THE IMPORTANCE OF PERIODONTAL SOFT TISSUE ASSESSMENT IN THE ORTHODONTIC TREATMENT PLANNING. REVIEW.

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Abstract

Orthodontic treatment can greatly impact the periodontium, especially in dentitions with a thin periodontal phenotype. Orthodontic tooth movement can result into iatrogenic sequelae to these vulnerable anatomic conditions, such as development and exacerbation of bony dehiscence or fenestration defects, which can manifest loss of periodontal support and gingival recession. Orthodontic treatment should be planned taking the periodontal phenotypes into account. A thin phenotype often requires a surgical procedure to thicken tissue before orthodontic treatment. In patients with a thick phenotype, in whom the risk of recession progression is lower, it is possible to introduce observation during orthodontic treatment and to correct defects after its completion, if possible. Periodontal diagnostics before the start of orthodontic treatment is used to assess periodontal features such as height and quality of the alveolar process and the type of a soft tissue phenotype. Most studies suggest improving the gingival phenotype before orthodontic treatment, but a decision should be made individually for each patient.

Keywords: *gingival phenotype, orthodontic treatment, soft tissue management*

Introduction

Thanks to the increasing demand in appearance, orthodontic treatment is being more and more adopted in the adult population. As adult orthodontic patients may also have restorative and periodontal needs, the interaction between different specialties becomes even more important. Many periodontal patients may present with pathological tooth migration or other deformities where orthodontics may represent an important part of their treatment. Both periodontists and orthodontists should understand the results of one's work on the other's and cooperate in clinical practice to deliver the best possible treatment to their patients.

The success of activities in the field of conservative aesthetic dentistry, prosthetics, implantology and orthodontics is mostly dependent on the structure of hard tissues, i.e. bones (structure, shape of the alveolar process), teeth (shape, eruption processes, alignment in the arch) and soft tissues (gingival phenotype). Periodontal features significantly affect the final treatment outcomes.

Depending on the gingival phenotype, different reactions can be expected to parafunctions, inflammation, dental treatment, as well as to traumas (caused, for example, by an incorrect brushing technique or tooth extraction) [1]. More predictable treatment outcomes are achieved in patients with a thick gingival phenotype. Contemporary periodontal surgery allows for a change/improvement of the phenotype from thin to pseudo-thick, i.e. one that is characterised by higher resistance of soft tissues.

Depending on the initial characteristics of a treatment site (gingival phenotype, location and type of tooth, or initial recession height) and the patient's hygiene habits, it is possible to change the gingival phenotype before or after orthodontic treatment.

Gingival phenotype/biotype

In periodontal terminology, there are three terms used to define a set of periodontal features: morphotype [2], biotype [3] and phenotype [4]. The first one refers to the variation of morphological traits, while the other two also take into account genetic (biotype) and physiological (phenotype) properties to which a given tissue is subject. Currently, it is postulated to use the term “phenotype” because it is a more precise description of features of periodontal tissues and bones.

Types of gingival phenotypes

The classification of a gingival phenotype is based on the morphological characteristics of bones, teeth and soft tissues of the periodontium. The gingival morphology is determined by the shape of the alveolar bone [5], the process of eruption and the shape and alignment of teeth in the dental arch [4]. Three terms are used to describe a morphotype of the alveolar process bone: “flat”, “scalloped”, “pronounced scalloped”. These terms refer to a difference between the level of the bone margin measured in interdental spaces and the margin on the vestibular side. In the flat type, the average distance between these points is up to 2.1 mm, in the scalloped type between 2.1 mm and 2.8 mm, and in the pronounced scalloped type it is 4.1 mm on average. It means that in the first type, the gingival margin lies within the enamel of a dental crown, and in the scalloped and pronounced scalloped types, it is placed at the level of CEJ (cementoenamel junction) or even root cement [6]. Becker et al. have shown that a pronounced scalloped type is at higher risk of bone dehiscence and fenestration [6].

Normal gingiva is characterised by a harmonious course of the gingival and bone scallop. The apex of the alveolar process is positioned about 0.5–1.9 mm below the cementoenamel junction and it is reflected by the course of the gingival scallop. The gingiva has a healthy, pink and compact structure. With regard to the gingival thickness, two types are usually distinguished: thin and thick [4]. In 1989, Siebert and Lindhe classified and named gingival biotypes for the first time: thick-flat (above 2 mm) and thin-scalloped (below 1.5 mm) [7]. Moreover, it was noted that a flat bone morphotype was usually accompanied by a thick gingival biotype, and a scalloped bone morphotype by a thin gingival biotype [8]. A thick periodontal biotype is characterised by flatly shaped soft tissues and alveolar process bones and a thick labial plate. The gingiva is compact, thick, with a wide area of keratinised tissue (min. 5 mm), lower but thicker gingival papillae (4.5 mm thick) and deeper gingival fissures [9]. In the case of a thin periodontal biotype, we observe a clearly marked gingival scallop, delicate, thin soft tissues, higher and thinner gingival papillae (approx. 3.8 mm thick) and a narrow zone (max. 3.5 mm) or absence of keratinised tissue and shallow gingival fissures [10].

Numerous studies demonstrate a relationship between the shape of incisors and a gingival biotype [2-6]. Individuals with narrow, long, triangular dental crowns and contact points of a small area, located close to incisal edges, have a relatively thin periodontal biotype. On the other hand, people whose teeth shape is square-like and extensive contact points are located more apically, are more likely to have a thick gingival biotype. Individuals with a thin gingival biotype are more predisposed to recession than those with a thick biotype [3]. They are also more often at risk of connective tissue attachment loss and gingival bleeding [11].

Morphometric parameters of the gingiva show significant individual variability. Even in the same patient they may differ in the maxilla and mandible, and depending on the type of tooth. In their studies, Müller et al. showed that the maxillary gingiva is thicker compared to the mandibular one, but studies by Vandana et al. do not confirm that [12].

According to some authors, a thick gingival phenotype is found in about 85% of the population and a thin one – in 15% [3]. However, other authors showed that the presence of a thin phenotype could be demonstrated in as much as 30% of subjects [13]. Because about 1/3 of the population cannot be qualified into any of the commonly defined biotypes, the third type of a gingival biotype – "normal" one [4] – has been proposed. Variability in this area is thought to be affected by race, genetic conditions, age (the younger the age, the thicker the gingiva) and sex [12]. Rasool et al. have shown that women are 4.2 times more likely to have a thin periodontal biotype than men, and thin gingiva is five times more likely to be present near mandibular incisors [14].

A periodontal phenotype, type and shape of a dental crown have a significant impact on the development of recession as a result of orthodontic treatment. Movement of a tooth close to or outside the lingual or labial compact plate of the alveolar process leads to secondary thinning of a periodontal phenotype and an increased risk of gingival recession [15]. During orthodontic tooth movement, there is bone remodelling with resorption on the side where the movement takes place. As a consequence, this leads to a reduced volume of the bone plate [16]. This process results in the formation of bone dehiscences or fenestrations and apical migration of the gingival margin (gingival recession) [17].

Measurements of soft tissue parameters

In order to perform predictable and safe orthodontic treatment, the gingival phenotype should be determined already at the stage of planning orthodontic movements. It is recommended to measure periodontal parameters, assess the alveolar process quality, determine the shape (height and width) of dental crowns and their positions in the arch. During a classical periodontal examination, the periodontal condition is determined by measuring the pocket probing depth (PPD), assessing the level of the gingival margin (GM), a clinical position of the clinical attachment level (CAL), bleeding on probing and the presence of dental deposits. As a result, it is possible to detect inflammation and recession before active orthodontic activities are taken [2].

Assessment of the alveolar process bone quality is based on probing through soft tissues to the bone and X-ray examination (panoramic radiograph, right angle dental x-ray). Such tests allow to detect bone defects and determine the alveolar process height. Limitations of these methods include the inability to assess defects on labial, lingual and palatal surfaces properly and the underestimation of a degree of skeletal defects [18]. These areas can be examined using cone-beam computed tomography (CBCT) [19].

The determination of a gingival phenotype is based on the measurement of the width and thickness of the keratinised tissue. While gingival width can easily be measured with a periodontal probe, gingival thickness measurement requires more advanced methods. Invasive methods include direct gingival probing, which is similar to bone probing. It is performed under local anaesthesia using a root canal tool (a spreader or file and endodontic gauge), a periodontal probe or a needle with an endodontic marker to mark the depth of tool penetration through the gingiva to the bone [20]. Olssoin and Lindhe [2] used a needle with endostop to puncture the gingiva at the base of a gingival fissure on the vestibular surface. Claffley et al. assumed that when measured with this technique, the gingival thickness < 1.5 mm is a thin biotype, and thickness > 2 mm – a thick gingival biotype [11]. The disadvantage of this method is its invasive nature, the need to position a tool appropriately (perpendicularly to the gingival surface), limitations due to the accuracy of a probe or gauge (accuracy up to 0,5 mm) and the deformation of tissue while probing [17]. Its advantages include availability and relative technical ease and low costs of use.

Non-invasive methods include a visual assessment, periodontal probe transparency method (TRAN), ultrasound examination, X-ray and computed tomography (CBCT). A visual assessment includes an assessment of the gingival structure, gingival scalloping, the shape of teeth and their alignment in the dental arch. Eghbali et al. demonstrated high efficacy of the visual method in recognising thick gingiva, but only 50% efficacy in evaluating a thin gingival type [20].

The TRAN method is a technique in which a periodontal probe calibrated to 1 mm is placed in a gingival fissure perpendicularly to its bottom. If the probe is visible through the free gingival margin, a thin gingival phenotype is diagnosed. Lack of transparency, on the other hand, determines that gingiva is classified as a thick phenotype [21]. This test is easy and quick to perform. Low costs and reliability (85% of consistent measurements performed by two different clinicians) make it a popular method for doctors [22]. However, mainly the free gingival margin is assessed here, and not the attached gingiva or alveolar process bone.

In order to assess the gingival thickness, ultrasound devices are also used. Some researchers support the ultrasound method because of its non-invasive character, high accuracy (up to 0.1 mm) as well as the reliability of results, especially regarding the gingival thickness ranging from 0.5 to 4 mm [23]. Disadvantages of this method include the difficulty of positioning the head perpendicularly to tissues (which causes measurement errors and requires previous experience in handling the device), as well as high costs and limited repeatability and reproducibility of a measurement at a given point [10].

Radiological evaluation of soft tissues can be performed on lateral cephalograms using a piece of lead foil applied to the gingiva on the labial side [24], as well as on 3D CT scans. Despite the high costs of the equipment and a higher dose of X-rays compared to panoramic radiographs and lateral cephalograms, CBCT is widely used in dentistry. From a diagnostic point of view, CBCT is characterised by high sensitivity and accuracy, ease of use, relatively few imaging artefacts and high repeatability [19].

Preparation of soft tissues for orthodontic treatment

Information about the height and quality of the alveolar process and a type of a soft tissue phenotype, obtained as a result of a thorough diagnosis, is an indication of whether and to what extent expansive orthodontic treatment may be performed. Based on the collected data, it can be decided to include periodontal surgery procedures such as keratinised tissue widening, gingival phenotype thickening or surgical treatment of gingival recession in the treatment plan.

Keratinised Tissue (KT) widening

The width of the keratinised tissue increases with age as a result of maturation and growth of the body (especially in the area of the maxilla and mandible), the eruption of permanent teeth and passive eruption associated with abrasion of tooth surfaces [25]. It is nowadays considered that the presence of a minimum zone of attached gingiva is not necessary to maintain healthy periodontium, but only on the condition that there is no accumulation of a bacterial plaque, teeth do not require fillings near gingivae or there is a prominent root shape around a tooth neck. If these conditions are not met, then it is recommended to maintain at least 2-mm keratinised tissue zone (1 mm of attached gingiva plus 1 mm of free gingiva) [26].

Gingival augmentation improves its resistance to mechanical traumas and bacteria present in a dental plaque and their enzymes. Augmentation is indicated because it allows a patient to perform hygienic procedures (brushing, flossing) correctly when the oral vestibule is shallow. Gingival margin tearing caused by functional tension of muscles and mucous membrane leads to increased accumulation of a bacterial plaque and an increased risk of infection. This reduces the resistance of the marginal gingiva, and the epithelial attachment loss and soft tissue recession develop easier [27].

Protection against recession or slowing down existing recessions, especially before planned orthodontic, prosthetic or conservative treatment, is an indication for keratinised tissue widening [28].

For many years, effective techniques have been developed to widen the keratinised tissue. Pedunculated grafts, flap techniques and free connective tissue grafts or tissue substitute grafts can be used [28-30]. Among the methods used to widen the gingival zone the following can be listed:

- free epithelial-connective tissue graft from the palatal mucous membrane;
- subepithelial connective tissue grafts from the palate, the area of the maxillary tuberosity and also the area behind molars;
- pedunculated soft tissue grafts;
- tissue substitute grafts, including: – allografts (of human origin – homologous), e.g. Alloderm (Acellular Dermal Matrix, ADM) or fascia lata graft;
  - xenografts (of other species origin – heterologous), e.g. type I and III collagen-based membranes, such as Mucoderm (Porcine Acellular Dermal Matrix, PADM) or porcine small intestinal submucosal grafts, e.g. DynaMatrix (Extracellular Matrix Membrane, ECM), xenogeneic collagen matrices (Bilayer Collagen Matrix, BCM) that are pure, e.g. Mucograft membrane, sponge, gel, or compound [28]
  - synthetic tissue bioengineering products, e.g. natural skin substitutes populated with living fibroblasts (Living Cellular Construct, LCC), such as Apligraph (a bovine collagen mesh containing allogeneic fibroblasts, keratinocytes and extracellular proteins), Dermagraft (biodegradable polyglactin mesh containing living fibroblasts, keratinocytes and extracellular proteins), meshes of fibrin origin, meshes composed of synthetic polymers or biopolymers, hybrid meshes having a biomimetic architecture that affects colonisation and growth of respective cells of the periodontal ligament and bone [28].

Regarding the materials mentioned above that are used to widen the attached gingiva, a gold standard is a graft of the patient's connective tissue, most often from the palate, covered with a pedunculated flap. The results obtained are the most predictable in terms of therapeutic outcomes (coverage of exposed roots) and aesthetic outcomes (matching of transplanted tissues with those in the recipient site in terms of surface structure and colour). On the other hand, achievements of tissue engineering are promising as an alternative to palatal soft tissue in case of its insufficient amount and they reduce the patient's discomfort associated with creating a second treatment site on the palate. Regardless of the technique, the gingival expansion is only stable in the long term if optimum hygiene is maintained [10, 28].

Changing a gingival phenotype

Specific phenotypic features that can be observed in the gingival area of the maxillary alveolar processes and the mandibular alveolar part also apply to the palatal mucosa. In case of a thin phenotype, multiple gingival recessions and thin palatal tissue are present. This is important when choosing a surgical technique to thicken the gingiva or cover a recession.

Phenotype thickening is often recommended for implantation procedures, bone regeneration and also before orthodontic treatment because a thin gingival biotype is more susceptible to injuries. Gingival thickness is particularly important for preserving a gingival papilla after implantation, preventing recessions and for effective periodontal regeneration [3]. Studies show that there is a relationship between the thickness of a flap and the effects of periodontal surgical procedures, such as the possibility of achieving complete coverage of a recession [1]. It has been shown that the thicker the flap, the more predictable treatment outcomes, the greater the resistance to mechanical traumas, the better the blood supply to the gingiva, and thus the easier the healing. Flap tension and postoperative wound stability play an important role in the healing process and in keeping the flap in the coronal position [31]. When a connective tissue graft is additionally placed under the flap, it results in a further increase in the thickness of marginal gingiva and stable effects of root surface coverage [32]. Baldi et al. proved that the minimum flap thickness needed to obtain predictable outcomes in covering a recession was 0.8 mm [33]. In cases where palatal tissues do not guarantee the required graft thickness, tissue substitutes mentioned earlier are used. Over the years, a number of techniques have been proposed for introducing a graft in the recipient site:

- Subepithelial connective tissue graft (CTG) in combination with pedunculated flap techniques:
  - coronally advanced flap + CTG and subsequent modifications to avoid vertical incisions (Zucchelli & De Sanctis) [34];
  - laterally positioned flap + CTG;
  - double laterally positioned pedunculated flap + CTG.
- Subepidermal connective tissue graft, including minimally invasive techniques:
  - technique of the supraperiosteal envelope by Raetzke + CTG [35];
  - tunnel technique by Allen [36].

Further modifications to the tunnel technique have significantly broadened surgical indications. They enable to cover deeper and wider multiple recessions accompanied by narrow attached gingival zone as a result of more significant coronal flap mobilisation, while maintaining the best possible blood supply and protection of interdental papillae. In the studies by Rebele et al., the average increase in gingival thickness after using the tunnel technique in combination with CTG was up to 1.63 mm after 12 months [32].

In relation to biomaterials, preparations containing a number of growth factors that are responsible for the regeneration of periodontal tissues have been used, mainly Emdogain (EMD) and platelet-rich fibrin (PRF). EMD (Enamel Matrix Derivative) is a product based on enamel matrix proteins and obtained from porcine tooth buds. Main components of EMD include amelogenin fraction proteins which stimulate the regeneration of bones, acellular root cement and fibres of the periodontal ligament [10]. Other EMD components show activity similar to that of TGF-β (Transforming Growth Factor β) and BMP (Bone Morphogenetic Protein) responsible for cellular differentiation and proliferation and bone formation [37]. In their experimental study on dogs, Al-Hezaimi et al. have demonstrated significant thickening (about 1.76 mm) of soft tissues after application of EMD to an exposed root of a tooth with recession, in combination with a coronally advanced flap [38].

PRF (Platelet Rich Fibrin) is an autologous biomaterial created by centrifugation of the patient's own venous blood. The obtained platelet-rich plasma concentrate has a high content of growth factors such as: TGF-β (transforming growth factor β), insulin-like growth factor-1 (IGF-1), platelet-derived growth factor (PDGF), vascular endothelial growth factor (VEGF), fibroblast growth factor (FGF), epidermal growth factor (EGF) and platelet-derived epidermal growth factor (PDEGF) responsible for fibroblast migration and collagen type I (Col-1) gene expression [39]. As a result of placing PRF at the site of a hard and soft tissue deficit, healing and regeneration of connective and bone tissue are accelerated [40]. Platelet-rich fibrin has been used in regenerative periodontal surgery in the form of a membrane, gel or clot (A-PRF+, or Advanced Platelet Rich Fibrin Plus and PRF (L), or Platelet Rich Fibrin Leucocytes) and in the liquid form for supra- or subperiosteal (i-PRF) injection.

There are reports indicating satisfactory outcomes of i-PRF injection under the alveolar process mucosa to thicken the gingiva [41]. This minimally invasive method of changing the gingival phenotype seems promising, but further clinical studies are still required.

A critical question remains: For patients planning to receive orthodontic treatment, is it better to perform hard and soft tissue augmentation before, during, or after orthodontic treatment? And, if it depends on each patient and their individual condition, what are the specific indications? From the AAP best evidence review [42], the recommendation is to perform gingival augmentation at teeth 1) with <2 mm keratinized tissue width; and 2) if the tooth is expected to have significant labial tooth movement [43]. Although current studies were unable to provide a definitive answer on the best timing to perform periodontal phenotype modification therapy, it is reasonable to suggest that augmentation before any labial tooth movement, especially in the presence of a thin phenotype or when there is <2 mm keratinized tissue width. However, each case is unique and should be treatment planned on a case-by-case basis.

A preliminary systematic review on the indications and timing of soft tissue augmentation was previously published [44]. However, no conclusions could be drawn from the limited studies published to date. Available studies are primarily autogenous gingival grafts with limited information regarding the technique performed, whether frenum is presented or not, and the degree of phenotypic augmentation or root coverage that was achieved [45]. Another interesting observation is that involving hard tissue augmentation with corticotomy-assisted orthodontic therapy has been shown to increase keratinized tissue width in one study although the direct influence between the involving hard tissue augmentation and keratinized tissue width is not fully understand [46]. All the included studies had limited or no reporting on gingival tissue or keratinized tissue width - an important outcome to evaluate periodontium; therefore, it is important for these indices to be reported in future studies (47).

Conclusions

A thorough analysis of tooth alignment, assessment of the gingival phenotype, width of the alveolar envelope and recession classification allow avoiding periodontal complications during treatment with fixed braces. Periodontal evaluation and gingival phenotype measurements should be performed before the onset of orthodontic treatment. Possible improvement of the gingival phenotype usually brings positive outcomes. Close cooperation between an orthodontist and a periodontist allows for the monitoring of tooth displacement and increases the predictability of treatment outcomes. The decision on the choice of a treatment method should be made individually for each patient .

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