In orthodontics, temporary anchorage devices represent a shift in the paradigm

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ABSTRACT

When it comes to controlling anchorage, orthodontists are accustomed to making use of patients' teeth as well as auxiliary appliances, both intraoral and extraoral. These methods have the limitation that it is frequently challenging to achieve results that are commensurate with the ideals we have set for ourselves. The orthodontic literature has recently seen the publication of a number of case reports that document the possibility of overcoming anchorage limitations through the use of temporary anchorage devices. These are biocompatible devices that are fixed to bone for the purpose of moving teeth, with the devices being removed after treatment has been completed. This article defines and classifies these devices, discusses their historical development, outlines some of the basic biologic parameters for their use, and articulates questions that need to be addressed with further experiments before the widespread incorporation of these technologies into everyday practise.

Keywords: Arthodontic, Anteroposterior, iridioplatinum, fracture, miniscrews.

INTRODUCTION

For many years, orthodontists have relied on the patient's teeth, as well as intraoral and extraoral appliances, to control anchorage. This has allowed them to restrict the movement of certain teeth while simultaneously achieving the desired movement of other teeth. However, our ability to completely control all aspects of tooth movement is limited by the third law of Newton, which states that for every action, there is a reaction that is equal and opposite in kind. This law states that for every action, there is an equal and opposite reaction. For instance, we frequently make use of mechanical systems that are insufficient in order to control anchorage. This frequently results in the loss of anchorage for reactive units and frequently results in the insufficient correction of intra- and interarch alignment issues. In addition, in an effort to circumvent these constraints, clinicians frequently resort to the use of cumbersome acrylic appliances or extraoral appliances. However, when coupled with the perennially difficult issue of patients who are unwilling to cooperate, this strategy is, at best, an attempt that is doomed to fail.

In the past five years, the literature on orthodontics has published a large number of case reports that document the possibility of using a variety of temporarily placed anchorage devices in approximation to bone with the goal of either improving upon or overcoming the limitations of traditional anchorage. These case reports include documentation of the use of several different types of anchorage devices.

The case report, despite its significance in describing what is clinically possible, is insufficient for documenting the fundamental biological and biomechanical parameters necessary for the widespread application of a new clinical modality. The scientific literature is just starting to see the publication of prospective clinical trials and experiments in the basic sciences, both of which should start to answer some of the important questions that have been raised. In order to accomplish this, the goals of this article are to provide a precise definition of these apparatuses, place them into a classification system that is easy to understand but flexible, discuss the historical progression of their creation, describe the biological parameters that should be considered when employing them, and pose a number of questions that need to be answered by conducting additional research.

Orthodontic Anchorage

In spite of the fact that the orthodontic anchorage principle has been tacitly understood at least since the 17th century, it does not appear to have been explicitly articulated until 1923, when Louis Ottofy defined it as "the base against which orthodontic force or reaction of orthodontic force is applied." The most recent definition of anchorage comes from Daskalogiannakis, who described it as "resistance to unwanted tooth movement. [1, 2]" It is also possible to define it as the maximum amount of movement that is permitted for the reactive unit. In order to use this definition, it is necessary to provide clarification regarding the reactive unit, which consists of the tooth or teeth that serve as an anchorage during the movement of the active unit, as well as the active unit, which consists of the tooth or teeth that are moving.

In addition, Ottofy summarised the anchorage categories that had been previously outlined by E.H. Angle and others as simple, stationary, reciprocal, intraoral, intermaxillary, or extraoral. These categories can be found in the mouth, in the maxilla, or outside the mouth. Since then, a number of well-known authors have revised or developed their very own classification. For instance, Moyers3 expanded Ottofy's classification system by elaborating on the various subcategories of extraoral anchorage and by subdividing simple anchorage into single, compound, and reinforced subcategories. Moyers also categorised reinforced anchorage as a distinct subcategory [3]. Later on, other people developed their very own terminology for classifying things. Gianelly and Goldman suggested the terms maximum, moderate, and minimum to indicate the extent to which the teeth of the active and reactive units should move when a force is applied [4]. These terms refer to the range of motion that should be allowed for the teeth. Marcotte and Burstone divided anchorage into three distinct categories—A, B, and C—based on the extent to which each anchorage unit contributed to the overall process of space closure [5, 6]. Tweed went on to define anchorage preparation, which is the uprighting and even the distal tipping of posterior teeth to make use of the mechanical advantage of the tent peg before retracting anterior teeth [7]. This was done in order to facilitate the use of the tent peg.

Temporary Anchorage Devices

A device that is temporarily fixed to bone for the purpose of enhancing orthodontic anchorage either by supporting the teeth of the reactive unit or by obviating the need for the reactive unit altogether, and which is subsequently removed after use, is referred to as a temporary anchorage device (TAD). This type of device is then referred to as a TAD.

They may be positioned endosteally, transosteally, or subperiosteally, and they may be attached to the bone in one of two ways: either mechanically (by being cortically stabilised) or biochemically (osseointegrated). It should also be pointed out that dental implants that are placed for the ultimate purpose of supporting a prosthesis are not considered to be temporary anchorage devices, regardless of the fact that they may be used for orthodontic anchorage. This is because dental implants are not removed and discarded after orthodontic treatment, so they are not considered to be temporary anchorage devices. Importantly, the use of dental implants and temporary anchorage devices (TADs) in orthodontic treatment made the possibility of infinite anchorage possible. Infinite anchorage has been defined in terms of implants as showing no movement (zero anchorage loss) as a result of reaction forces [2].

Historical Development

The development and improvement of traditional orthodontic anchorage, dental implants, and orthognathic fixation methods were the foundation for the evolution of temporary anchorage devices. Later on, various alterations of these techniques were unified with the fundamental biologic and biomechanical principles of osseointegration into orthodontic mechanics, which were then ultimately improved based on the experiences gained through interdisciplinary dentistry.

Orthodontic Anchorage: Orthodontists realised very early on in our field's history that there were limitations to the practise of using teeth as anchorage to move other teeth. As early as 1728, Fauchard described the use of the expansion arch, which broadened the crowded dentition to a more normal form by ligating the teeth to an ideally shaped rigid metal plate [8]. This was done in order to make room for additional teeth. A little over a century and a half later, Gunnell asserted that he had used occipital anchorage as early as 1822, but he did not describe the procedure until 1841 [9]. In the year 1841, J.M.A. Schange perfected Delabarre's "crib" and used it to attach the palatal plate as anchorage. This enabled the use of a labial arch and ligatures made of silk or gold wires to accomplish a variety of tooth movements. Later, in 1891, Angle achieved a level of perfection in occipital anchorage. It is said that Desirabode, in the year 1843, used teeth that had roots that were both longer and stronger as anchorage in order to move other teeth. Naturally, no discussion of orthodontic anchorage would be complete without mentioning the contributions made by E.H. Angle, who also presented the concept of stationary anchorage in the year 1887 and occlusal anchorage in the year 1891 [9].

Dental Implants: In spite of the fact that Branemark and his colleagues [10, 11] were the pioneers of the original experimental work that established the principle of osseointegration, Branemark was a long way behind those who initially imagined the possibility of utilising biocompatible materials to replace missing teeth. The fact that the majority of the background information is not available in the clinical literature and is instead primarily found in patent documents is the primary reason why this has been overlooked. Those who are willing to make the trip to the library are the only ones who can make use of our original dated journals because they are not available online and cannot be accessed there.

Orthognathic Fixation: Before the 1800s, the majority of fractures were treated with splints, bandages, and various combinations of intraoral and extraoral appliances. Current fixation techniques for orthognathic surgery are performed primarily using bone plates and screws. In 1847, Gordon Buck is credited with being the first person to successfully place an interosseous wire in a patient with a mandibular fracture [12]. However, Milton Adams is credited with being the one who brought the method into widespread use. In the late 1800s, Thomas Gilmer was the first American to use the dentition as a means of securing maxillomandibular fixation (wires) in the treatment of jaw fractures [13, 14]. This procedure was pioneered in the United States.

First TAD Experience: In 1983, Creekmore and Eklund used a vitallium bone screw to treat a patient who had a deep impinging overbite. This was the first clinical report that was published in the literature about the use of TADs. Ten days after the screw was initially placed, it was screwed into the front of the nose to intrude and root the upper incisors, and then an elastic was connected from the screw to the incisors to correct their alignment [15].

Despite the fact that the first clinical TAD procedure documented the successful application of TADs, this method did not gain instant acceptance at the time. This was most likely the result of a lack of widespread acceptance of surgical procedures, a field of implant dentistry that is still not widely accepted, a lack of scientific data on the use of implantable materials, and a fear of the potential for complications. In its place, conventional anchorage mechanics continued to serve as the primary mode of treatment for the management of orthodontic issues.

Interdisciplinary Dentistry: It would appear that the first report concerning the use of osseointegrated implants for both restorative and orthodontic purposes was published in 1969 when Linkow used a blade implant in the mandibular 1st molar region as a partial abutment for a bridge that was restored before orthodontics was performed. In order to make tooth movement easier, class II elastics were worn all the way from the implant-supported bridge to the upper arch [16]. Since this initial application, the utilisation of osseointegrated dental implants as anchorage for orthodontic treatment has been thoroughly researched and documented. Kokich, Smalley, and Smalley and Blanco have developed protocols for determining how to accurately place dental implants in the final desired location for restorative procedures before orthodontic therapy [17-19]. This allows the implants to be used for both orthodontic anchorage as well as the subsequent restorative therapy. These protocols were developed by Kokich and Smalley [20, 21].

Current Devices

An ideal anchorage device would have several qualities, such as being easy to use, affordable, immediately loadable, having small dimensions, being able to withstand orthodontic forces, being immobile, not requiring compliance, being biocompatible, and providing clinically equivalent or superior results when compared to traditional anchorage systems. TADs have to have primary stability and the ability to withstand orthodontic force levels when they are first placed in the mouth. This is a bare minimum requirement. The maximum load that can be applied to integrated implants is proportional to the amount of osseointegration, whereas the maximum load that can be applied to nonintegrated implants is proportional to the surface area of the bone that is in contact with the implant.

Important Factors to Consider

To this day, the vast majority of the scientific research on osseointegrated implants has been published in journals that are associated with restorative dentistry, while only a relatively small amount has been published in orthodontic journals. Therefore, it follows that any discussion of the fundamental biology must also start with the initial research on dental implants. Several of the debates that are currently taking place regarding orthodontic TADs are not new; rather, they have their roots in implant dentistry.

Delayed Versus Immediate Loading

At the moment, there are two methods that can be utilised in order to secure temporary anchorage devices to bone: either biochemically (osseointegrated) or mechanically (cortically stabilized). In the beginning, however, based on Brnemark's work [10,11,15] it was believed that a healing period of between four and six months should be given to all implants before they could be functionally loaded. Because the authors believed, based on both clinical and experimental evidence, that premature loading caused micromotion of the implants, which in turn allowed the invasion of fibrous tissue and resulted in the failure of the implants, this conclusion was reached. This was supported by the findings of Roberts and colleagues41, who used a rabbit model to study static orthodontic-type implant loading of 100 g after 6, 8, or 12 weeks of healing. Roberts and colleagues used a rabbit model to study static orthodontic-type implant loading [22]. On the basis of his findings, Roberts came to the conclusion that the earliest an implant could be loaded after placement was after 6 weeks had passed in rabbits. Because sigma, also known as the length of time it takes for remodelling to occur, is approximately three times longer in humans than it is in rabbits, he reasoned that the same length of time would be equivalent to 18 weeks in humans.

Dynamic versus Static Loading

It appears, on the basis of some of the more relevant studies, that implants meant to be osseointegrated can be loaded earlier than was previously thought as long as the implants are splinted together. However, this is only the case if the implants are connected to one another (ie, micromotion is minimized). Micromotion should be less than approximately 100 metres, as stated by Szmukler-Moncler and colleagues [23]. When compared to dynamically loaded or unloaded control implants, statically loaded implants have more dense cortical lamellar bone and higher bone:implant contact on the loaded surface. Implants that are statically loaded are very similar to orthodontically loaded implants in the sense that they are typically loaded in only one direction and with a force that is relatively consistent throughout the course of a considerable amount of time.

Future Directions

The concept of temporary anchorage devices is a relatively new application of clinical methodologies that have been around for a longer period of time. Even though the clinician can look to the published research for many answers, there are still many questions that haven't been answered and won't be until well-designed prospective basic science and clinical trials are carried out. Establishing a more complete understanding of the biology and biomechanics associated with both osseointegrated and nonintegrated TADs will be possible thanks to the future development of temporary anchorage devices for orthodontic anchorage.

One of the most important questions that needs to be answered is whether the miniscrew implant ought to have a self-tapping or drill-free design. The latter option does not require a pilot hole; however, do you think it will be more difficult to control the angle at which the component is placed? How likely is it that the bone will become overcooked if a pilot hole is drilled into it? In terms of length, diameter, head design, thread design, body design, end design, and material, what are the ideal characteristics of miniscrew implants? When viewed in relation to the surface of the bone and the direction of the force vector, what is the optimal orientation of the TAD? For purposes other than integration, should only a polished implant be used, or does it not make a difference? Is there a difference between the two surface patterns in terms of the microorganisms that they attract? What is the absolute limit to the amount of force that a TAD can take? Osseointegrated implants are presumed to be able to withstand more force than nonintegrated TADs; however, the validity of this assumption has not been established. Are TADs capable of being utilised in the application of orthopaedic forces? In that case, what is the upper limit of the force? Damage to the tooth root, infection of the local bony or soft tissue, or perforation of the maxillary sinus are likely to be the most serious complications associated with TAD applications. If that's the case, how are these handled? TADs are now being used to dentally correct musculoskeletal malocclusions that, ideally, would be treated by orthognathic surgery. Despite the fact that the stability of tooth movement has been well documented, TADs are still being used. When treating cases of skeletal openbite with posterior dental intrusion, what is the long-term stability of the patient's bite?

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