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A review on recent advances in orthodontics

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Abstract
Since the inception of orthodontics, it has undergone remarkable progress in terms of development of more effective orthodontic appliances, brackets, and bonding agents. One of the most important advancements in the field of orthodontics has been the development of 3D Imaging systems and the use of mini-implants. This review describes the recent advancements in the field of orthdotontics highlighting the important developments of esthetic brackets, low-nickel brackets, gold-colored brackets, NiTi archwires, clear aligners, 3D imaging systems, and mini-implants in orthodontics.

Keywords: recent advances; orthodontics; 3d imaging; mini-implants

Introduction

In the past decade, the field of orthodontics has grown by leaps and bounds. There have been advances in the orthodontic brackets, bonding agents, imaging systems, technology, use of mini-implants, and expanding the scope of orthodontics to sleep apnea [1-5]. Most advances in the orthodontic field arise from the demand for higher efficiency. Orthodontic clinics usually work on a fast-paced setting. And thus, increased efficiency in terms of better technology can help the clinicians treat the patients in a better, faster, and easier manner.

Orthodontic Brackets

The brackets used mainly in orthodontics are stainless steel brackets. These brackets are durable and have been used for a long-time by orthodontists. However, they have unaesthetic metal appearance. And thus, various bracket types have been developed over time.

1. **Tooth-colored brackets:** Tooth-colored brackets are the aesthetic variants of the metal orthodontic brackets. They are made up of either ceramic or plastic. As the color of these brackets is similar to that of the surrounding tooth-structure, the brackets blend with the surroundings and are not immediately noticeable. Such aesthetic brackets are usually demanded for by the adult orthodontic patients who dislike the noticeable appearance of the metal brackets. Although the tooth-colored brackets are aesthetic, there are certain disadvantages with these brackets when compared with conventional stainless steel brackets. The brackets made with plastic are not strong enough to handle the orthodontic forces and often wear and deform with heavy forces [5]. However, ceramic brackets are stronger and do not wear as readily as the plastic brackets. But ceramic brackets tend to have increased friction than the stainless steel brackets, and they also lead to wear of the teeth in occlusion with the brackets [6]. To maintain the aesthetics of the ceramic brackets and overcome the disadvantage of friction, ceramic brackets with stainless steel slot have been designed.
2. Recently, gold-colored brackets have also been introduced to the orthodontic market. These are not essentially tooth-colored brackets but they give a more aesthetic appeal than stainless steel brackets. These brackets are essentially made from stainless steel and then coated with gold or titanium to produce the gold shade.
3. **Low-nickel brackets:** Low-nickel brackets are developed from materials such as super ferritic steel, cobalt-chromium, and titanium. The development of low-nickel brackets was done in order to decrease the exposure to nickel in patients with nickel hypersensitivity. An increase in the development of the nickel hypersensitivity has been found in the recent times. The stainless-steel brackets contain nickel as one of the ingredient and thus, it has been hypothesized that stainless-steel brackets may contribute to nickel hypersensitivity [7]. On the other hand, it has also been proposed that orthodontic treatment may lead to desensitization and not hypersensitivity. Thus, there is a controversy surrounding nickel hypersensitivity and stainless-steel brackets.

Orthodontic Materials

Archwires

A major advancement in the field of orthodontics has been the arch-wires has occurred in the field of arch-wires. With the development of Nickel-titanium (NiTi) wires, the alignment phase of orthodontic treatment can be performed very easily [8]. NiTi wires in the orthodontic field were established as a side-shoot from the NASA space programs. The main advantage of

NiTi wires is that it has a low elastic modulus and a high elastic limit. This property provides the arch-wire with resistance from undergoing permanent deformation [9]. Thus, when the arch-wire is engaged into the crowded teeth, the arch-wire does not deform and applies low level physiological forces to the teeth. Esthetic arch-wires with coatings have also been developed but because of the disadvantages of low durability of the coatings, such wires are not being used widely in orthodontics. Gold-colored wires have also been designed to match the color of the gold brackets.

Aligners: Aligners are thermoplastic materials used for moving teeth sequentially in a pre-determined manner [10]. These days, aligners are enjoying substantial popularity due to their aesthetic appearance as compared to arch-wires and brackets. In the recent times, an increased number of adult patients are undergoing orthodontic treatment [11]. There is a higher emphasis on aesthetic treatment modalities with the adult population. Aligners are typically used for mild to moderately complex orthodontic cases [12]. However, for orthodontic cases that require complex treatment mechanics and extraction of teeth often need conventional orthodontic brackets for proper finishing and detailing.

Bonding Agents

Orthodontic bonding agents in the earlier days were mostly chemically cured composites. However, with the advancements of light-cure composites as orthodontic bonding agents, the bonding of orthodontic brackets has become faster, easier and more comfortable [13]. The light-cure composites afford increased working time than chemically cured composites. Additionally, the extra composite or flash after placing the orthodontic brackets can be removed before the setting of light-cure composites [14]. With the recent advancements of plasma arc curing lights, the rapid curing times of approximately 1 to 2 seconds per bracket, the popularity of light-cured composites has increased even more. The most commonly used light-cure composite Transbond XT has shown bond-strength of more than 6 Mega-pascals on initial bonding and rebonding of brackets after breakage [15]. This bond-strength is more than that required for routine orthodontic purposes. Although Transbond has the advantage of high bond-strength, the disadvantage of light-cure composite is that it requires a clean, dry field for a successful bonding. Thus, more advancement in the bonding agents have been done and cyanoacrylate bonding material has been developed, which can bond to wet tooth surfaces. The bonding strength of cyanoacrylate has been found to be adequate for orthodontic purposes for first bonding [16]. When cyanoacrylate was introduced as an orthodontic bonding agent, it was developed as a self-cure bonding agent [17]. Lately light-cure cyanoacrylate bonding agent has been introduced. Thus, orthodontists have an additional bonding agent in their armamentarium which can be used in cases where isolation is difficult such as impacted canine (expose and bond), in patients with high salivation, and second molars.

Imaging Systems

Conventional radiographs used in orthodontic include panoramic radiographs, lateral cephalometric radiographs, periapical radiographs, occlusal radiographs, and postero-anterior radiographs. With the advancement of digital imaging, video imaging, 3D-Imaging, Cone-Beam Computed Tomography (CBCT), 3D surgical simulations have helped in the diagnosis and treatment planning of orthodontic and orthognathic surgical patients [18, 19].

Video Imaging

The development of video imaging systems have provided the clinicians the ability to perform two-dimensional (2D) simulations on lateral cephalograms for orthognathic surgical patients. Such simulations help in communicating with the patients on how they would look after the surgical procedure [19]. It should be noted that such simulations act as an aid to the clinician for the surgical planning but there may be differences in the final outcomes based on individual response to orthognathic surgical procedure.

3D-Imaging

3D-Imaging was developed as Computed Tomography (CT) in the medical field. However, the high radiation and high cost prevented its widespread adoption in the orthodontic field. In the orthodontic field, 3D-imaging was adapted as Cone-beam Computed Tomography (CBCT), which exposes the patients to considerable lower radiation compared to CT scans. CBCT does not have the disadvantages of the 2D radiographs such as distortion and magnification and it leads to accurate quantification of head and neck structures [18, 20]. In orthodontics, radiographs are used for the diagnosis and treatment planning using the analysis of skeletal, dental, and soft-tissue components in the lateral cephalograms. Moreover, orthodontists also analyze the skeletal maturation of the patients using cervical vertebrae maturation index (CVMI). Conventional 2D imaging methods can lead to errors in such measurements. 3D-Imaging such as CBCT can be used for accurate assessment of CVMI as compared to lateral cephalograms [20]. The effects of orthodontic treatment such as root resorption can also be diagnosed more accurately with 3D-Imaging as compared to 2D radiographs [21, 22]. In addition, to skeletal, dental, and soft-tissue assessment that can be done on 2D radiographs, CBCT also helps in performing measurements on airway [20, 23-24]. 3D imaging has also led to the development of a new voxel-method of superimposition which is independent of operator landmark identification, and thus more accurate than 2D superimposition [25].

Temporary anchorage devices (TADs) or mini-implants

Orthodontic TADs have become very popular in the modern orthodontic practice for the treatment of complex malocclusion. TADs can be used in orthodontic for the correction of transverse, anteroposterior, and vertical discrepancies. TADs have high success rates for orthodontic purposes, specifically the palatal TADs. Consequently, palatal TADs are more commonly used than buccal TADs.

Transverse discrepancies

The most common use for palatal TADs has been in expansion of maxillary arch with an expansion screw connected to the palatal TADs with the appliance known as mini-screw assisted rapid palatal expansion (MARPE) or bone-anchored maxillary expansion (BAME) [24, 26]. With the help of palatal TADs, it has also become possible to expand the maxillary arch unilaterally

with Unilateral mini-screw assisted rapid palatal expander (U-MARPE) [27].

Anteroposterior discrepancies

In addition to expansion of constricted maxillary arch, TADs have been used commonly for distalization purposes. Distalization with TADs can be done either for the maxillary arch, mandibular arch, or entire maxillary and mandibular arches. In addition, TADs have proved to be very useful in patients requiring high anchorage for retraction of incisors after extraction of premolars. The retraction power-chain can be applied from TADs to the teeth directly and en-mass retraction can be performed to preserve anchorage [28].

Vertical discrepancies

The most critical part of orthodontic treatment in patients with anterior open-bite is the control of vertical dimension. The intrusion of posterior teeth of maxillary arch leads to correction of the anterior open bite because of the wedge effect [29]. The patients with anterior open bite and vertical skeletal pattern, frequently have increase gonial angle and deficient chin. Additionally, posterior intrusion also leads to counterclockwise rotation of mandible leading to improvement of mandibular chin prominence. In addition to maxillary mini-implants, mini-plates have been applied in the mandibular arch for intrusion of mandibular molars. Simultaneous intrusion of maxillary and mandibular posterior teeth increases the effect of closure of anterior open bite [30].

Conclusion

Recent advance in Orthodontics have changed the way clinicians practice. It has afforded more efficiency to the clinicians so that they can provide better orthodontic treatment to their patients effectively. Such advances have also contributed to the increase the number of patients seen every day by orthodontists. This review summarized the key advances in the field of orthodontics in recent years.

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