 2,000 years so this report will tackle only the major developments in braces for the past 50 years in order to give a focused and detailed analysis of the main advancements in braces. From the 1960’s to the present, braces have seen more rapid advancements than at any other period and is therefore, the most relevant period to study and subsequently the economic, social and health benefits of these developments shall be considered thoroughly.

2. Analysis of the Developments:

With each new development, there are economic, social, and health benefits and in many instances these are interlinked, one having a subsequent effect on another. However, with each benefit, there are also limitations.

Nitinol Archwire

The typical, traditional fixed brace involves metal brackets being bonded onto the teeth and then a wire passed through the brackets, with ligatures, small elastic ties that may be coloured, holding the wire to the bracket. The wire, known as the archwire, had traditionally been made of stainless steel however, the discovery of Nitinol and its shape memory properties by NASA in the early 1960's overlooked the implementation of a far more superior material to be the archwire in braces.^{3, 4} Stainless steel archwires require continuous and regular tightening by the orthodontist, once it is placed around the teeth. Although the alloy exerts a force onto the teeth to cause them to move, the alloy exerts very little force afterwards, once they have moved. Thus, this archwire is need of constant tightening by the orthodontist to ensure it continues to exert a force upon the teeth.

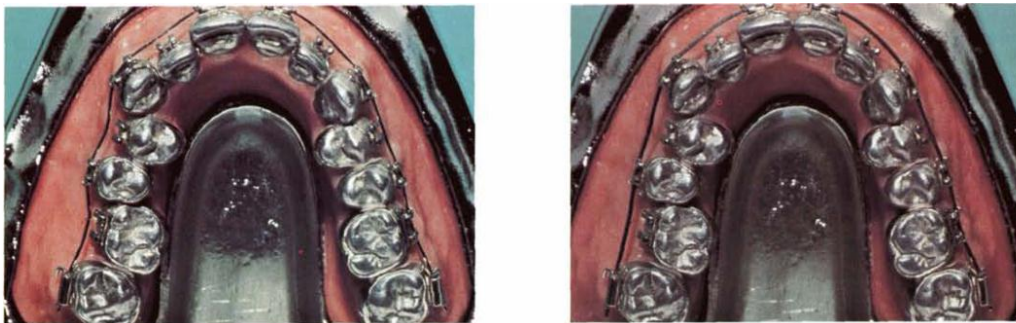


In direct contrast, Nitinol is a shape memory alloy. A Nitinol archwire, comprised of almost equal amounts of Nickel and Titanium⁵, is able to 'remember' a shape and change into it of its own accord, exerting large forces in the process. Nitinol has two different crystalline structures called the Austenite phase and the Martensite phase, yet both have the same chemical structure of Nickel and Titanium. Nitinol wire can be 'set', or annealed, to remember the shape of the correct dental arch. When it is then cooled, the Nitinol changes into its Martensite crystal structure and is able to be bent and deformed. The wire can then be placed around the teeth and bent as it is attached to each tooth that needs to move. Once in the mouth, the wire is heated due to the body temperature, and this causes a shift from the Martensite structure to the Austenite structure. The Austenite structure is the correct dental arch that the wire was 'set' to remember, and hence, the wire moves into the correct dental arch, pulling the teeth along with it.⁴ This is a continuous process as the Nitinol wire provides a constant force to pull the teeth back to its 'remembered' shape of the correct dental arch. Thus, the Nitinol archwire does not need to be retightened enabling fewer appointments with the orthodontist.⁸

As a result, the orthodontist can spend longer periods without seeing the patient, and hence enables him/her to have more time to spend on other patients. This greater efficiency consequently results in increased profits for the dental surgery as increased patients inevitably mean that the surgery or orthodontist is paid more money to see those extra patients. Thus, the increased capacity to see more patients is a great benefit that the advancement to a Nitinol archwire brings. Moreover, fewer appointments are further favourable to the patient as fewer appointments subsequently result in the patient having less disruption to his daytime schedules and may potentially result in fewer days off work for many patients. Thus, the economic benefit of this development in braces can clearly be seen to bring great advantages

to both the patient and the surgery and is therefore highly significant. Additionally, the regular retightening that stainless steel archwires need generally causes considerable pain for the patient. In contrast, due to not requiring the same degree of retightening, Nitinol causes less pain⁸ for the patient and thus, increased patient care and satisfaction. The reduction in pain is highly significant for patients especially since the pain can, temporarily, be debilitating and prevent the patient from carrying out tasks effectively. This improved care for the patient through the use of Nitinol archwires is also beneficial for the dental surgery in trying to establish a reputation through word of mouth, and consequently attract new patients.

What is more, Nitinol's high flexibility and kink resistance allows the archwire to be significantly bent around the teeth without permanently deforming and failing to apply pressure.⁴ In contrast, stainless steel can form 'kinks' in its structure if bent which causes it to no longer produce a force to move the teeth. The orthodontist has to continually adjust the braces, and at times the archwire itself needs to be removed and another put in. This can cause additional pain for the patient and consequently, Nitinol features another advantage over stainless steel.¹¹



The diagram above highlights the aforementioned advantage: "The arch wire in the left photo is stainless steel, bent once and released; the arch line is irregular. In the right photo is a Nitinol arch wire bent and released 100 times; it still maintains its original shape."¹¹ Moreover, the shape memory alloy contains further superior properties to stainless steel. Nitinol is more biocompatible as it is more easily accepted by the surrounding body tissue.⁸ Therefore, Nitinol is clearly more suitable to be used as an archwire and be placed in the mouth than stainless steel.

Due to these clear benefits, most of the dental archwires now used are made from Nitinol, whereas formerly stainless steel archwires were commonly used.⁴ This large scale adoption of the Nitinol archwire clearly indicates the great significance of this development. However, it should also be noted that there still remain surgeries which do continue to use stainless steel as the main archwire, indicating that Nitinol did not completely dominate the market of archwires. Nonetheless, the development is still highly significant.

Lingual Braces

Nitinol's discovery in 1962 provided a great many benefits⁵; however, cosmetically it looked almost identical to the traditional stainless steel braces. In 1975, development was underway to create Lingual braces. These new braces, although functioning in a similar manner to the traditional braces through the use of brackets and wires, had a notable difference in that they were attached to the back of the teeth, as can be seen in the diagram, whilst former braces were attached to the front. Lingual braces provided a new 'invisible' way of orthodontic treatment as the majority of the braces could not be seen, providing immense social benefits, albeit if looked at closely, parts of the brace could be seen. As a result, lingual braces provided an alternative of correcting misaligned teeth without affecting the appearance of the individual. Consequently, models, actresses, TV broadcasters and other professionals whose appearance has a direct effect upon their ability to acquire work, have been known to use lingual braces due to this benefit.⁷ The development reduces the negative social consequences of wearing braces as people can no longer see the braces thus, resulting in many adults, including those who are self-conscious, to prefer these 'invisible' braces.



However, along with this benefit, there is a considerable limitation to the impact of lingual braces in the market. Orthodontists require additional specialist training in order to be able to administer lingual braces to patients. Consequently, relatively few dental surgeries are able to provide these braces⁶, and what is more, a survey conducted by the British Lingual Orthodontic Society found that "72% of people are unaware of lingual braces."¹³ The survey was conducted in 2009, and thus it becomes evident that the significance of the aesthetic development is undermined due to the low percentage of people who are aware of lingual braces. Moreover, it can further be interpreted that the popularity of the appliance is relatively low for few to know about it. Thus, it can be seen, that unlike Nitinol, which largely replaced stainless steel as the archwire in most cases, lingual braces did not have the same effect, with many orthodontists reluctant to use them; consequently, the significance of the development of lingual braces is considerably less when compared to Nitinol. Nonetheless, it would be incorrect to say that the development bears no significance; many celebrities such as Kelly Brook¹³ have had lingual treatment and the aesthetic appearance of braces is a major element for many people. However, the significance of the development has been comparatively low especially when compared to Nitinol and other developments which will shortly be assessed.

Lingual braces are complicated to administer which can deter some orthodontists from using them, whilst the high cost compared to traditional braces, can deter patients, however, these problems are neither pivotal nor highly important, and can generally be disregarded as minor limitations to the significance of lingual braces. For parents in the UK, the high cost of lingual braces may deter them since conventional braces are provided free under the NHS for children, however, for many adults the aesthetic advantages of lingual braces compensates for the slightly increased cost. Therefore, the significance of the

development is further dependent upon which part of society is analysed, as for children the advancement is relatively insignificant, whereas for adults, it is beneficial.

Invisalign

A significant development in the braces market was the invention of Invisalign[®] in 1997, which brought with it a great deal of advantages. Treatment with Invisalign[®] involves a series of clear, transparent aligners that are worn by the patient. The aligners work in the same way as conventional braces, applying a gentle force to the teeth to move them in the right direction, however, a significant difference between the two is that the Invisalign aligners can easily be removed or put on by the patient. Although, the plastic trays need to be worn for approximately 20-22 hours per day in order to have sufficient effect on the teeth, the ability to remove them brings both oral hygiene benefits and increased patient care. The aligners can be removed before eating, thus the treatment does not inhibit the patient from eating certain foods whereas in contrast, conventional braces result in the patient being prohibited from consuming numerous foods: including sticky foods, chewing gum, hard foods such as nuts as well as an overall reduction in sweets.⁷ Moreover, the disadvantage of food becoming stuck in between brackets that existed for conventional braces and being irritable is also not present since the aligners can be taken off before eating. Additionally, a key benefit from being able to remove the aligners, is that they can be done so before brushing the teeth. This enables better oral hygiene as the entire surface of the teeth can be brushed without the obstruction of any appliances. For that same reason, the amount of demineralisation and tooth decay is significantly higher for patients who wear conventional braces compared to those who wear Invisalign[®], due to the inability to remove them.



The plastic trays are provided in a set to the patient, with a new aligner replacing the old one every two weeks. All the trays that are used for the treatment are provided in full from the beginning to the patient, so the treatment time can be easily calculated for the patient. However, there is a limitation to this advantage in that not always do the aligners correctly move the teeth to the desired position and additional trays need to be ordered and used thus adding to the treatment length. Nevertheless, this added difficulty exists also with conventional braces and hence, is not a factor that makes conventional braces superior to it. Therefore, Invisalign[®] is still a significant development.

Initially, Invisalign[®] could only treat certain, relatively simple cases, and be unsuitable for severe cases. This was a limit to the influence of the development however, Dr Paquette indicates that “virtually any malocclusion can now be treated with quality results and the scope of capabilities continues to grow every day.”

What is more, conventional braces provide greater forces than Invisalign[®]. In the accepted study by Dr K.B. Miller (2005), he found that “Adult patients treated with Invisalign experienced less pain...during the first week of treatment” compared to fixed, traditional braces.⁹ Invisalign[®] still causes pain, since it provides a force to move the teeth, however, it provides less pain compared to the traditional braces, and the increased comfort is

an important development for the patient. The improved patient care and increased satisfaction results in increased co-operation from the patient towards the treatment.

In addition, the Invisalign[®] aligners aggravate the gums and lips substantially less than conventional braces. Archwires that have been accidentally loosened from the bracket, can scratch and gash the gums and lips. This can continue for the gums to become inflamed. Even Nitinol archwires can cause this problem, so Invisalign[®] is a welcome relief for the patient.²² The plastic aligners of Invisalign[®] provide increased comfort to the patient in this respect, as well as in the movement of the teeth.

Ultimately, the greatest advantage of Invisalign[®] is its aesthetic appeal. The transparent aligners are almost invisible, thus making it a more preferable treatment for most patients. As can be seen in diagram 5, the Invisalign[®] aligners are far more inconspicuous compared to the conventional braces. Consequently, they are highly popular among the public particularly among the self-conscious or those whose work pays special attention to their social appearance. Due to this and the additional advantages, Invisalign[®] is major competition for lingual braces since the main benefit of lingual braces was its cosmetic appeal. Whilst initially Invisalign couldn't be used to correct complex malocclusions, and lingual braces had an advantage over it to treat those cases, now Invisalign can treat most malocclusions as Dr Paquette highlights.¹⁰



However, there is a significant limitation to the use of Invisalign[®]. Although Invisalign[®] can be used to treat most cases; it's considerably less effective at treating certain malocclusions compared to fixed braces. A study by Garret Djeu found "Invisalign did not treat malocclusions as well as braces" and that "Invisalign scores were consistently lower than braces scores" on the objective grading system used by the American Board of Orthodontics. Despite Invisalign[®] being more proficient at being able to "close spaces and correct anterior rotations," it is far less able to correct most malocclusions compared to fixed braces. This limits the significance of the developments. Although Invisalign[®] provided great benefits in cosmetic appeal, its weaknesses in correcting bites mean that it has not been able to dominate lingual braces in the market. Instead, there are occasions where lingual braces are more suitable to correct malocclusions which Invisalign[®] is "especially deficient" at correcting.¹² Consequently, Invisalign[®] has not been a total ground breaking development that has replaced traditional braces.

Nevertheless, the studies by Dr K.B. Miller (2005) do show that Invisalign[®] has a significantly less negative impact on the patient's quality of life than fixed, conventional braces in all three of his categories analysed: functional, psycho-social and pain related.⁹ Invisalign[®] has the immense benefit of aesthetic appeal, whilst the added advantages of increased comfort, patient care and satisfaction make Invisalign[®] a highly significant technological development to correct the alignment of the teeth. Thus, it can be concluded, that although Invisalign[®] has not been a radical development that has completely replaced the standard, fixed braces, it still is a significant improvement from the conventional braces in many respects.

3. Why Braces fail to be significant

The significance of braces and their developments is largely dependent upon which area of the world is analysed. Within the USA, where according to the American Association of Orthodontists 4.8 million were wearing braces in 2008, the significance of the developments in braces is high due to having the capability to affect a large proportion of people. However, within the poorer, less economically developed countries, particularly in Africa, the importance of improving dental health or cosmetic looks is miniscule since, far more basic health needs are at the forefront of their minds particularly acquiring food. The lack of dental clinics and the inability of a large proportion of the population to afford dental braces are further factors which render braces, and their subsequent developments, of minor relevance to the majority of LEDC's.

Therefore, it must be stressed that it is within the developed western world where the developments in braces plays a truly significant role. Consequently, this report is aimed exclusively at focusing on the significance of the developments in braces in the western world, in countries such as the USA, and Canada. In these areas, the developments, and the braces themselves can affect a relatively large portion of the population, and so they are the most suitable backdrop to analyse the significance of the developments.

Another limitation of braces is the negative social reputation that braces have which can result in children and teenagers to be reluctant to wear braces. Although the extent of this is dependent upon the area, braces including those using Nitinol archwires can cause psychological stress for the patient due to the potential bullying that the child or teenager can be subjected to by his or her peers. The fear and stigma of braces can result in children refusing to undergo treatment thus limiting the significance of braces. However, the developments towards lingual braces and Invisalign[®] assist in providing discreet treatment towards malocclusions and in minimising the potential for such psychological stress. Rob Slater, Chairman of the British Lingual Orthodontic Society, stated "Already we are finding that a fair proportion of teenagers would rather, where possible, pay privately to have lingual braces because it makes them feel less self-conscious, joining forces with those in their 30s and 40s who, for professional reasons, prefer not to have visible braces." Nevertheless, an inherent problem within the United Kingdom is the fact that the National Health Service, only provides free treatment towards malocclusions using fixed, labial braces (braces attached to the front of the teeth) which are highly visible and can result in the bullying mentioned.¹³ As many of the families of the under 18 year olds cannot afford or wish to avoid the high costs of improved braces such as Invisalign[®], many teenagers still accept the free treatment provided for by the NHS, and as a result, are prone to be made to feel inadequate by their peers. In addition, substantially more needs to be done in order to tackle the psychological burdens placed upon individuals through the wearing of braces by trying to remove the "stigma" of braces, and not just providing 'non-visible' braces.

However, within the USA, there has been considerable development and improvement in this area. The American Association of Orthodontics has found that the number of people using braces has risen by 103% since the mid 1980's. Labial braces that can have different colour ligatures, and brackets that can be shaped as hearts and footballs¹⁴, as well as the growing use of braces, have all helped to reduce the negative reputation of braces, and have resulted in many people regarding it as a fashion accessory. Rob Slater's comments reinforce this improvement as he says, "...in the USA...people tend to be happy to talk about the work they are having done" indicated that the negative stigma around braces has reduced greatly. However, Europeans in "countries like Italy and France...appreciate the discretion of invisible braces," implying that the stigma in these areas towards braces is still strong. Moreover, despite the improvements in the USA, it would be incorrect to assume that the USA has undergone a complete removal of the negative reputation of braces; rather it has had a considerable reduction in this aspect.



Hence, these attitudes towards braces are an area that still needs to be continually addressed and further improved both within the USA and the rest of the developed world, in order to halt any negative psychological impacts that braces can cause.

4. On-going problems with Braces

Despite the developments in braces, many clinical problems still occur with the treatment of malocclusions using braces. One clinical example is that of a patient in the USA who required a slight movement of his upper right molars and premolars into the correct position. However, the braces applied by the orthodontist resulted in his entire upper teeth to shift left, worsening his malocclusion from its original state. This drift, an incorrect movement of the teeth, causing what was supposed to be a 6 month treatment to last for 3 years and what was meant to be a simple movement of a few teeth to become a highly painful experience.¹⁵

Another illustration of the shortcomings of braces is my own personal experience with braces. My adult, upper right canine had erupted, emerged from the gums to become visible, without my baby tooth having fallen out yet. This resulted in my adult canine to grow into the position behind the baby tooth resulting in overcrowding. By the time I saw the orthodontist, my adult canine had substantially grown and subsequently I required treatment with braces for the canine to be pulled into the correct position, where the former baby tooth was, once the baby tooth had been removed. However, although initially being pulled into the correct position, the upper right canine continued to be pulled forwards, so that it now protrudes forwards compared to the rest of the teeth and whilst having also been rotated. Due to this, an additional year has been required to bring the canine back into its proper place.

What these examples show is that treatment using braces has not been perfected, despite the great developments. Although they are not necessarily reflections of most clinical cases, they reveal that substantially more improvements can still be made to the functioning of braces.

5. Conclusion

The significance of the developments in dental braces is largely dependent upon which conditions they are analysed in. In Less Economically Developed Countries, where for the overwhelming majority of people braces are neither affordable nor is dental health of particular importance, the developments in dental braces have been largely insignificant. The on-going clinical problems that occur with braces as well as the improvements that can still be made to the negative social reputation of braces, further limit the significance of the developments made.

However, when considered against the backdrop of countries with a relatively high usage of braces, the developments in braces have provided enormous benefits to a wide range of people. A study in England revealed that approximately one third of 12 year olds would benefit from some degree of orthodontic treatment¹⁶ whilst another survey led on behalf of the British Orthodontic Society revealed that “20% of UK adults would consider having some form of orthodontic treatment to improve the alignment and appearance of their teeth.”¹⁷ The developments in braces do indeed have a significant impact in areas such as these.

Ultimately, the developments in braces are primarily only significant for the individuals who are actually in need of braces or for those who administer braces. Nevertheless, the introduction of Nitinol archwires, lingual braces, and Invisalign[®] have resulted in dental braces making great leaps over the past 50 years. The superiority of Nitinol archwires over stainless steel in correcting archwires, as well as the economic benefits to the orthodontist and the improved care for the patient has been significant to the extent that it has replaced stainless steel as the main archwire in fixed appliances. Although there are limitations to the benefits of the different braces developed, the weaknesses of one type of braces are generally compensated for by the use of another type. For example, if a complex malocclusion needs to be treated and Invisalign[®] is, as a result, not suitable, then lingual braces can be used since, they provide both the benefits of aesthetic appeal, and the greater ability of fixed braces to treat malocclusions. Despite their weaknesses, the cosmetic benefits of lingual braces and Invisalign[®] as well as their additional advantages of increased comfort have meant that far more people, who would not ordinarily have considered orthodontic treatment, are now willing to do so, due to the increased discretion and convenience on offer. Their ‘invisible’ nature also provides great psychological benefits for the patient, due to them feeling less self-conscious with them; however, this is a field which can yet further be improved for Nitinol braces.

As with any product, braces have seen large technological advances in recent years. Although still imperfect, braces have considerably improved upon their former versions and have provided a multitude of benefits. As a result, one can conclude, that with the high degree of malocclusions to be treated and the great desire for many individuals to improve their facial appearance, the developments of dental braces and their consequent economic, social and health benefits have been highly significant.

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