# PERIODONTAL ASPECTS OF ORTHODONTIC TREATMENT WITH INVISALIGN® VERSUS FIXED APPLIANCES IN THE SAME PATIENTS. A PILOT STUDY

Lanteri V.*, Poggi S.**, Blasi S. **, De Angelis D.**, Gangale S**, Farronato M.*, Maiorani C. ***, Butera A. ***

*Department of Biomedical, Surgical and Dental Sciences, Unit of Orthodontics and Pediatric Dentistry, University of Milan
** Department of Integrated Surgical and Diagnostic Sciences (DISC), University of Genoa
*** Department of Diagnostic, Pediatric, Clinical and Surgical Sciences, University of Pavia

**Abstract**

*Aim*: the purpose of this study is to evaluate orthodontic treatment with aligners (top arch) and traditional fixed appliances (lower arch) in relation to oral hygiene and periodontal health.
*Material and Methods*: in this study we selected four patients, all treated by the same operator with an average age of 26 years, but all older than 18 years; we have adopted exclusion factors from research, in relation to the predisposing causes to periodontal disease and to the accumulation of plaque and calculus on dental surfaces.
*Results*: according to the scientific literature, fixed orthodontic appliances predispose to a greater accumulation of plaque and a worsening of periodontal health conditions compared to aligners; in patients who have not maintained good hygiene conditions, there has been a maintenance of the starting conditions at the level of the upper arch, but a noticeable worsening at the lower level, with plaque buildup and increased tissue inflammation.
*Conclusions*: the results also highlighted the importance of individual oral hygiene procedures during orthodontic therapy, which are essential for maintaining good tissue health; the aligners have shown greater respect for periodontal tissues, also inducing an improvement in plaque accumulation levels and reducing gingival inflammation.

**Key words**
Orthodontics appliances, oral hygiene, periodontal status

**Ethical Compliance**
*Source of Funding*: This study did not require financial support or any funding.
*Disclosure of Interest*: The authors declare that they have no conflict of interest.
*Informed Consent*: Informed consent was obtained from each individual participant involved in this study.
*Statement of Human Rights*: This study was conducted in accordance with the 1964 Declaration of Helsinki and its subsequent amendments.

**Corresponding Author**
Andrea Butera, andrea.butera@unipv.it

## 1. Introduction

Through controlled dental movement, orthodontics takes care of solving occlusion's anomalies caused by irregularity teeth's and arches' form, allowing to improve teeth's alignment, aestetic's equilibrium of lips and face, masticatory function's efficacy, teeth and support tissues' preservation and smile's armony. Clinically, to realize these objectives removable, fixed or mixed orthodontics appliances are used. Orthodontics appliances can make oral hygiene practies more complicated and can retain leftovers, pioneers of dental plaque, generating potential risks for enamel and periodontal tissues [34,35]. Periodontal clinical picture, judged through plaque index, gingival index and bleeding on probing, results particularly delicate in patients treated with traditional fixed orthodontic tecniques. In 1999 was introduced a new generation of appliances, based on removable aligners that cover all teeth and part of marginal gum, achieving bit by bit movement up to ideal position. Beyond aestetic's valency, aligners submit the vantage that they can be remove by patient, which is able to do oral hygiene practies and that reduce the risk of develop periodontal tissues inflammation [13, 25]. Scientific studies, which analyzed concurrently orthodontic fixed therapy and aligners in the same patient, do not exist.

### *1.1 Prevention's general basics in fixed orthodontic*

To reduce risks of diseases, orthodontic patients are undergo to control and oral hygiene motivation on average each month. Food's indications must be given, as a varied and complete diet represents an important contribution to oral health, just as sticky food or filamented meat, which remainings are many difficult to remove, must be avoid. When systematics removal of dental plaque is disregarded, may arise two problem's categories: periodontal damages, that debut with clinical signs of marginal gingivitis which, if it's not treated, may evolve up to cause depth and recessions and/or coronal damages with enamel's superficial demineralization (white spot), that can be result in actual caries. Recent studies have shown that dental plaque consists of microbial organization with more complex characteristics than those attributable to single sum of microbial species' properties, that compose it [5]. The common starting point and universally shared is that complete dental plaque and inflammation control before starting any dental movements. A large number of bacteria can may stick, procreate and organize in potentially pathological biological biofilm on hard tissues: after a few minutes from professional oral hygiene, glycoprotein film "acquired" of salivary derivation settles on enamel, which gets colonized by coccoid bacteria agglomeration, mainly *Streptococcus Mutans, S. Sanguis, S. Salivaris*. The bacterial nucleus thus formed, grows and organized itself, supporting further bacterial species adhesion potentially pathological. Biofilm's production and allocation taking peculiar properties in presence of orthodontic appliances, therefore to make therapeutic iter more rational from the point of view of prevention and oral hygiene, five temporal phases corresponding clinical aspects very different from each other stand out [15]:

1. *Before treatment.* General prevention program is characterized by proper food's hygiene, periodic professional cleansing, treatment with fluoride and sealing the grooves. Some studies confirm that the use of adhesive systems containng fluoride is useful for the preventon of demneralization due to orthodontic brackets [2]; other studie show lossoff effectiveness of adhesiondeu to some prevention protocols [38,39,40]. To date, other agents able to promote correct enamel remineralization are available, which not interfer with brackets' chemical adhesion. Therefor can choose between a vastness of domestic protocols, should be perform careful analysis of enamel, considering individual susceptibility and benchmarks (Bewe) combined with patient's valuation of periodontal tissues. In this way, it's possible obtain combined and favourable result for correct performance of therapy and tissues' preservation [45].

2. For fixed appliances, these are characterised by different elements: attachments, products in different materials, have horizontal fissure, called slot, in that arches are accommodated, in a number ranging from two to six, which support the bindings and may be supplemented by auxiliary structures for anchoring elastic tractions and insertion of various devices. Specific indications of oral hygiene according to method of fixing used: direct bonding or orthodontic bands cementation [39,40]. The use of orthodontic bands is reduced almost exclusively at the molars. Prevention consists to minimize band/enamel space bound to cement and in the precise adaptation of the band edges and in the careful removal of excess cement. Inadequate bandage is a prerequisite for plaque accumulation and increases the frequency of cement deiscences exposing patients to serious risks of oral tissue damage.

3. *During active orthodontic treatment*, individual requirements relating to the type of equipment used and its specific risks should be added. It must be the orthodontist's care to choose effective and efficient but limited encumbrance devices [41,42]; pain control also plays an important role in patient compliance [43]. The presence of structures foreign to the natural oral environment induces a significant modification of the bacterial flora, with an increase of steptococcus mutans and lactobacilli. Many studies have shown that there is a cause/effect relationship between the application of orthodontic appliances and changes in bacterial flora at the marginal periodontal level. In particular, the increase of sticks and spirochaetes is an indication of increased virulence of plaque, often associated with flogosis of gingival tissues. In addition, mechanical obstacles caused by appliances make oral hygiene more difficult. Numerous co-factors are important in determining the impact on oral health. These include type and number of pathogenic bacteria present, quantity and frequency of intake of fermentable sugars, quality of the enamel and motivation of the patient. In summary, the presence of complex appliances facilitates the accumulation of plaque and food residues; it is therefore essential to provide the patient with the appropriate tools and teach an appropriate method of cleaning the apparatus. For this multifactoriality in play during orthodontic therapy, orthodontist and dental hygienist should collaborate closely, performing monthly or quarterly support calls, according to the patient's needs and drafting taylor-made protocols with a view to restoring altered biological conditions. Work on reducing the bacterial load, changing and re-evaluating the recommended house subsidies and using airflow powders, glycine and erythritol based for elimination of bacterial biofilm, turns out to be one of the focus points for the success of the orotodontic therapy and the proper maintenance of the gingival state of health.

4. *At the end of the treatment*, careful removal of cement or composite residues should be carried out, which would be a favourable surface for adhesion of the bacterial plaque. The procedure is not risk-free as the detachment force, if not carefully managed, can cause damage to the enamel in the form of parcel detachments or cracks. The term debonding refers to all procedures aimed at the complete restoration of the dental surface, as similar as possible to the original conditions. Insufficient removal of the composite from the enamel surface may cause the formation of"flat spot", that

is, areas that do not reflect light such as the surrounding intact dental tissue, with the formation of imperfections if the phenomenon concerns the front sections of dental arches [32].

5. *After treatment*, some patients carrying removable restraining appliances are covered by the general prevention protocol, while the majority carry fixed restraints (lingual arches, cleft bows, retainers) requiring systematic controls for the risk of accidental, partial or total detachment, accumulation of plaque and tartar.

*1.2 General principles of oral hygiene and thermoprinted aligners*

Among the removable appliances, the system based on transparent aligners, produced in series according to precise therapeutic indications and sophisticated construction methods, is becoming increasingly popular, which is a more aesthetic and less invasive alternative to fixed orthodontic appliance. Oral hygiene in this method is undoubtedly facilitated and is entirely comparable to that required by any other mobile appliance. To complete the therapy with optimal results, a high patient compliance is required, which must wear the aligners regularly and maintain an adequate level of oral hygiene [24]. To monitor hygiene in patients treated with transparent aligners, in order to develop a specific protocol that takes into account the peculiarities of the method, a questionnaire was introduced at the Graduate Course in Dental Hygiene of the University of Pavia, given to all patients treated with aligners. The questionnaire includes 22 questions concerning the methods used for cleaning aligners, the frequency, the use or not of particular instruments, the use of principals such as mouthwash or dental floss, reference to dietary and consumption habits of tobacco or alcohol during therapy. On the basis of the data collected, the following oral hygiene protocol for patients receiving aligners was developed (Tab 1).

Tab. 1 **ORAL HYGIENE PROTOCOL FOR PATIENTS IN TREATMENT WITH ALIGNERS**

Wash your hands thoroughly with soap and water before taking the aligners.

***Mantenance***

- Clean the aligners before each use with soft bristle brush and toothpaste or with warm water and soap or with the washing system provided by the manufacturer (e.g. invisalign cleaning system) . Rinse well with water

- Do not use detergents for implants or mouthwashes because they can damage the surface of the plastic, making it opaque and therefore more visible

***Oral hygiene***

- Always remove aligners before meals

- Carefully brush your teeth after each meal and before reinserting aligners

- Follow the routine procedure for cleaning teeth

- Periodic check-ups and daily oral hygiene guarantee the health of teeth and gums

***Advices***

- Drink only water or drink no dyes to avoid staining aligners

- Do not smoke to avoid yellowish colour changes

- Follow the schedule of monitoring visits to monitor treatment progress

Some authors have carried out research with the aim of examining the capacity of removable thermoplastic appliances (*removable thermoplastic appliance - RTA*) to absorb different hygienic solutions and inhibit bacterial growth, and with the aim of assessing the effectiveness of three hygiene protocols in reducing the adhesion of the biofilm to removable appliances. Thermoplastic appliances, like aligners, are composed of a plastic resin with elastic properties: surface changes in these materials have been shown to facilitate the adhesion of bacteria resulting in physical changes such as micro-fractures visible under the microscope and small abraded areas [6]. As RTAs are worn by patients for a few weeks in the case of transparent

aligners, but also for longer in the case of orthodontic retainers of restraint, a protocol for the control of bacterial adhesion is essential. This study involved 11 patients with an average age of 29 years, 8 females and 3 males, from the Department of Orthodontics in Tel-Aviv and all treated with aligners, to which three sanitization protocols have been sequentially allocated. A total of 132 aligners (12 for each patient) were examined over approximately 6 months of treatment. In the first stage patients received two aligners with regular dental cleaning instructions and aligners with the use of toothpaste containing 1400 ppm fluoride. These removable appliances served as a control group: a total of 22 aligners were examined in the first 28 days. In the second stage, in which 55 aligners were examined every two weeks, was asked to clean the next five aligners only with toothbrush each evening and subsequently dip them in a chlorhexidine mouthwash (CHX) for 15 minutes, rinse with water and put in their mouth. Chlorhexidine is a well-known and widely used antimicrobial agent for plaque control and gingival health which can also be used for removable appliances. In the last stage, in which 55 other aligners were examined, patients received hygiene instructions with the help of sonic baths with solutions '"Cleaning-Crystals" for the next five devices. 'Cleaning-Crystals (CS) solutions are used in conjunction with vibrating baths and dissolved in water in accordance with the manufacturing company's instructions. These consist mainly of sodium sulphate (60%), sodium carbonate (30%), sodium tripolyphosphate (7.5%) and other agents with chemical cleaning properties (e.g. sodium hyaluuril sulphate) and disinfectants and are capable of neutralizing pH. The aligners were placed in the sonic instrument for 15 minutes, then rinsed and put back into the mouth. At the end of the collection of all 132 aligners, each was rinsed with water, dried and colored with gentian violet at 1%, a dye that is retained by bacterial species that can be identified and highlighted. The coloured aligners were cut into flat vestibular and palatal segments of one or two dental units. For each dental unit, six sites were measured with the photodensitometer to analyse the intensity of the accumulation of plaque. As regards the results are concerned, with regular toothpaste cleaning the maximum bacterial adhesion has been recorded, more pronounced at the level of the posterior region of the aligners (premolars/molars) in accordance with the accumulation of plaque on the teeth. Another area of great accumulation of bacteria has proven to be the front incisal part of the aligners, due to the shape of these which tend to create in that area a reservoir of collection of residues of various nature. The crystal cleaning system has proven to be three times more effective than chlorhexidine, demonstrating the advantages of vibrations given by the sonic instrument. In fact, it has been hypothesized that during a period of two weeks the plate can be transformed into calcified deposits, only removable from these vibrations. In summary, the study has shown that to increase the performance of treatment with thermoprinted aligners and improve the aesthetic requirements it is desirable to use the solutions "Cleaning-System" with the help of the sonic vibratory bath [8].

*1.2.1 Effects of orthodontic treatment on periodontal tissues*

In recent years, due to the increased number of adult patients undergoing orthodontic treatment, orthodontists are increasingly facing periodontal problems, which increase with the advancing age. The coordinated multidisciplinary treatment of orthodontist, periodontologist and dental hygienist is essential to optimize treatment results. The most common orthodontic problems found in a patient with periodontal impairment include the inclination of the anterior maxillary teeth, an irregular interdental spacing, rotation, migration, the loss of teeth or the presence of a traumatic occlusion. These conditions are the consequence of a diminished compromised tissue support, deriving in principle from an insufficient oral hygiene, leading to an accumulation of plaque and tartar, primary etiological factors of periodontal disease [10, 11, and 17]. A well designed and conducted orthodontic treatment can contribute to the overall rehabilitation (aesthetic and functional). On the contrary, orthodontic appliances that are not properly managed, from a biomechanical point of view and in relation to oral hygiene, can lead to a worsening of periodontal conditions [35]. For this reason, orthodontic treatment is sometimes considered improperly a predisposing factor for periodontal disease. The most significant problem is not the aggregation itself, but the change of subgingival plaque to a more aggressive flora, which favors the conversion of gingivitis into periodontitis [4, 7, 14, and 20]. All this appears to be related to the oral hygiene regime applied before and during orthodontic treatment, since, if this is thorough and well performed, there are no obvious increases in the rate of gingival bleeding or in the amount of plaque. Several clinical studies have shown that patients with reduced, but healthy, periodontal may receive orthodontic treatment without aggravation of their periodontal condition, if plaque control is adequate [16]. Other studies have shown that, when inflammation is not fully controlled, orthodontic treatment can trigger inflammatory processes and accelerate progression of periodontal disease, leading to further loss of attack [18, 19]. In particular, the combination of inflammation, uncontrolled orthodontic forces and occlusal trauma can produce a more rapid destruction than would be the case with inflammation alone [21]. In 1989 Boyd et al. described the case of ten adults with generalized periodontitis who had undergone a preorthodontic periodontal treatment including surgery, followed by a regular maintenance phase at intervals of three months over a two-year period of orthodontic treatment. Patients were compared with ten adult controls that showed normal periodontal tissue and 20 adolescent orthodontic patients. The results showed that adults were more efficient in plaque removal than adolescents, especially during the more advanced stage of orthodontic treatment, that dental movement in adults with reduced but healthy periodontitis did not cause a further significant loss of attack and that, in adults with unhealthy periodontal tissue, further destruction and loss of teeth due to abscesses may occur during orthodontic treatment [3]. Some studies also report an increase in depth of survey during orthodontic treatment, often attributable to modest gingival hyperplasia. Moreover, some

heterogeneous results regarding the effects of appliances on periodontal health are related to the different materials used and the different methods of treatment used [33, 34]. In accordance with recent systematic reviews, there is however no significant and irreversible periodontal destruction that can achieve the application of orthodontic appliances. More specifically, some long-term clinical and radiographic studies support the fact that periodontitis develops more in molars with orthodontic bands, as these predispose to gingival inflammation and a greater loss of connective attack than teeth with brackets. This is mainly due to the mechanical irritation caused by the band or cement residues that hinder the removal of the bacterial plaque [12, 33]. Orthodontic equipment should be designed to generate effective anchorage without causing tissue irritation, remaining aesthetically acceptable. The attacks are preferable to the bands as it is demonstrated that, teeth with brackets have a lower accumulation of plaque, a lower degree of gingivitis and a less loss of interprossimal attack than the bandaged teeth. After the application of the orthodontic appliances, patients receive further explanations and instructions on oral hygiene and dental cleaning is carried out at quarterly intervals during the treatment period, after regular follow-up examinations, at intervals of six or twelve months depending on the situation [1]. Checks should include recording depth of sampling, dental mobility, bleeding at the spot, suppuration, gum recessions and bone levels. Only by taking into consideration also the periodontal situation of the patient undergoing orthodontic therapy, results can be obtained that do not harm others: each periodontal reference epidemiological index should be monitored and supportive therapy should be adjusted whenever the previously observed conditions change. A patient with altered periodontal status needs strict controls that aim at restoring biological conditions and are minimally invasive, such as the use of ultrasonic inserts that are best suited to the shape of the element taken into consideration or diamond inserts, if forks are also involved; the aggressiveness of a manual instrumentation, would lead to a satisfactory result for the re-entry of bleeding and periodontal pockets, but also to a greater loss of tissue, that is an increase of the gum recessions and probable loss of adherent gums. Without counting the aesthetic impact. Moreover, in an environment that is increasingly being defined by the mini-invasiveness of any therapy that aims at restoring the aesthetic, also antimicrobial agents should be reviewed. Similar results to those obtainable with the irrigation of the pockets with chlorhexidine, are with the use of ozone, whether in liquid, gaseous or gel form for an immediate decontamination of the grooves and/or periodontal pockets, being a powerful natural disinfectant. Also, for the control of gingival inflammation and for a proper restoration of the oral microbiome, an alternative may be the use of lactobacilli-based probiotics, administering 2 of them daily, in such a way as to reduce the bacterial population, particularly streptococci**.**

*1.2.3 Periodontal considerations on orthodontic treatment with thermoprinted aligners*

Although fixed orthodontic appliances are more suitable for the control of tooth movements in the three planes of space, aligners, where clinical conditions permit, can be preferred thanks to their superior aesthetic characteristics [44]. Initially indicated in adult patients, aligners now find multiple applications at any age [46]. Several clinical studies have shown an improvement in periodontal health conditions during treatment with aligners: no cases of decalcification of the enamel have been detected and there is a lower risk of radicular resorption compared to fixed appliances [23]. In addition, research has shown a significant reduction in pain resulting from soft tissue lesions and temporomandibular joint disorders. The main advantages of treatment include better aesthetics, greater comfort, greater acceptance of treatment by the patient, greater ease in your oral hygiene. A limitation to the use of aligners is the need for high patient collaboration, the lack of which can frustrate all treatment planning. Another limit is represented by the inability to obtain all the orthodontic movements desired, which is why sometimes the treatment is integrated with orthodontic fixed type [30]. All branches of dentistry are affected by an increase in the aesthetic demand of the patient: a good dental aesthetic is considered fundamental for the psycho-physical well-being [9]. All this in orthodontics has led to three fundamental consequences: increased demand for orthodontic treatments aimed at improving the aesthetic of the smile, increasing the proportion of adult patients and the need for aesthetic appliances. To this end new methods have been developed, among which stand out the aligners proposed for the first time by align Technology (Santa Clara, California) in 1999 with the Invisalign system. Today the market offers many other proposals such as: Clear aligner, Clear correct, Perfect Clear, Originator, Orthoclase, Clear step, Star Aligners, All In, Simpli 5, Arc Angel, Alleo and more. The original technique was actually introduced in orthodontics in the 80's and involved the use of transparent thermoplastic sheets pressed with a special thermal printer to adapt them to plaster models. Initially used for restraining purposes, they were soon employed also for corrective purposes. To make corrections, a sequence of aligners built on a series of plaster models was necessary, each of which can generate limited displacements, arranged by set-up [27, 28]. The introduction of digital technologies, in particular scanners and 3D printers, has given an extraordinary boost to this field of orthodontics, to the point that today the number of patients treated or treated is estimated at around 6 million. The manual set-up has been replaced by computer simulations while the current materials (polyvinylsillossani or polyethers) are equipped with precision, elastic memory and optimal biocompatibility. Sequential aligners base their action on an elastic and intermittent orthodontic force as they are removed during meals and oral hygiene procedures [22]; they may also exploit occlusal forces and any auxiliary forces resulting from attachment, button and elastic application. In relation to the possible clinical uses of orthodontic aligners, there are disputes between orthodontists. Mc namara in 2000 gave as indications slight or moderate crowding (1-6 mm), slight or moderate excess space (1-6 mm), dental arches not contracted from a skeletal point of view and relapsed after fixed therapy [29]. In 2005 the manufacturers of the Invisalign system provided as indications the

closing of spaces, the post-stripping alignment, the dental expansion, the detachment and the closing of the extractive space of the anterior incisor. In 2007 Phan et al. published an article highlighting the contraindications to the use of aligners: defect or excess space > 2 mm - sagittal skeletal discrepancies > 2 mm - open bite front or rear - front covered bites - extrusions of dental elements - teeth with reduced clinical crown - arches with numerous missing elements - extractive cases, due to the difficulty of realizing bodily movements [30]. According to Boyd, author of many publications on the subject, the indications to use have increased due to the evolution of the method. With the introduction of new types of attachments and the possibility of using intermaxillary elastics, the Author extends the indications also to sagittal correction, root control, cuspid's derotation [26,31] and extractive cases. Lanteri V. et alii (44), compared a sample of 100 patients treated with aligners invisalign, with a group of 100 patients treated with fixed devices and confirmed the full effectiveness of the method in the treatment of the lower incisors crowding.

## 2. Aim of the study

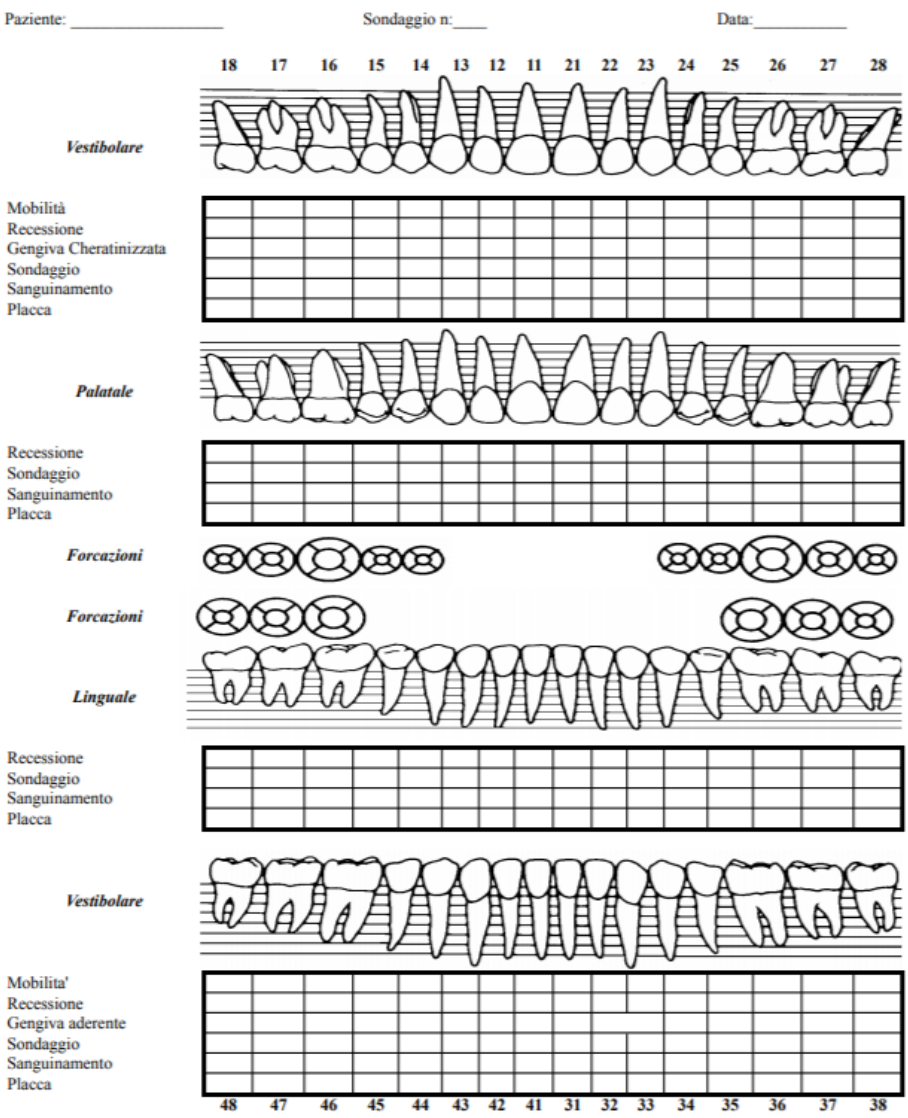
The purpose of this study is to evaluate orthodontic treatment with traditional fixed appliances and aligners in relation to oral hygiene and periodontal health. More specifically, the two methods being used simultaneously in all patients (top arch with aligners and lower arch with fixed appliance), the aim is to accurately compare the two treatment systems at cross-sectional level between all the patients involved in the research and at individual level in each patient considered individual

## 3. Material and methods

In this study we selected N=4 patients, all treated by the same operator, N=3 female and N=1 male with an average age of 26 years, but all older than 18 years. We have adopted exclusion factors from research, in relation to the predisposing causes to periodontal disease and to the accumulation of plaque and calculus on dental surfaces, to avoid creating "false positive" or "false negative" and thus standardize the chosen group. In particular, on the basis of the risk factors most supported by scientific evidence, the exclusion criteria were as follows:

- smoking patients: smoking is one of the main risk factors for periodontitis; smokers show a marked increase in the likelihood of developing periodontal disease and respond worse to periodontal therapies than non-smokers; lastly, in smokers periodontal disease progresses more rapidly;
- patients with diabetes mellitus (both type 1 and type 2): epidemiological data show that diabetes can contribute to the development of altered periodontal conditions;
- obese patients: obesity promotes inflammatory frameworks, alters lipid metabolism and induces insulin resistance, all of which can increase periodontal support failure.
- patients with HIV, which is closely related to periodontitis due to progressive loss of immune function;
- patients with hormonal changes such as pregnancy or menopause, due to significant changes in the gum causing and, more generally, periodontal changes. Gingiva is a target tissue for the action of steroid hormones: in particular estrogens affect collagen metabolism and angiogenesis and interact with inflammation mediators;
- patients with family histories of periodontitis, in order to exclude the genetic component;
- patients undergoing drug therapy with contraceptives, antidepressants, antihypertensives and other medicines that may cause increased gum volume.

All subjects involved in the study had a mild/moderate overcrowding and therapy of up to one year. We proposed the system with transparent aligners to all those patients who, where indications allowed, have exposed particular aesthetic needs for relational reasons. The originality of our sample consists in the fact that it includes only patients treated simultaneously in the upper arch with aligners and in the lower arch with fixed appliances. Following the first visit, an ortho-pantomography (OPT) was performed and fingerprints were collected for the case study. At the time of delivery of the first aligner, at the same time as the installation of the fixed appliance (TO), all patients were subjected to a periodontal survey, an assessment of the health conditions of the tissues, to an accurate professional hygiene and have been trained to a house hygiene according to precise protocols (see Tab. 1). A multi bracket system using the "straight-wire" technique was used in the inferior arch. Periodontal monitoring was carried out according to the following timing: one month after the start of treatment (T1), five months after the start of treatment (T2) and at the end of treatment (9-12 months) (T3). We have followed as protocol the periodontal folder provided by the Italian Society of Periodontalogy (SIDP) below (Tab. 2) taking into account that periodontal patients with mobility or severe recessions were excluded from research.




Tab 2. Periodontal folder proposed by Italian Society of Periodontology (SIDP)

## 4. Results

Patient 1 – N.C 25aa

PATIENT N°1 Vestibular upper arch

| | TEMPO/DENTI | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Periodontal probing | $T_0$ | 2,1 | 2,1 | 2,2 | 2,2 | 2,4 | 2,3 | 2,1 | 2,1 | 2,2 | 2,4 | 2,2 | 2,2 | 2,2 | 2,1 |
| | $T_1$ | 2,1 | 2,1 | 2,2 | 2,2 | 2,4 | 2,3 | 2,1 | 2,1 | 2,2 | 2,4 | 2,2 | 2,2 | 2,2 | 2,1 |
| | $T_2$ | 2,1 | 2,1 | 2,2 | 2,2 | 2,4 | 2,3 | 2,1 | 2,1 | 2,2 | 2,4 | 2,2 | 2,2 | 2,2 | 2,1 |
| | $T_3$ | 2,3 | 2,3 | 2,4 | 2,3 | 2,5 | 2,4 | 2,2 | 2,2 | 2,3 | 2,5 | 2,3 | 2,2 | 2,2 | 2,1 |
| | TEMPO/DENTI | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Bleeding | $T_0$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_1$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $T_2$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $T_3$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | TEMPO/DENTI | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Plaque | $T_0$ | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| | $T_1$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $T_2$ | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| | $T_3$ | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |

Tab 3. Numerical representation of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (vestibular upper arch patient n°1)

PATIENT N°1 Palatal upper arch

| | TIME/TEETH | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Periodontal probing | $T_0$ | 2,4 | 2,4 | 2,2 | 2,2 | 2,4 | 2,3 | 2,1 | 2,1 | 2,2 | 2,4 | 2,2 | 2,2 | 2,5 | 2,5 |
| | $T_1$ | 2,4 | 2,4 | 2,2 | 2,2 | 2,4 | 2,3 | 2,1 | 2,1 | 2,2 | 2,4 | 2,2 | 2,2 | 2,5 | 2,5 |
| | $T_2$ | 2,6 | 2,6 | 2,2 | 2,2 | 2,4 | 2,3 | 2,1 | 2,1 | 2,2 | 2,4 | 2,2 | 2,2 | 2,7 | 2,7 |
| | $T_3$ | 2,8 | 2,8 | 2,4 | 2,3 | 2,5 | 2,4 | 2,2 | 2,2 | 2,3 | 2,5 | 2,3 | 2,2 | 2,8 | 2,9 |
| | TIME/TEETH | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Bleeding | $T_0$ | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| | $T_1$ | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| | $T_2$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $T_3$ | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| | TIME/TEETH | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Plaque | $T_0$ | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| | $T_1$ | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| | $T_2$ | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| | $T_3$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

Tab 4. Numerical representation of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (palatal upper arch patent n°1)

PATIENT N°1 Vestibular lower arch

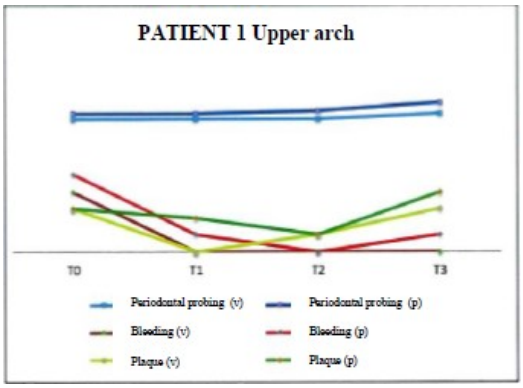
| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Periodontal probing | $T_0$ | 1,9 | 1,9 | 1,8 | 1,8 | 2 | 1,7 | 1,7 | 1,7 | 1,7 | 2 | 1,9 | 1,9 | 1,9 | 1,9 |
| | $T_1$ | 1,9 | 1,9 | 1,8 | 1,8 | 2 | 1,7 | 1,7 | 1,7 | 1,7 | 2 | 1,9 | 1,9 | 1,9 | 1,9 |
| | $T_2$ | 2,1 | 2,1 | 2 | 2 | 2,2 | 1,9 | 1,9 | 1,9 | 1,9 | 2,2 | 2,1 | 2,1 | 2,1 | 2,1 |
| | $T_3$ | 2,3 | 2,3 | 2,2 | 2,2 | 2,4 | 2,1 | 2,1 | 2,1 | 2,1 | 2,4 | 2,3 | 2,3 | 2,3 | 2,3 |
| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| Bleeding | $T_0$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_1$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_2$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $T_3$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| Plaque | $T_0$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_1$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_2$ | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | $T_3$ | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

Tab 5. Numerical representation of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (vestibular lower arch patient n°1)

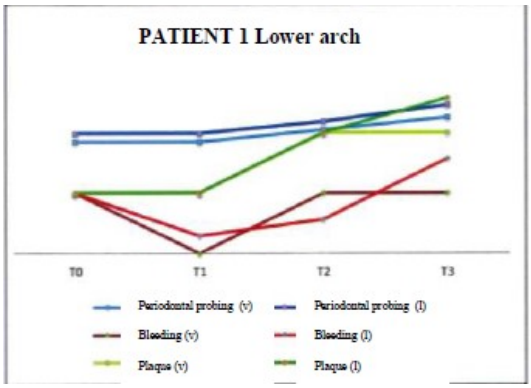
PATIENT N°1 Lingual lower arch

| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Periodontal probing | $T_0$ | 2,1 | 2,1 | 2 | 2 | 2,1 | 1,8 | 1,8 | 1,8 | 1,8 | 2,1 | 2 | 2 | 2,1 | 2,1 |
| | $T_1$ | 2,1 | 2,1 | 2 | 2 | 2,1 | 1,8 | 1,8 | 1,8 | 1,8 | 2,1 | 2 | 2 | 2,1 | 2,1 |
| | $T_2$ | 2,3 | 2,3 | 2,2 | 2,2 | 2,3 | 2 | 2 | 2 | 2 | 2,3 | 2,2 | 2,2 | 2,3 | 2,3 |
| | $T_3$ | 2,7 | 2,7 | 2,4 | 2,4 | 2,5 | 2,2 | 2,2 | 2,2 | 2,2 | 2,5 | 2,4 | 2,4 | 2,7 | 2,7 |
| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| Bleeding | $T_0$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_1$ | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| | $T_2$ | 1 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| | $T_3$ | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| Plaque | $T_0$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_1$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_2$ | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | $T_3$ | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |

Tab 6. Numerical representation of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (lingual lower arch pz n°1)




Graphic 1. Representation of course of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (upper arch patient n°1)




Graphic 2. Representation of course of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (lower arch patient n°1)

Patient 2 - V.M 37 aa

PATIENT N°2 Vestibular upper arch

| | TIME/TEETH | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Periodontal probing | $T_0$ | 1,4 | 1,4 | 1,4 | 1,4 | 1,7 | 1,2 | 1,2 | 1,2 | 1,2 | 1,7 | 1,4 | 1,4 | 1,4 | 1,4 |
| | $T_1$ | 1,2 | 1,2 | 1,4 | 1,4 | 1,7 | 1,2 | 1,2 | 1,2 | 1,2 | 1,7 | 1,4 | 1,4 | 1,2 | 1,2 |
| | $T_2$ | 1,2 | 1,2 | 1,4 | 1,4 | 1,6 | 1,3 | 1,3 | 1,3 | 1,3 | 1,6 | 1,4 | 1,4 | 1,2 | 1,2 |
| | $T_3$ | 1,5 | 1,5 | 1,5 | 1,5 | 1,8 | 1,3 | 1,3 | 1,3 | 1,3 | 1,8 | 1,5 | 1,5 | 1,5 | 1,5 |
| | TIME/TEETH | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Bleeding | $T_0$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_1$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $T_2$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $T_3$ | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| | TIME/TEETH | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Plaque | $T_0$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_1$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $T_2$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $T_3$ | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |

Tab 7. Numerical representation of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (vestibular upper arch patient n°2)

PATIENT N°2 Palatal upper arch

| | TIME/TEETH | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Periodontal probing | $T_0$ | 1,6 | 1,6 | 1,4 | 1,4 | 1,7 | 1,6 | 1,6 | 1,6 | 1,6 | 1,7 | 1,4 | 1,4 | 1,6 | 1,6 |
| | $T_1$ | 1,6 | 1,6 | 1,4 | 1,4 | 1,7 | 1,2 | 1,2 | 1,2 | 1,2 | 1,7 | 1,4 | 1,4 | 1,6 | 1,6 |
| | $T_2$ | 1,4 | 1,4 | 1,4 | 1,4 | 1,7 | 1,2 | 1,2 | 1,2 | 1,2 | 1,7 | 1,4 | 1,4 | 1,4 | 1,4 |
| | $T_3$ | 1,5 | 1,5 | 1,5 | 1,5 | 1,8 | 1,3 | 1,3 | 1,3 | 1,3 | 1,8 | 1,5 | 1,5 | 1,5 | 1,5 |
| | TIME/TEETH | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Bleeding | $T_0$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_1$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $T_2$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $T_3$ | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| | TIME/TEETH | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Plaque | $T_0$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_1$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $T_2$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $T_3$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

Tab 8. Numerical representation of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (palatal upper arch patient n°2)

PATIENT N°2 Vestibular lower arch

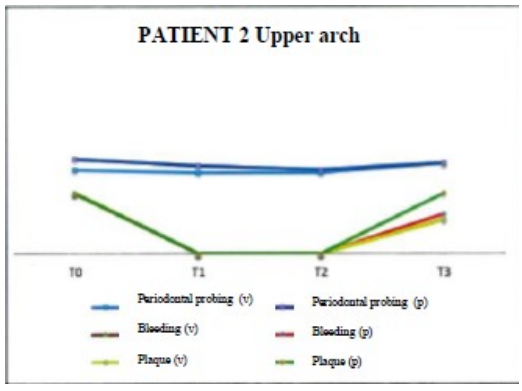
| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Periodontal probing | $T_0$ | 1,9 | 1,9 | 1,9 | 1,9 | 2,1 | 2 | 2 | 2 | 2 | 2,1 | 1,9 | 1,9 | 1,9 | 1,9 |
| | $T_1$ | 1,9 | 1,9 | 1,9 | 1,9 | 2,1 | 2 | 2 | 2 | 2 | 2,1 | 1,9 | 1,9 | 1,9 | 1,9 |
| | $T_2$ | 2,1 | 2,1 | 2,1 | 2,1 | 2,3 | 2,2 | 2,2 | 2,2 | 2,2 | 2,4 | 2,1 | 2,1 | 2,1 | 2,1 |
| | $T_3$ | 2,9 | 2,9 | 2,9 | 2,9 | 3,1 | 3 | 3 | 3 | 3 | 3,2 | 2,9 | 2,9 | 2,9 | 2,9 |
| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| Bleeding | $T_0$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_1$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $T_2$ | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| | $T_3$ | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| Plaque | $T_0$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_1$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_2$ | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | $T_3$ | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 |

Tab 9. Numerical representation of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (vestibular lower arch patient n°2)

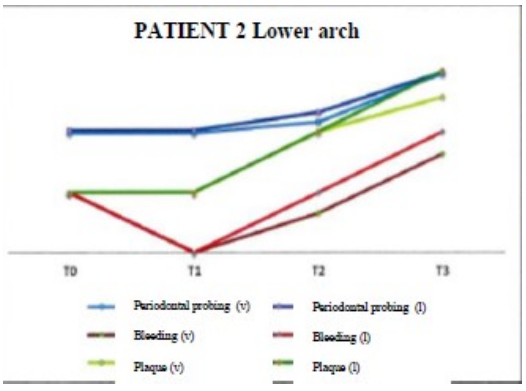
PAZIENTE N°2 Lingual lower arch

| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Periodontal probing | $T_0$ | 2,1 | 2,1 | 1,9 | 1,9 | 2,2 | 2 | 2 | 2 | 2 | 2,2 | 1,9 | 1,9 | 2,1 | 2,1 |
| | $T_1$ | 2,1 | 2,1 | 1,9 | 1,9 | 2,2 | 2 | 2 | 2 | 2 | 2,2 | 1,9 | 1,9 | 2,1 | 2,1 |
| | $T_2$ | 2,3 | 2,3 | 2,3 | 2,3 | 2,6 | 2,2 | 2,2 | 2,2 | 2,2 | 2,6 | 2,3 | 2,3 | 2,3 | 2,3 |
| | $T_3$ | 3,1 | 2,9 | 2,9 | 2,9 | 3,2 | 3 | 3 | 3 | 3 | 3,2 | 2,9 | 2,9 | 2,9 | 2,9 |
| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| Bleeding | $T_0$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_1$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $T_2$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_3$ | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| Plaque | $T_0$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_1$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_2$ | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | $T_3$ | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

Tab 10. Numerical representation of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (lingual upper arch patient n°2)




Graphic 3. Representation of course of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (upper arch patient n°2)




Graphic 4. Representation of course of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (lower arch patient n°2)

Patient 3- G.L 39aa

PATIENT N°3 Vestibular upper arch

| | TIME/TEETH | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Periodontal probing | $T_0$ | 3,1 | 3,1 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3,1 | 3,1 | 3,1 | 3,1 |
| | $T_1$ | 2,9 | 2,9 | 2,8 | 2,8 | 2,8 | 2 | 2 | 2 | 2 | 2,8 | 2,9 | 2,9 | 2,9 | 2,9 |
| | $T_2$ | 2,9 | 2,9 | 2,8 | 2,8 | 2,8 | 2,2 | 2,2 | 2,2 | 2,2 | 2,8 | 2,9 | 2,9 | 2,9 | 2,9 |
| | $T_3$ | 2,5 | 2,5 | 2,4 | 2,4 | 2,4 | 3 | 3 | 3 | 3 | 2,4 | 2,4 | 2,5 | 2,5 | 2,5 |
| | TIME/TEETH | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Bleeding | $T_0$ | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 |
| | $T_1$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_2$ | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| | $T_3$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | TIME/TEETH | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Plaque | $T_0$ | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | $T_1$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_2$ | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| | $T_3$ | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |

Tab 11. Numerical representation of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (vestibular upper arch patient n°3)

PATIENT N°3 Palatal upper arch

| | TIME/TEETH | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Periodontal probing | $T_0$ | 3,1 | 3,1 | 3 | 3 | 3 | 2,9 | 2,9 | 2,9 | 2,9 | 3 | 3,1 | 3,1 | 3,1 | 3,1 |
| | $T_1$ | 3,1 | 3,1 | 3 | 3 | 3 | 2,9 | 2,9 | 2,9 | 2,9 | 3 | 3,1 | 3,1 | 2,9 | 2,9 |
| | $T_2$ | 2,9 | 2,9 | 2,8 | 2,8 | 2,8 | 2,7 | 2,7 | 2,7 | 2,7 | 2,8 | 2,9 | 2,9 | 2,9 | 2,9 |
| | $T_3$ | 2,6 | 2,6 | 2,6 | 2,5 | 2,5 | 2,4 | 2,4 | 2,4 | 2,4 | 2,5 | 2,6 | 2,6 | 2,6 | 2,6 |
| | TIME/TEETH | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Bleeding | $T_0$ | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 |
| | $T_1$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_2$ | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $T_3$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | TIME/TEETH | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Plaque | $T_0$ | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 |
| | $T_1$ | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 |
| | $T_2$ | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| | $T_3$ | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |

Tab 12. Numerical representation of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (palatal upper arch patient n°3)

PATIENT N°3 Vestibular lower arch

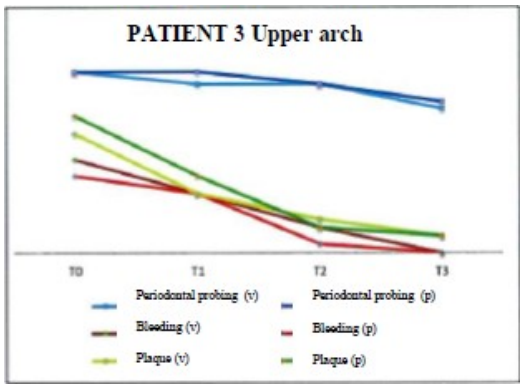
| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Periodontal probing | $T_0$ | 3,1 | 3,1 | 3 | 3 | 3 | 2,9 | 2,9 | 2,9 | 2,9 | 3 | 3,1 | 3,1 | 3,1 | 3,1 |
| | $T_1$ | 3,1 | 3,1 | 3 | 3 | 3 | 2,9 | 2,9 | 2,9 | 2,9 | 3 | 3,1 | 3,1 | 3,1 | 3,1 |
| | $T_2$ | 3,2 | 3,2 | 3,1 | 3,1 | 3,1 | 3 | 3 | 3 | 3 | 3,1 | 3,2 | 3,2 | 3,2 | 3,2 |
| | $T_3$ | 3,2 | 3,2 | 3,1 | 3,1 | 3,1 | 3 | 3 | 3 | 3 | 3,1 | 3,2 | 3,2 | 3,2 | 3,2 |
| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| Bleeding | $T_0$ | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 |
| | $T_1$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_2$ | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 |
| | $T_3$ | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 |
| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| Plaque | $T_0$ | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| | $T_1$ | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| | $T_2$ | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| | $T_3$ | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 |

Tab 13. Numerical representation of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (vestibular lower arch patient n°3)

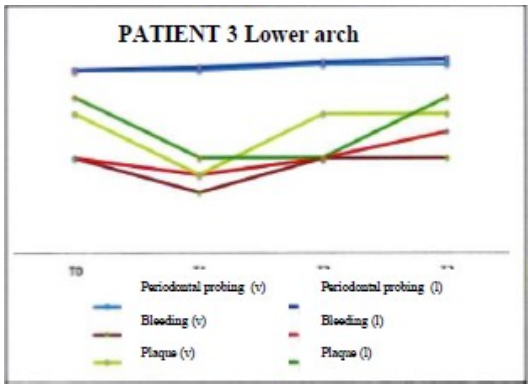
PATIENT N°3 Lingual lower arch

| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Periodontal probing | $T_0$ | 3,1 | 3,1 | 3 | 3 | 3 | 2,9 | 2,9 | 2,9 | 2,9 | 3 | 3,1 | 3,1 | 3,1 | 3,1 |
| | $T_1$ | 3,1 | 3,1 | 3 | 3 | 3 | 3,1 | 3,1 | 3,1 | 3,1 | 3 | 3,1 | 3,1 | 3,1 | 3,1 |
| | $T_2$ | 3,2 | 3,2 | 3,1 | 3,1 | 3,1 | 3,2 | 3,2 | 3,2 | 3,2 | 3,1 | 3,1 | 3,1 | 3,2 | 3,2 |
| | $T_3$ | 3,3 | 3,3 | 3,1 | 3,1 | 3,1 | 3,3 | 3,3 | 3,3 | 3,3 | 3,1 | 3,1 | 3,1 | 3,3 | 3,3 |
| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| Bleeding | $T_0$ | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 |
| | $T_1$ | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 |
| | $T_2$ | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 |
| | $T_3$ | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| Plaque | $T_0$ | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| | $T_1$ | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| | $T_2$ | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| | $T_3$ | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |

Tab 14. Numerical representation of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (lingual lower arch patient n°3)




Graphic 5. Representation of course of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (upper arch patient n°3)




Graphic 6. Representation of course of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (lower arch patient n°2)

Patient 4- M.M 46aa

PATIENT N°4 Vestibular upper arch

| | TIME/TEETH | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Periodontal probing | $T_0$ | 2,2 | 2,2 | 2,2 | 2,2 | 2,4 | 2,3 | 2,3 | 2,3 | 2,3 | 2,4 | 2,2 | 2,2 | 2,2 | 2,2 |
| | $T_1$ | 2,2 | 2,2 | 2,2 | 2,2 | 2,4 | 2,3 | 2,3 | 2,3 | 2,3 | 2,4 | 2,2 | 2,2 | 2,2 | 2,2 |
| | $T_2$ | 2,3 | 2,3 | 2,3 | 2,3 | 2,5 | 2,6 | 2,6 | 2,6 | 2,6 | 2,5 | 2,3 | 2,3 | 2,3 | 2,3 |
| | $T_3$ | 2 | 2 | 2 | 2 | 2,2 | 2,2 | 2,2 | 2,2 | 2,2 | 2,2 | 2 | 2 | 2 | 2 |
| | TIME/TEETH | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Bleeding | $T_0$ | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| | $T_1$ | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| | $T_2$ | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| | $T_3$ | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| | TIME/TEETH | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Plaque | $T_0$ | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 |
| | $T_1$ | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| | $T_2$ | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| | $T_3$ | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 |

Tab 15. Numerical representation of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (vestibular upper arch patient n°4)

PATIENT N°4 Palatal upper arch

| | TIME/TEETH | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Periodontal probing | $T_0$ | 2,4 | 2,4 | 2,2 | 2,2 | 2,3 | 2,3 | 2,3 | 2,3 | 2,3 | 2,4 | 2,4 | 2,4 | 2,4 | 2,4 |
| | $T_1$ | 2,4 | 2,4 | 2,2 | 2,2 | 2,3 | 2,3 | 2,3 | 2,3 | 2,3 | 2,4 | 2,4 | 2,4 | 2,4 | 2,4 |
| | $T_2$ | 2,3 | 2,3 | 2,1 | 2,1 | 2,1 | 2,5 | 2,5 | 2,5 | 2,5 | 2,5 | 2,1 | 2,1 | 2,3 | 2,3 |
| | $T_3$ | 2 | 2 | 2 | 2 | 2 | 2,3 | 2,3 | 2,3 | 2,3 | 2,3 | 2 | 2 | 2 | 2 |
| | TIME/TEETH | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Bleeding | $T_0$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_1$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_2$ | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| | $T_3$ | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| | TIME/TEETH | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Plaque | $T_0$ | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | $T_1$ | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 |
| | $T_2$ | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| | $T_3$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

Tab 16. Numerical representation of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (palatal upper arch patient n°4)

PATIENT N°4 Vestibular lower arch

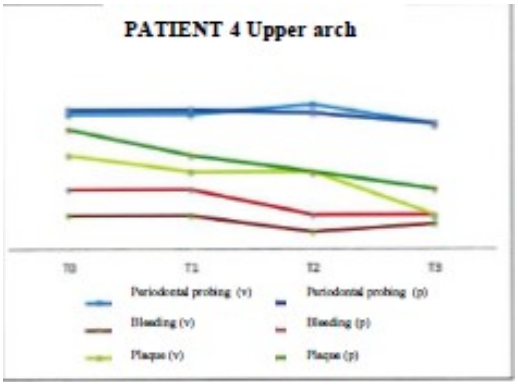
| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Periodontal probing | $T_0$ | 2,2 | 2,2 | 2,2 | 2,2 | 2,4 | 2,3 | 2,3 | 2,3 | 2,3 | 2,4 | 2,2 | 2,2 | 2,2 | 2,2 |
| | $T_1$ | 2,3 | 2,3 | 2,3 | 2,3 | 2,5 | 2,4 | 2,4 | 2,4 | 2,4 | 2,5 | 2,3 | 2,3 | 2,3 | 2,3 |
| | $T_2$ | 2,5 | 2,5 | 2,5 | 2,5 | 2,7 | 2,6 | 2,6 | 2,6 | 2,6 | 2,7 | 2,5 | 2,5 | 2,5 | 2,5 |
| | $T_3$ | 3 | 3 | 3 | 3 | 3,2 | 3,1 | 3,1 | 3,1 | 3,1 | 3,2 | 3 | 3 | 3 | 3 |
| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| Bleeding | $T_0$ | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| | $T_1$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_2$ | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 |
| | $T_3$ | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| Plaque | $T_0$ | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 |
| | $T_1$ | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 |
| | $T_2$ | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| | $T_3$ | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |

Tab 17. Numerical representation of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (vestibular lower arch patient n°4)

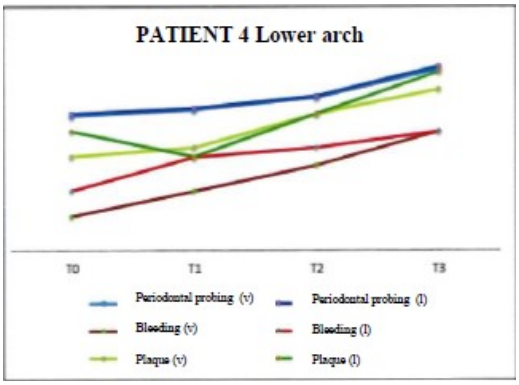
PATIENT N°4 Lingual lower arch

| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Periodontal probing | $T_0$ | 2,4 | 2,4 | 2,2 | 2,2 | 2,3 | 2,3 | 2,3 | 2,3 | 2,3 | 2,3 | 2,2 | 2,2 | 2,4 | 2,4 |
| | $T_1$ | 2,5 | 2,5 | 2,3 | 2,3 | 2,4 | 2,4 | 2,4 | 2,4 | 2,4 | 2,4 | 2,3 | 2,3 | 2,5 | 2,5 |
| | $T_2$ | 2,7 | 2,7 | 2,5 | 2,5 | 2,6 | 2,6 | 2,6 | 2,6 | 2,6 | 2,6 | 2,5 | 2,5 | 2,7 | 2,7 |
| | $T_3$ | 3,2 | 3,2 | 3 | 3 | 3,1 | 3,1 | 3,1 | 3,1 | 3,1 | 3 | 3 | 3 | 3,2 | 3,2 |
| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| Bleeding | $T_0$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | $T_1$ | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| | $T_2$ | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 |
| | $T_3$ | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | TIME/TEETH | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| Plaque | $T_0$ | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | $T_1$ | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 |
| | $T_2$ | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| | $T_3$ | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

Tab 18. Numerical representation of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (lingual lower arch patient n°4)

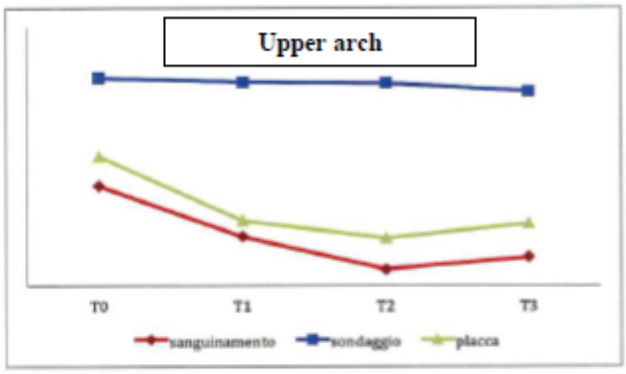



Graphic 7. Representation of course of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (upper arch patient n°4)

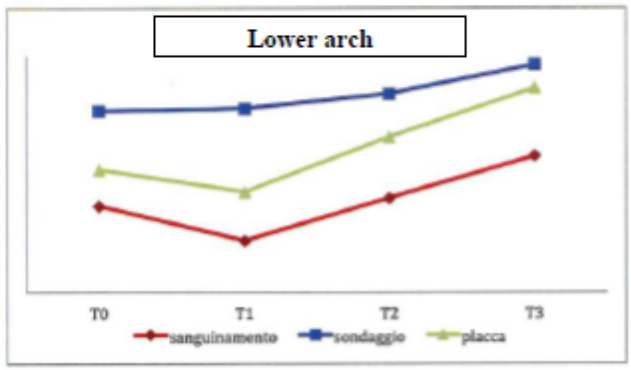



Graphic 8. Representation of course of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 (upper arch patient n°4)

**Cros-sectional results among the four patients obtained from the algebraic mean of the evaluation of all patients in the four different times**




Graphic 9. Representation of the average trend of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 in upper arch treated with Invisaling




Graphic 10. Representation of the average trend of periodontal probing, plaque index and bleeding index in T0, T1, T2, T3 in upper arch treated with fixed orthodontic appliances

## 5. Discussion

Over the years it has been shown that fixed orthodontic appliances can encourage the accumulation of plaque and worsen periodontal conditions in relation to periodontal indices. Some studies suggest that periodontal health improves with the removal of orthodontic appliances, while after their positioning the subgingival bacterial flora changes from aerobie Gram-positive species to other Gram-positive anaerobics negative, typical of periodontitis, as Intermediate Prevotella. Conflicting the periodontal status of subjects treated with fixed and removable appliances have been reported mixed results: some authors find significant differences in the loss of depth of survey, while others do not come to important considerations. Between February 2002 and August 2003 a study was conducted in Germany where periodontal health conditions were assessed in patients treated with fixed orthodontic appliances or with the invisalign system. With regard to materials and methods, thirty patients treated with fixed orthodontics and thirty with aligners were examined, all under the Department of Orthodontics and Dental-Facial Orthopaedics of the Berlin Charity University, which were monitored periodontally by three evaluations during treatment. The parameters evaluated were the gingival index, the index of plaque, the index of papillary bleeding and the loss of depth of survey. The first three indices were recorded alternately at vestibular and lingual/palatal level in all permanent teeth from the central incisor to the first molar: vestibular in the right maxillary quadrant and left mandibular quadrant, palatally in the left maxillary quadrant and lingually in the right mandibular quadrant. The loss of the depth of the survey was assessed in four areas: mesially, distally, lingually and vestibly in the first molar and premolar of each quadrant. Each control visit concluded with individual and detailed oral hygiene instructions. All patients were between 18 and 51 years of

age and were treated for at least six months in both dental arches. Any evidence of gingival inflammation was assessed by reference to Lòe's Gingival Index (GI) & Silness and Saxer & Miihlemann's Papillary Bleeding Index (PBI), while the accumulation of plaque was assessed on the basis of Lòe & Silness's Plate Index (PI). The GI was evaluated by reference to the color and texture of the tissue according to the severity of the existing inflammation of the marginal gum.The GI was evaluated by reference to the color and texture of the tissue according to the severity of the existing inflammation of the marginal gum. PBI was evaluated in five degrees by carefully guiding a probe while observing bleeding intensity. The PI was evaluated according to four degrees according to the accumulation of plaque in the gum area with the help of a probe. To allow a better comparison between the various index results, an average score was calculated for each patient, reflecting the average periodontal situation of each patient. At first check the gingival index, the index of papillary bleeding and loss of depth of survey were similar in the two study groups; The only index that showed a significant difference in the first control was the plate index between patients treated with invisalign and those treated with fixed appliances in favor of patients with the invisalign system. This result reflected the greater difficulty presenting brackets, bands, arches and all fixed equipment in the manoeuvres of oral hygiene and removal of the plate than aligners, which do not present any impediment by being removable. All the indices showed however some improvement from the first to the last visit, probably due to hygiene instructions received by patients at each check-up. As for the invisalign system, this did not show"periodontal performance" highly superior to traditional equipment, as opposed to what was expected. This is probably because the coverage, almost all day, of dental surfaces, can lead to the accumulation of various substances resulting in inflammation, especially in patients who consume snacks or drinks with high sugar content. Moreover the margins of the aligners, never perfectly smooth, can irritate the marginal gum. However, this was far outweighed by the possibility of carrying out physiological and more accurate oral hygiene than dentition, with less accumulation of plaque, a primitive etiological factor of periodontal disease [36]. In another recent study, the periodontal status of adult patients treated with fixed orthodontic appliances and aligners was assessed during one year of active therapy: 42 subjects from the Department of Orthodontics at the University of New York were compared, 22 with fixed orthodontics and 20 with removable aligners, all between 18 and 60 years old, non-smoking and without a history of periodontitis. The periodontal indices taken into account were: plate index (PI), gingival index (GI), poll bleeding (BOP) and loss of survey depth (PPD). In addition, the plaque samples were evaluated through the BANA test, a test using a complex chemical molecule (=benzoil-DL-argine-naphthylamide) is able to detect bacteria specific to subgengival plaque that produce toxic sulphur metabolites. Checks were performed prior to treatment, 6 weeks, 6 months and 12 months after initiation of therapy and measurements were made using descriptive statistics. The hypothesis was that of a worsening of the periodontal state associated with an increase in the scores of the BANA test. As for the BANA scores there were no differences between the two groups at the beginning of treatment and after 6 weeks, however after 6 months the patients treated with fixed equipment had a 5 probability,7 times higher than having higher scores. The presence of species such as treponema denticola, Porphyromonas gingivalis and Tannerella forsythia was detected in patients carrying fixed appliances, all anaerobic bacterial Gram-species involved in periodontitis. In summary, the results of the study suggest that the use of removable aligners facilitates oral hygiene with an improvement in the periodontal situation as documented by decreasing plaque levels, gingival inflammation of bleeding at the poll and BANA test scores. These results suggest that the planning of treatment with transparent aligners can be considered in adult patients at risk of periodontal disease [37].

## 6. **Conclusions**

Although not leading to statistically significant results due to the low number of patients considered in the pilot study, the peculiarity of our research allows for the first time the comparison between two different orthodontic methods, based on data collected in the same patient and therefore in identical basic biological conditions, opening up interesting perspectives for further research. According to the scientific literature, fixed orthodontic appliances predispose to a greater accumulation of plaque and a worsening of periodontal health conditions compared to aligners. This has been verified in all patients in our sample. The results also highlighted the importance of individual oral hygiene procedures during orthodontic therapy, which are essential for maintaining good tissue health. In fact, in patients who have followed the recommended hygiene protocols it has been noted that, in the upper arch, treated with aligners, there has been an improvement in all the parameters taken into consideration, while in the lower arch, treated with fixed appliances, only a slight worsening was observed. On the contrary, in patients who have not maintained good hygiene conditions, there has been a maintenance of the starting conditions at the level of the upper arch, but a noticeable worsening at the lower level, with plaque buildup and increased tissue inflammation. The periodontal survey is the value that has remained more stable throughout the duration of the study, except for one case that showed an increase in depth of survey, due to a hyperplasia of the gum in the inferior arch. Both examined orthodontic procedures are not found to be significantly harmful to periodontal tissues, in the presence of effective bacterial plaque control. The aligners have shown greater respect for periodontal tissues, also inducing an improvement in plaque accumulation levels and reducing gingival inflammation. We can therefore state that, from the periodontal point of view, aligners, when compared with fixed techniques, represent the best therapeutic solution in adult collaborating patients and with precise aesthetic needs.

**Bibliografy**


1. Lanteri C, Lanteri V, Segù M, Collesano V. Igiene orale in Ortodonzia: principi clinici e protocolli operativi. (ISBN 978–88-7572-055-1) Collana di Ortodonzia n°22 Ed. Martina Bologna, 2008 Novembre

2. Lodaya SD, Keluskar KM, Naik V. Evaluation of demineralization adjacent to orthodontic bracket and bond strength using fluoride-releasing and conventional bonding agents. Indian J Dent Res. 2011 Jan-Feb;22(1):44-9

3. Boyd RL, Baumrind S. Periodontal consideration in the use of bonds or bands on molars in adolescents and adults. Angle Orthod. 1992;62:117-126.

4. Diamanti-Kipioti A, Gusberti FA, Lang NP. Clinical and microbiological effects of fixed orthodontic appliances. J Clin Periodontol. 1987;14:326-333.

5. Shungin D, Olsson AI, Persson M. Orthodontic treatment related white spot lesions: a 14-year prospective quantitative follow-up, including bonding material assessment. Am J Orthod Dentofacial Orthop. 2010 Aug;138(2):136:1-8

6. Gracco A, Mazzoli A, Favoni O, et al. Short-term chemical and physical changes in Invisalign appliances. Aust Orthod J. 2009;25:34-40.

7. Naranjo AA, Trivino ML, Jaramillo A, Betancourth M, Botero JE. Changes in the subgingival microbiota and periodontal parameters before and 3 months after bracket placement. Am J Orthod Dentofacial Orthop. 2006 Sep;130(3):17- 22

8. Shpack N, Greenstein RB, Gazit D, Sarig R, Vardimon AD, Efficacy of three hygienic protocols in reducing biofilm adherence to removable thermoplastic appliance, Angle Orthod. 2013 June 20.

9. Proffit WR, Fields HM, Sarver DM. Contemporary orthodontics. 4th edn. St.Louis: CV Mosby, 2007.

10. Ngom PI, Diagne F, Benoist HM, Thiam F. Intraarch and interarch relationships of the anterior teeth and periodontal conditions. Angle Orthod. 2006;76:236—242.

11. Cochran DL. Inflammation and bone loss in periodontal disease. J Periodontol. 2008;79(8 Suppl):1569-1576.

12. Alexander SA. Effects of orthodontic attachments on the gingival health of permanent second molars. Am J Orthod Dentofacial Orthop. 1999;100:337-340.

13. Van Gastel J, Quirynen M, Teughels W, Coucke W, Carels C. Longitudinal changes in microbiology and clinical periodontal variables after placement of fixed orthodontic appliances. J Periodontol. 2008;79:2078-2086.

14. Paolantonio M, Festa F, Di Placido G, D'Attilo M, Catamo G, Piccolomini R. Site-specific subgingival colonization by Actinobacillus actinomycetemcomitans in orthodontic patients. Am J Orthod Dentofacial Orthop. 1999;15:423-428.

15. Thornberg MJ, Riolo CS, Bayirli B, Riolo ML, Van Tubergen EA, Kulbersh R. Periodontal pathogen levels in adolescents before, during, and after fixed orthodontic appliance ther- apy. Am J Orthod Dentofacial Orthop. 2009;135:95— 98.

16. Boyd RL, Leggott PI, Quinn RS, Eakle WS, Chambers D. Periodontal implications of orthodontic treatment in adults with reduced or normal periodontal tissues versus those of adolescents. Am J Orthod Dentofacial Orthop. 1989;96:191-198

17. Artun J, Urbye KS. The effect of orthodontic treatment on periodontal bone support in patients with advanced loss of marginal periodontium. Am J Orthod Dentofacial Orthop. 1988;93:143-148.

18. Wennstrom JL, Lindskog-Stokland B, Nyman S, Thilander B. Periodontal tissue response to orthodontic movement of teeth with infrabony pockets. Am J Orthod Dentofacial Orthop. 1993;103:313-319.

19. Lindhe J, Karring T, Lang NP, eds. Clinical periodontology and implant dentistry. Copenhagen, Den- mark: Munksgaard, 2003:519—560.

20. Sinclair PM, Berry CW, Bennett CL, Israelson H. Changes in gingiva and gingival flora with bonding and banding. Angle Orthod. 1987;57:271-278.

21. van Gastel J, Quirynen M, Teughels W, Carels C. The relationships between malocclusion, fixed orthodontic appliances and periodontal disease. A review of the literature. Aust Orthod J. 2007;23:121-129.

22. Boyd RL. Periodontal and restorative considerations with clear aligner treatment to establish a more favorable restorative environment. Compend Contin Educ Dent. 2009 Jun;30(5):280-2, 284, 286-8

23. Brezniak N, Wasserstein A. Root resorption following treatment with aligners. Angle Orthod. 2008;78(6):1119-1125.

24. Nedwed R, Miethke RR. Motivation, acceptance, and problems of Invisalign patients. J Orofac Orthop. 2005; 66(2):162-173.

25. Miller KB, McGorray SP, Womack R, et al. A comparison of treatment impacts between Invisalign aligner and fixed appliance therapy during the first week of treatment. Am J Orthod Dentofacial Orthop. 2007;131(3):302.

26. Boyd RL. Complex orthodontic treatment using a new protocol for the Invisalign appliance. J Clin Orthod. 2007;41(9):525-547.

27. Francioli D, Angori G, Ortodonzia Invisibile: l'utilizzo degli allineatori dentali nella pratica ortodontica. 2013, Marzo

28. Garino F, Principi di base ed applicazione clinica del sistema Invisalign. Mondo Ortodontico 2010 Feb; 55-74

29. Mc Namara JA, Brudon WL, Orthodontics and dentofacial ortophedics. Ann Arbor (Mich): Needam Press; 2001 58 30.

30. Phan X, Ling PH, J, Clinical limitations of Invisalign. Can Dent Assoc. 2007 Apr; 73(3):263-6

31. Schuster S, Eliades G, Zinelis S, Eliades T, Bradley TG. Structural conformation and leaching from in vitro aged and retrieved Invisalign appliances. Am J Orthod Dentofacial Orthop. 2004;126:725—728.

32. Sallum EJ, Nouer DF, Klein MI, Goncalves RB, Machion L, Sallum AW, Sallum ES. Clinical and microbiologic changes after removal of orthodontic appliances. Am J Orthod Dentofacial Orthop. 2004;126:363—366.

33. Tuncer AV, Baylas H. Examination of the effects of various orthodontic appliances on periodontal tissues [in Turkish]. Turk Ortodonti Derg. 1990;3:13- 18.

34. Artun J, Spadafora AT, Shapiro PA, McNeill RW, Chapko MK. Hygiene status associated with different types of bonded, orthodontic canine-to-canine retainers. A clinical trial. J Clin Periodontol. 1987;14:89-94.

35. Dubey R, Jalili VP, Garg S. Oral hygiene and gingival status in orthodontic patients. J Pierre Fauchard Acad. 1993;7: 43-54.

36. Miethke R, Vogt S. A comparison of the periodontal health of patients during treatment with the Invisalign system and with fixed orthodontic appliances. J Orofac Orthop. 2005;66: 219-229.

37. Karkhanechi M, Chow D, Sipkin J, Sherman D, Boylan R, Norman R, Craig R, Cisneros G. Periodontal status of adult patients trated with fixed buccal appliances and removable aligners over one year of active orthodontic therapy. Angle Orthodontist, Vol 83, No 1, 2013

38. Lanteri V., Segù M., Doldi J., Butera A. Pre-bonding prophylaxis and brackets detachment: an experimental comparison of different methods International Journal of Clinical Dentistry Vol 7 Issue 2 2014

39. Cossellu G., Lanteri V., Butera A., Sarcina M., Farronato G.P. Effects of six different preventive treatments on the shear bond strength of orthodontic brackets Acta Biomaterialia Odontologica Scandinavica 1-1 pag 13-17 2015

40. Cossellu G., Lanteri V., Butera A., Merlini A., Laffi N., Farronato GP. Timing considerations on the shear bond strength of orthodontic brackets after topical fluoride varnish applications Journal of Orthodontic Science Vol 6/1: 11-15, 2017

41. Lanteri C., Lanteri V., Gianolio A., Beretta M., Cherchi C., Franchi L., A new way for no compliance palatal expansion: the leaf expander Journal of Clinical Orthodontics volume 50: number 09: 552-560 2016

42. Beretta M., Lanteri C., Lanteri V., Cherchi C., Franchi L., Gianolio A., Evolution of the leaf expander: a maxillary self expander *Journal of Clinical Orthodontics* May 2019 Volume 53, Issue 5

43. Cossellu G, Lanteri V, Lioni R, Ugolini A, Cozza P, Farronato M Efficacity of ketoprofen lysine salt and paracetamol/acetaminophen to reduce pain during rapid maxillary expansion: a randomized controlled clinical trial *DOI: 10.1111/ipd.12428* International Journal of Paediatric Dentistry 2019 Jan;29(1):58-65

44. Lanteri V, Caravita R, Farronato GP, Lanteri C, Cossellu G, The efficacy of orthodontic treatments for anterior crowding with invisalign compared with fixed appliances using the peer assessment rating index Quintessence International 2018;49 (7) 581-587

*45.* Butera A., Matera C., Chiesa A., Scribante A., Cossellu G., Maciocco G.R., Lanteri V. The effect of six different preventive treatments on the shear bond strengths of orthodontic brackets: an in vitro study *International Journal of Clinical Dentistry 2019, Vol. 12 Issue 3, 209-217*

46. Favero R, Volpato A, Favero L. Managing early orthodontic treatment with clear aligners. *J Clin Orthod. 2018 Dec;52(12):701-709*