EGAS MONIZ SCHOOL of HEALTH & SCIENCE | INSTITUTO UNIVERSITÁRIO EGAS MONIZ

INSTITUTO UNIVERSITÁRIO EGAS MONIZ

MESTRADO INTEGRADO EM MEDICINA DENTÁRIA

PERCEPÇÃO, SATISFAÇÃO E QUALIDADE DE VIDA NOS PACIENTES TRATADOS COM ALINHADORES: REVISÃO NARRATIVA

Trabalho submetido por

Yosmely Altagracia Then Hiciano

para obtenção do grau de Mestre em Medicina Dentária

Outubro de 2023

EGAS MONIZ SCHOOL of HEALTH & SCIENCE | INSTITUTO UNIVERSITÁRIO EGAS MONIZ

INSTITUTO UNIVERSITÁRIO EGAS MONIZ

MESTRADO INTEGRADO EM MEDICINA DENTÁRIA

PERCEPÇÃO, SATISFAÇÃO E QUALIDADE DE VIDA NOS PACIENTES TRATADOS COM ALINHADORES: REVISÃO NARRATIVA

Trabalho submetido por

Yosmely Altagracia Then Hiciano

para obtenção do grau de Mestre em Medicina Dentária

Trabalho orientado por

Prof. Doutora Teresa Sobral Costa

Outubro de 2023

RESUMO

Os alinhadores transparentes têm se destacado como uma das opções terapêuticas de eleição nos últimos anos, no que respeita a tratamentos ortodônticos.

Hoje em dia, os pacientes tornaram-se mais exigentes, e as suas expectativas de usufruir de uma melhor experiência de tratamento potenciaram a evolução dos aparelhos ortodônticos no sentido de oferecer mais estética e mais conforto.

Nesta revisão narrativa, foram avaliadas a perspetiva, satisfação e a qualidade de vida geral de pacientes que fizeram o seu tratamento ortodôntico com alinhadores invisíveis. Os critérios da pesquisa efectuada foram de artigos e revistas de Janeiro de 2013 a Janeiro de 2023, em Inglês, Espanhol e Português. Os motores de busca utilizados foram Google Scholar, PubMed, Web of Science, Science Direct, SciELO, NCBI, Springer Nature, Sciendo, and APOS.

Os pacientes são atraídos pela ortodontia com alinhadores transparentes devido aos benefícios anunciados de maior conforto, flexibilidade e apelo estético em relação aos aparelhos tradicionais. No entanto, o sucesso da terapia com alinhadores depende fortemente da adesão do paciente, representando um obstáculo significativo para alcançar os resultados desejados do tratamento. A literatura sugere que a terapia com alinhadores transparentes apresenta maior aceitação, satisfação, conforto e estética quando comparada aos aparelhos ortodônticos fixos. A utilização de alinhadores invisíveis permite ao paciente integrar sem esforço o sistema no seu dia a dia sem influenciar a sua autoconfiança e relações sociais, reportando menos limitações funcionais e melhorando a sua qualidade de vida relacionada com a saúde oral. No entanto, mais pesquisas são necessárias para validar e expandir essas descobertas. Estudos de acompanhamento de longo prazo podem ajudar a avaliar a durabilidade e a estabilidade dos resultados da terapia com alinhadores, bem como explorar possíveis variações na percepção e satisfação do paciente com base na complexidade do tratamento e em fatores específicos do caso.

Palavras-chave: “Invisalign patient perspective”, “Clear aligner patient experience”, “Fixed braces”, “Clear aligners”.

ABSTRACT

Over the last few years clear aligners have stood out as one of the preferred therapeutic options when it comes to orthodontic treatment.

Nowadays patients have become more demanding, and their expectations of encountering a superior treatment experience has promoted the evolution of orthodontic appliances in a manner of enhancing aesthetics and comfort.

In this narrative review, the perspectives, satisfaction and general quality of life of patients undergoing orthodontic treatment with invisible aligner was evaluated. The search criteria used was from articles and journals from January 2013 to January 2023, in English, Spanish and Portuguese. The search engines used were Google Scholar, PubMed, Web of Science, Science Direct, SciELO, NCBI, Springer Nature, Sciendo, and APOS.

Patients are attracted to clear aligner orthodontics due to the advertised benefits of improved comfort, flexibility, and aesthetic appeal over traditional braces. However, the success of aligner therapy is heavily dependent on patient compliance, posing a significant obstacle to achieving desired treatment outcomes. Literature suggests clear aligner therapy displays greater acceptance, satisfaction, comfort and aesthetics when compared to fixed orthodontic appliances. The use of invisible aligners allows the patient to effortlessly integrate the system into their daily lives without influencing their self-confidence and social relationships, reporting less functional limitations and improving their Oral health-related quality of life (OHRQoL). Nevertheless, further research is warranted to validate and expand upon these findings. Long-term follow-up studies can help assess the durability and stability of aligner therapy outcomes, as well as explore potential variations in patient perception and satisfaction based on treatment complexity and specific case factors.

Keywords: “Invisalign patient perspective”, “Clear aligner patient experience”, “Fixed braces”, “Clear aligners”.

INDEX TABLE

Index of Figures

Index of Tables

ABBREVIATION LIST

ABO- The American Board of Orthodontics

ANOVA- Two-way analysis of variance

BPA- Bisphenol-A

CAD/CAM- Computer-aided design/computer-aided manufacturing

CAT- Clear Aligner Therapy

DTC-Direct-to-consumer

IASP- International Association for the Study of Pain

NASA- National Aeronautics and Space Administration

OHIP-G14 - The German short version of OHIP -14

OHIP-14- Oral Health Impact Profile-14 questionnaire

OHRQoL- Oral health-related quality of life

PIDAQ- Psychosocial Impact of Dental Aesthetic Questionnaire

QOL- Quality of Life

SE- Self esteem

STAI- The State-Trait Anxiety Inventory

TPA- Translucent polycrystalline alumina

VAS- Visual analog scale

WHO- World Health Organization

3D- Three Dimensional

1 INTRODUCTION

1.1 Contextualization and justification

The last two decades have witnessed a huge development in modern orthodontics. Fixed appliances have been the most traditional and effective method for orthodontic treatment throughout the years. However studies have reported some negative side effects involving this technique. Plaque accumulation, difficulty of oral hygiene, pain and self confidence are becoming a matter of concern that is directly influencing patient's satisfaction.

Growing demand for inconspicuous alternatives to metal brackets during fixed appliance therapy led to a significant increase in inquiry for the use of esthetic fixed ceramic braces, and furthermore lingual brackets to provide a truly invisible fixed orthodontic treatment experience.

A new system of thermoplastic clear aligner therapy, Invisalign®, was introduced to the field of orthodontics in 1997. Invisalign® aligners consist of a series of clear, removable, plastic appliances that the patient wears sequentially to achieve the final result. Just as with fixed appliance systems, Clear Aligner Therapy (CAT) holds an extensive range of performance, construction and applications in orthodontics.

Recent developments have led to major changes in patients' interest in orthodontic therapy. Modern orthodontics is striving to offer patients a comfortable and pleasant treatment journey. Align Technology™ advertises Invisalign® treatment as a superior patient experience over traditional fixed appliances by emphasizing superior comfort, aesthetics, hygiene, and overall lifestyle.

The standard way to assess a patient's perspective and satisfaction relies on surveys and questionnaires. The comprehension of patient perspectives can help clinicians get a better understanding of patient experience in order to anticipate future problems, which also serves as a guide for future patients. Understanding a patient' point of view is a key factor in improving treatment satisfaction. Patients' outlook is so important that high impact journals like the British Medical Journal have launched the

patient and public partnership strategy, designed to promote co-production of the journal content and amplify the global debate on patient and public involvement in healthcare.

For two decades, studies on aligners technology have focused mainly on the description of the system and the efficiency in terms of predictability of dental movements. However, few published studies have been interested in patient satisfaction.

Patient experience of aligner treatment and influencing factors are still poorly understood.

1.2 Objectives

The main objective of this narrative review is to evaluate the perception, and satisfaction of patients treated with clear orthodontic aligners and how the use of this modern removable appliance impacts their overall quality of life.

1.3 Methods

The search criteria used in this Narrative Revision is from articles, and Journals from January 2013 to January 2023 in English, Spanish and Portuguese. The search is performed in the following database, Google Scholar, PubMed, Web of Science, Science Direct, SciELO, NCBI, Springer Nature, Sciendo, and APOS. Keywords: “Invisalign patient perspective”, “Clear aligner patient experience”, “Fixed braces”, “Clear aligners”.

2 DEVELOPMENT

2.1 Dental Malocclusions

The term malocclusion was first attributed to Simeon Guilford; he described malocclusion as any irregularity in occlusion beyond the accepted range of normal (Basavaraj Subhashchandra Phulari, 2013).

Malocclusion can also be defined as an abnormal alignment of teeth or poor dental arch relationships, resulting in structural and functional changes (Martins et al., 2021). However, years later The World Health Organization (WHO) defines malocclusion as a handicapping dento-facial anomaly (Moimaz et al., 2021).

Malocclusion, is recognized by the (WHO) as a significant oral health problem, following caries and periodontal disease. Its prevalence varies widely ranging from 39% to 93% among children and adolescents (Cenzato et al., 2021). Malocclusions are caused by a range of factors including genetics, environment, tooth anomalies, oral habits, and missing teeth (Haralur et al., 2014).

Aspects related to malocclusion have strong influences on facial aesthetics. Poor dental occlusion is now considered not only an oral health problem, but is also linked to the perception of quality of life. Many reports have revealed that the perception of facial esthetics can influence psychological development from early childhood to adulthood (Perillo et al., 2014). Orthodontic therapy focuses on correcting malocclusions and craniofacial skeletal discrepancies, ultimately improving mastication and aesthetics (Rouzi et al., 2023).

Factors that influence the oral health related quality of life (OHRQoL) include caries, tooth loss, malocclusion, age and expectations. Minor imperfections can be of great concern for the individuals, potentially affecting self-esteem. The aesthetic and psychosocial impacts of malocclusions have been found to be a common reason for seeking orthodontic treatment (Närhi et al., 2022).

2.2 Orthodontics in Dentistry

The specialty of orthodontics focuses on identifying, intercepting and correcting occlusal and dentofacial anomalies, commonly referred to as malocclusion. Orthodontics is a branch of dentistry dedicated to the investigation and practice of moving teeth through the bone (Li et al., 2018). Orthodontics rose as a specialized field in the late nineteenth century, but humans had long strived to straighten their teeth prior to this development (Basavaraj Subhashchandra Phulari, 2013).

The American Board of Orthodontics (ABO) defines Orthodontics as "the specific area of the dental profession that has the responsibility, study and supervision of the growth and development of dentition and its related anatomical structures from birth to dental maturity, including all preventive and corrective procedures of dental irregularities requiring the repositioning of teeth by functional and mechanical means to establish normal occlusion and pleasing facial contours."

Poorly aligned teeth predispose a number of unfavorable sequelaes such as poor oral hygiene, periodontal disease and dental caries. The problems attributed to misaligned teeth consequently lead to poor esthetics, allowing a gap for psychosocial problems, increased risk of trauma, and function abnormalities (Basavaraj Subhashchandra Phulari, 2013).

Patients with physical anomalies, particularly those affecting their facial appearance, experience psychological and social consequences that often cause significant stress for both patients and their loved ones (Vaida et al., 2015).

2.3 Fixed Orthodontic appliance

Edward Angle introduced the first orthodontic bracket in the 20th century, leading to multiple advancements in materials and design over time, with stainless steel brackets becoming highly popular (Alrejaye et al., 2017). The success of fixed orthodontic appliances relies on the secure attachment of brackets and bands to teeth to

prevent loosening during treatment. Various adhesive systems are used to bond these components to the tooth posteriorly (Millett et al., 2016).

Over the last several years, there has been an increase in adults seeking orthodontic treatments. The modern beauty standards have raised public awareness and considerably influenced and increased treatment desire (Abbing et al., 2020).

Orthodontic treatment is now one of the most common dental treatments in children and adults thanks to their innovative technology and constant new techniques (Marincak et al., 2022).

Ceramic Orthodontic Appliance

Constant demands for aesthetics during fixed orthodontic appliance therapy led to ceramic braces. Ceradyne, a dental equipment and supply company in 1986 was contacted with the request of an aesthetic material to be used in orthodontics. Ceradyne went on to recommend translucent polycrystalline alumina (TPA) developed by National Aeronautics and Space Administration (NASA), shortly after in 1987, ceramic brackets were introduced. Nowadays the majority of ceramic brackets are produced from aluminum oxide particles, and these brackets are available in polycrystalline and monocrystalline forms. Ceramic braces' tensile strength is 1% compared to 20% with traditional metal braces. This suggests that ceramic braces are much more likely to fracture than metal braces under identical conditions and that the exposure of alumina to water or saliva minimizes fracture toughness (Elekdag-Türk & Ebulkbash, 2018). Moreover, one of the major disadvantages of alumina brackets is their low fracture toughness and brittleness leading to frequent fractures during archwire ligation, torsion, or tipping (Alrejaye et al., 2017).

The aesthetic properties of ceramic brackets make it an ideal option for many patients. Depending on the aesthetic requirements of the patient, one can choose between polycrystalline ceramic brackets that reflect light and result in some degree of opacity (Figure 1B) or monocrystalline brackets that allow the complete passage of light, making them practically transparent (Figure 1A). Nevertheless, it is important to

mention both monocrystalline and polycrystalline ceramic braces undergo change in color depending on the patient's diet (Elekdag-Türk & Ebulkbash, 2018).

Figure 1- (A) - *Intraoral image of monocrystalline ceramic brackets.*
(B) - *Intraoral image polycrystalline ceramic brackets.*

Source: (Elekdag-Türk & Ebulkbash, 2019)

Nowadays when we refer to zirconium there is limited access to published research on zirconia (zirconium oxide) brackets (Alrejaye et al., 2017).

Ceramic braces made from polycrystalline zirconium were once highly regarded but have become obsolete over time. Due to aesthetic problems concerning the yellow color it was characterized for and the opacity level it delivered, granting it poor translucency, kept the interest in this material in retrospect (Elekdag-Türk & Ebulkbash, 2018).

Lingual Orthodontic Appliance

The lingual orthodontic appliance has been the most sought after fixed appliance when searching for aesthetics without minimizing the biomechanical efficiency. The lingual technique is considered to be relatively complicated due to the preparation of appliances, setup, indirect bonding, and rebonding of loose brackets throughout the course of treatment. The lingual orthodontic appliance technique has been shown to necessitate a high level of manual dexterity and expertise, demonstrating the need for skilled practitioners (Kara-Boulad et al., 2022).

The lingual orthodontic appliance is considered the most aesthetic option for fixed orthodontic treatments in adults. Findings indicate that patients treated with labial and lingual appliances rate equally the pain experienced during treatment. However patients treated with lingual orthodontic appliances reported hygiene difficulty during treatment which resulted in gingival inflammation (Bacci, 2022).

Fixed orthodontic appliances, including lingual appliances, have been found to have a significant impact on speech difficulty. Additionally, tongue soreness induced by lingual orthodontic appliances is another important cause of speech distortion (Chen et al., 2017).

2.3.1 Oral Hygiene in Fixed Orthodontic appliance

Traditional orthodontic procedures were once seen as noninvasive, but maintaining oral hygiene during treatment is a major challenge. Microbiological studies show that placing fixed orthodontic appliances increases the number of bacteria, which can lead to disease development in the oral cavity (Saloom et al., 2013). According to Marincak et al, (2022), the placement of fixed orthodontic appliances compromise a patient's oral environment and the presence of additional surfaces prevents hygiene maneuvers that affect the balance of the oral microbiota.

The presence of fixed appliances in the oral cavity of orthodontic patients could alter the nature of dental plaque. The metabolism and composition of dental plaque changes, leading to the incrementation of the microbial population (Freitas et al., 2014). Plaque has demonstrated to be the most important factor in the progression of periodontal disease and dental caries. Orthodontic treatment involving brackets, belts, springs, coils, and belt wires can make oral hygiene challenging (Telatar & Telatar, 2021). A study conducted by Čalušić Šarac et al., (2021), concluded that the use of fixed orthodontic appliances did not interfere with the patients' maintenance of oral hygiene. However, despite this it was still advised that orthodontists should provide patients with detailed instructions on hygiene maintenance and adequate food consumption to minimize the negative side effects of the fixed orthodontic treatment. Telatar & Telatar (2021), on the other hand completely deferred since their study

concluded that plaque values and white spot lesions significantly increased during fixed orthodontic treatment and accordingly advised the importance of clinicians and patients to be aware of these risks in order to take precautions (Figure 2).

Figure- 2 *White spot lesions (orthodontic treatment side-effect)*

Source: How To Reduce White Spots During Orthodontic Treatment | Dental News | Trycare, UK. (n.d.).

2.3.2 Pain and oral impacts in fixed orthodontics

Orthodontic pain is defined as orofacial pain induced by orthodontic tooth movement. Pain is considered an inevitable orthodontic treatment side effect (Long et al., 2016).

Fixed orthodontic appliances may generate discomfort. The use of fixed orthodontic appliances have been linked to oral ulcers and pain, especially the first few months of treatment. Pain and functional limitations during the first initial stages of therapy may disappoint patients, affecting their motivation, cooperation, and even leading to treatment abandonment. However, long-term use of fixed orthodontic appliances leads to increased satisfaction (Gallegos-Delgado et al., 2018).

Findings by Olteanu et al. (2022), indicate that patients with fixed orthodontic appliances experience the most pain during the initial days of treatment, often needing to rely on analgesic medication.

2.3.3 Aesthetics in Fixed Orthodontics

The mouth and teeth are important features to consider in facial aesthetics and the face as a whole is the most important component that determines one's physical look (Saini et al., 2022). Currently, aesthetics is a main concern of patients undergoing orthodontic treatment (Pithon et al., 2019).

Nonverbal channels play a significant role in human communication, particularly through facial expressions. A smile conveys happiness, politeness, self-confidence and therefore stimulates positive social reactions. A smiling face is regarded as more attractive compared to a non-smiling one (Coppola et al., 2023). The beauty of a smile may be remarkably enhanced with fixed orthodontic treatment. However, this is ultimately perceived by patients during treatment finalization (Saini et al., 2022). Evidence concerning the effect of orthodontic treatment on facial attractiveness demonstrates that individuals who received ortodontic treatment are perceived as 9% more attractive compared to untreated patients (Coppola et al., 2023).

Orthodontists frequently encounter patients requesting ceramic, lingual, or thermoplastic braces as an alternative to metal braces in order to improve esthetics (Pithon et al., 2019).

2.3.4 Self-esteem, self confidence and anxiety with Fixed Orthodontic Appliance

The term self-esteem (SE) is used to describe a person’s overall feeling of self-worth or personal value. Studies have suggested a positive relationship between improvements in dental aesthetics and the resulting psychological profile (Johal et al., 2014).

Irregularities in tooth position have an important effect on the attractiveness and aesthetics of a smile. Dental asymmetries can disrupt social interaction, interpersonal relationships, and mental wellbeing leading to feelings of inferiority (Samsonyanová & Broukal, 2014). Furthermore, psychological evaluations of adult orthodontic patients suggest that patients with severe anterior crowding and protrusive lip profile have lower

self esteem and quality of life compared to those patients with minor crowding and/or protrusions (Jung, 2015).

Interceptive orthodontic treatment reduces low self-confidence and dissatisfaction with facial appearance caused by social stereotypes. Factors like dentist recommendation and peers wearing braces drive adolescents to seek orthodontic treatment (Samsonyanová & Broukal, 2014).

Orthodontic treatment can result in quality of life deteriorating in terms of pain, discomfort, functional limitation, and emotional well-being. However, completion of orthodontic treatment results in improvement of OHRQoL, particularly in regards to social and emotional well-being (Yassir et al., 2019); on the other hand Mandava et al. 2021, dissent concluding the relationship between OHRQoL and self esteem during fixed orthodontic treatment leaned towards negativity.

Furthermore, ensuring a smooth and painless removal process is essential for patients undergoing conventional bracket removal, as anxiety and discomfort may arise, emphasizing the need for efficiency (Curto et al., 2022).

2.3.5 Patient Perception, Satisfaction, and OHRQOL with Fixed Orthodontic Appliance

Around 16% of patients experience discomfort when using fixed orthodontic appliances and this draws out a negative impact on their overall quality of life. Patients tend to announce incrementing pain the first 4 to 24 hours after treatment adjustments. Fixed orthodontic users also report normality returns after a week, suggesting patients can adapt to pain and discomfort with advancement of their treatment (Marques et al., 2014).

The World Health Organization (WHO) in 1948 defined “Health as a state of complete physical, mental and social well-being and not only the absence of disease or infirmity”. However, when we describe the oral health related quality of life (OHRQoL) it is globally described as a measure that focuses on “the impact of oral diseases and

disorders on everyday life, that are of adequate magnitude, in terms of frequency, severity or duration to affect a person's experience and perceptions of their overall life" (Javidi et al., 2017). Patients' overall health related quality of life has always been measured by social, functional, or psychological factors (Mandava et al., 2021).

Fixed orthodontic appliances have proven to enhance occlusal function and dentofacial aesthetics resulting in improved psychological well-being (Mandava et al., 2021). Studies report orthodontic treatment during childhood leads to moderate improvements in the emotional and social well-being aspects of OHRQoL (Javidi et al., 2017). However, Pain, psychological discomfort, and physical limitations particularly during the initial stages of fixed orthodontic treatment were associated with patient dissatisfaction and jeopardized OHRQoL (Yassir et al., 2019).

The appeal of a person's face largely determines their level of attractiveness. Individuals deemed attractive are often seen as friendly, interesting, and socially competent, prompting patients to seek orthodontic treatment. To cater to patient expectations, orthodontists adhere to beauty guidelines. Research reveals that children exhibit a greater focus on individuals with attractive appearances, diverting less attention toward those considered less attractive (Samsonyanová & Broukal, 2014).

2.3.6 Advantages and Disadvantages in Fixed Orthodontic Appliances

Fixed orthodontic appliances are an ideal option to achieve more elaborate dental movements when compared to aligner therapy. Additionally reducing the active participation of patients diminish the possibilities of these affecting treatment results (Bacci, 2022).

The placement of labial or lingual fixed appliances may lead to indirect interactions between the lips, teeth, or tongue. These alterations create perception modification, tension and pain that can lead to speech distortion during the initial stages of treatment (Chen et al., 2017). Orthodontic treatment can result in quality of life deterioration, resulting in pain, discomfort, and low self-esteem during initial stages of treatment (Yassir et al., 2019). However, effects of orthodontic treatment on facial

attractiveness demonstrate that individuals who received orthodontic treatment are regarded as more attractive compared to untreated patients (Coppola et al., 2023).

2.4 Clear Aligner Therapy (CAT)

Clear aligner treatment (CAT) is an orthodontic technique to align teeth by means of removable, comfortable, and scarcely visible appliances (Mampieri et al., 2022). Clear aligners are transparent devices made of thermoplastic material that are worn over the teeth for a secure and discreet alignment correction (Shi et al., 2022). Clear aligners are made primarily of polyethylene terephthalate glycol and polyurethanes, all displaying common characteristics (Putrino et al., 2022).

The theory of using an aligner to straighten teeth was first suggested by Kesling in 1945. Keslings retainers, acquired through wax ups, allowed minor tooth movements while maintaining alignment of the remaining teeth in the arch (Ganta et al., 2021).

Over 50 years later, align technology introduced Invisalign® in 1999 (Hennessy & Al-Awadhi, 2016). Invisalign® aligners consist of a series of clear, removable, appliances that the patient wears sequentially, each worn for 2 weeks on an average, to accomplish the desired tooth movements (Kundal & Shokeen, 2020). Invisalign® became the first orthodontic appliance to use computer aided design (CAD) and computer-aided manu-facturing (CAM). Diverse aligner manufactures and systems, later on emerged employing similar principles (Table 1) (Hennessy & Al-Awadhi, 2016).

The first generation of clear thermoplastic aligners had no auxiliary elements. However, as aligner systems developed, the second generation began to incorporate the use of attachments to improve tooth movement. Additionally, the third generation had attachments placed automatically in the aligners by the manufacturer’s software (Hennessy & Al-Awadhi, 2016).

Table 1
Examples of clear aligner manufacturers

Name of appliance	Country of origin	3D technology used	Website	Attachments	How many aligners	Generation
Clear aligner™	UK	Laser	www.clearaligner.co.uk/	No	Unlimited	First
Clear path™	USA	Laser	www.clearpathdental.com	No	Unlimited	First
Clearstep™ now Smilelign	UK	Laser	www.smilelign.com/	Yes	Unlimited	Second
Simplifive™-Red, White and Blue Aligner	USA	Manual production	www.ormco.com	No	Seven aligners	First
MTM Clear-Aligner™	USA	Laser	www.mtmclearaligner.com/	No	Unlimited	First
Nimrodental Clear aligner™	UK	Laser	www.nimrodental.com/	No	Unlimited	First
Clear Image Aligners™	USA	Manual production	www.specialtyappliances.com	No	Unlimited	First
ClearAligner™	USA	Manual production	www.clear-aligner.com	No	Unlimited	First
ClearCorrect™	USA	Laser	www.clearcorrect.com	Yes	Unlimited	Second
Invisalign™	USA	Laser	www.invisalign.com	Yes	Unlimited	Third

Source: (Hennessy & Al-Awadhi, 2016)

The fourth-generation aligners offered advancements such a smart-force, optimized root control attachments, and a new multi-tooth method for open bite modifications. Furthermore, fifth-generation aligners introduced pressure areas for better intrusions, deep bite attachments for premolar extrusion, and bite ramps to promote posterior space (Ganta et al., 2021).

The development of aligners has advanced orthodontic treatment, particularly in tooth extraction and movement management. Each generation of aligners has brought improvements, such as SmartStage™ and SmartForce™ technologies for better control and parallelism. The latest eighth-generation aligners focus on deep-bite correction using SmartForce™ technology. These advancements have greatly enhanced the overall effectiveness of orthodontic treatment (Bichu et al., 2023).

Aligner systems incorporate three types of attachments ellipsoid, bevelled, and rectangular. Ellipsoid attachments are uniquely used for de-rotations (Figure 3), or in pairs when the aim is to produce root movements (Figure 4). However, ellipsoid attachments are used for incisors, canines and premolars (Hennessy & Al-Awadhi, 2016).

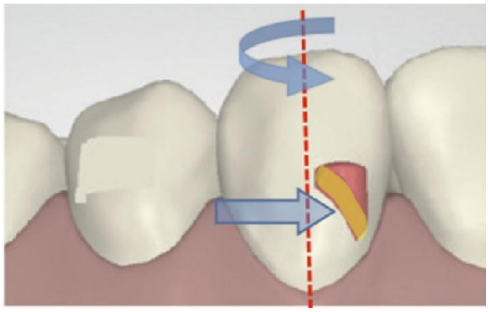

Figure 3- *Ellipsoid de-rotation attachments*

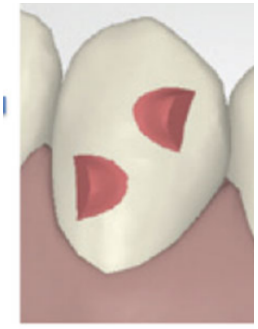

Figure 4- *Ellipsoid paired root movement attachments*

Source: (Hennessy & Al-Awadhi, 2016)

Bevelled attachments are commonly used in tooth extrusion, these attachments are designed to prevent slipping between the aligner and the tooth (Figure 5). Rectangular attachments, on the other hand, have different dimensions and make possible larger mesio-distal movements (Figure 6). Initially, all attachments are not fully attached but become more active as the patient moves onward through aligners (Hennessy & Al-Awadhi, 2016). Attachments are force guides that enhance the biological movement of aligners (Nucera et al., 2022). Overall, attachments play a crucial role in guiding tooth movement during orthodontic treatment (Hennessy & Al-Awadhi, 2016).

Figure 5- *Bevelled attachments for tooth extrusions*

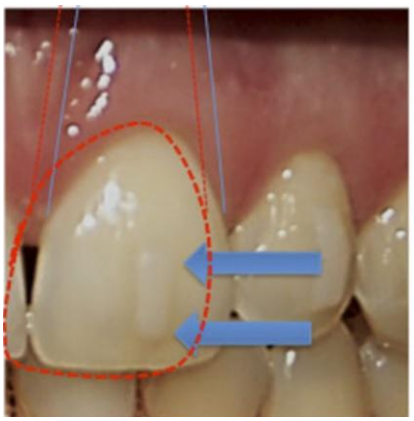

Figure 6- *Rectangular attachments for mesio-distal movement*

Source: (Hennessy & Al-Awadhi, 2016)

When considering clear aligner fabrication the possible margin designs are scalloped, straight cut at the gingival zenith, and straight cut 2mm above the gingival zenith (considered the most retentive) (Figure 7) (Kundal & Shokeen, 2020).

Figure 7- *Gingival margin design of aligners: (a) Scalloped, (b) straight cut at gingival zenith, (c) straight cut 2 mm above the gingival zenith.*

Source: (Kundal & Shokeen, 2020)

The gingival margin design directly affects aligner success, and modern tendencies gravitate towards favoring straight margins over scalloped (Putrino et al., 2023). The prolongation of straight edge gingival margins has the ability to provide greater retention to the aligner, especially in aligners without attachments to favor further retentive functions (Putrino et al., 2022). Dasy et al. (2015), propose various factors, such as attachment placement, aligner design, and clinical crown size, have been identified as additional influences on aligner retention. Additionally, Tepedino et al., (2018), concur revealing clear aligner success is influenced by numerous factors, including shape and position of attachments, material and thickness of aligners, and the production techniques used. Patient characteristics, bone density and tooth morphology also impact treatment outcomes. Factors related to the clinician, such as accuracy in performing required interproximal reduction, are also important but often underestimated (Tepedino et al., 2018).

Materials employed for the production of clear aligners are mainly polymers. CAT employs different polymers types that meet specific characteristics to withstand various stress factors in the mouth. These polymers are chosen for their flexibility, durability, and moldability to ensure a comfortable and viable orthodontic treatment (Bichu et al., 2023).

Aligner generations have witnessed advancements in accuracy, precision, orthodontic tooth movement, and patient conformity. Digital scanning, computer-aided design, and 3D printing have played a crucial role in developing clear aligner efficiency. Overall, clear aligner technologies have transformed orthodontics by providing patients with a more inconspicuous and comfortable alternative to traditional braces (Hennessy & Al-Awadhi, 2016).

2.4.1 Aligners

Arrays of companies are manufacturing aligners today. The common feature among aligner systems is that they are all fabricated with clear thermoformed plastic (Figure 8) (Ganta et al., 2021). Internet search proclaims more than 96 clear aligner brands are presently available for orthodontic treatment. However, not all clear aligners are alike or offer the same innovations (Shi et al., 2022).

Align Technology introduced Invisalign® in 1997, with the aim of revolutionizing orthodontic treatment by providing a comfortable and aesthetically pleasing option for patients (Morton et al., 2017). Invisalign® clear aligner treatment utilizes transparent thermoplastic materials to sequentially adjust the patient's teeth until the desired outcome is achieved (Figure 9) (Kaur et al., 2021).

Invisalign® is made from a patented SmartTrack® material. SmartTrack® is a thermoplastic polyurethane with integrated elastomer, designed to provide continuous light forces to the teeth to improve predictability in orthodontic movements (Lombardo et al., 2015). Invisalign® transformed orthodontics (AlSeraidi et al., 2021). Treatment involves scanning the teeth to promote a computer simulation of the final results. Align technology manufactures a series of clear aligner trays that are worn for 1-2 weeks until the desired movement (Rooz, 2022). According to Bichu et al. (2023), Invisalign® is a patented aligner with 0.75 mm thickness.

Invisalign® treatment includes SmartTrack material, Smart Stage technology, and SmartForce attachments. Align Technology provides ClinCheck software for

treatment planning. These aligners gradually move teeth by 0.25-0.33 mm every 7 days and feature scalloped edges that align with the gum line (Putrino et al., 2023). According to Hartshorne and Wertheimer (2022), aligner recommendation use is for 20-22 hours a day to achieve optimal results.

Figure 8- *CAT systems, Standardized images of volunteers with (A-G) and without (H) CAT systems: A) ClearCorrectTM aligner; B) MODERN CLEAR system; C) Ortho Aligner; D) Ideal Smile® ALIGNER; E) Orthocaps® SLP 800; F) Orthocaps® DLP 460; G) Orthocaps® DLP 580.*

Source: (LIVAS et al., 2023)

Invisalign® introduction led to the emergence of diverse aligner manufacturers and systems (Hennessy & Al-Awadhi, 2016). Many companies developed different aligners with various features, which have different materials, designs, and attachment shapes to enhance retention and facilitate complex movements (Dasy et al., 2015). Aligner thickness can vary between 0.50 and 1.5 mm among different manufacturers (Lombardo et al., 2015).

Figure 9- *Invisalign® Clear Aligners*

Source: (Kaur et al., 2021)

ClearCorrect emerged as one of the clear aligner systems following the introduction of Invisalign®. ClearCorrect was established in 2006 (Weir, 2017). These aligners are made from medical grade plastics by the Straumann Group, employing clear pilot software and demonstrating improved comfort (Hartshorne & Wertheimer, 2022). ClearCorrect aligners are designed to improve aligner retention by overlapping the attached gingiva. However, ClearCorrect aligners' enhanced retention requires additional gingival preciseness in impressions and scans (Weir, 2017). ClearCorrect aligners incorporate CAD-CAM generated, bonded resin attachment promoting 0.3mm of tooth movement per aligner (Kundal & Shokeen, 2020). These aligners have 0.75 mm of thickness and operate with clear quartz material. Its enhanced elasticity and comfortable inner layer promote steady force. Furthermore, compared to other aligners, ClearQuartz sustains initial force and shape throughout wear time (Bichu et al., 2023). ClearCorrect, has become a favorable treatment option in the orthodontic field, and has shown remarkable color stability, gaining widespread acceptance and popularity (Kundal & Shokeen, 2020).

Spark™ clear aligner system designed by ORMCO corp, employed patented TruGEN™ and TruGEN™ aligner material (Rooz, 2022). Spark™ clear aligner therapy showcases exceptional contact surface retention and long-lasting force. It not only offers superior qualities but also stands out for its innovative features such as the integration of

virtual treatment planning platforms, enhanced efficiency in tooth movement, and stain resistance (Hartshorne & Wertheimer, 2022). The Spark™ clear aligner system eliminates the need for separate attachment bonding by incorporating pre-designed attachments within the aligners. A study comparing Spark™ and Invisalign® aligners found that debonding of attachments was nearly nonexistent among participants using Spark™ aligners (Bruno et al., 2021). The remarkable progress in Spark™, capitalizes on the latest innovations in 3D imaging technology and cutting-edge artificial intelligence algorithms to meticulously craft bespoke treatment plans. These aligners integrate SmartTrack material, which is a blend of comfort, precision fit, and efficacy, offering a discreet alternative to fixed appliances. Overall, the Spark™ aligner system represents significant progress in orthodontic treatment (Hartshorne & Wertheimer, 2022).

Suresmile clear aligners, created by Dentsply Sirona, offer customized treatment planning with fitted scalloped or straight zenith designs (Hartshorne & Wertheimer, 2022). SureSmile aligners provide advanced technology and proven materials, offering patients comfortable and seamless aligners. They also ensure detailed treatment preferences and customized treatment plans from SureSmile Digital Lab (“Dental Chair Upgrade Offer Extended,” 2023).

Furthermore, in 2019, G.E.O. S.r.l. introduced a system called Nuvola® OP SystemTM, which combines exclusively designed aligners with a prefabricated myofunctional appliance called FreedomTM (Alessandro, 2022). Nuvola® aligners are made of polyethylene terephthalate glycol material (Inchingolo et al., 2023). The Nuvola system is a professional, step-by-step process that uses up to 12 aligners to align teeth. Patients wear aligners for 22 hours a day, replacing them every 14 days, and take new impressions after each step to progress in treatment (Tepedino et al., 2018). Nuvola® OP System is a highly effective tool for achieving dental expansion in adult patients. The OP system is an orthodontic therapy system that combines aligners and a specialized device called FreedomTM. The purpose of the system is to apply orthodontic movement to the cranial sutures through the contraction of the masticatory muscles. This generates strong forces independent of occlusion. The FreedomTM device is worn for 30 minutes a day with the aligners, while the aligners are worn for

the rest of the day. The aligners have reinforcement areas that stiffen specific dental groups, affecting palatal areas corresponding to the sutures. The device also includes lingual pins that improve tongue functionality and target the premaxilla (Figure 10) (Massimo Del Fabbro, 2022).

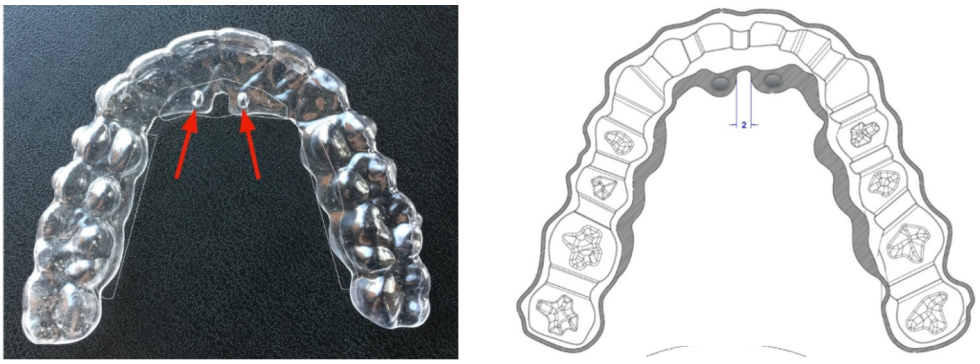

Figure 10- ***(a)*** *Nuvola® Aligners shown with "lingual pins" indicated by the red arrows;* ***(b)*** *drawing of the aligner; the gray areas represent the reinforced regions, which apply mastication forces to specific teeth groups.*

Source: (Massimo Del Fabbro, 2022)

SmileDirectClub™ is a direct-to-customer clear aligner treatment. SmileDirectClub™ clear aligners are made from thermoplastic material and prescribed via remote diagnosis. Patients request home impression kits or visit a smileshop for a digital scan. This clear aligner system incorporates licensed dental professionals that certify the suggested treatment plan, and furthermore the aligners are mailed directly, requiring no chairside consultations. SmileDirectClub™ aligner trays require 22 hours of daily use. However, the new SmileDirectClub nighttime treatment enables the patient to wear aligners only 10 hours a day, requiring less wear time but increasing treatment duration (Rooz, 2022). The increase of direct-to-consumer (DTC) orthodontics among patients has caused considerable controversy amongst dentists and orthodontists. SmileDirectClub is known to own the largest DTC ortodontic share in the market, signing opulent deals with CVS and Walgreens. SmileDirectClub™ makes clear aligners accessible to a broader number of individuals. However, while direct-to-consumer orthodontics offers accessibility and affordability, it may not be suitable for everyone, particularly those with bite incompetence who report less

satisfaction and serious side effects (Wexler et al., 2020). Correspondingly, Byte® clear aligners are also a direct-to-consumer orthodontic treatment that can be prescribed and ordered online. The therapy offers two options for clear aligner treatment: a daytime aligner that needs to be worn for 22 hours per day, and a nighttime aligner that must be worn for 10 hours overnight. However, the Candid™ clear aligners system is prescribed by dentists and sent to patients in a kit that includes teeth whitening foam and Candid Monitoring™ materials. Consequently, patients wear the aligners as directed and send photo scans of their teeth to dentists every two weeks to track progress (Rooz, 2022).

Nonetheless, Invisalign continues to be a leading clear aligner treatment, showcasing Align Technology's commitment to innovation (Morton et al., 2017).

2.5 Oral Hygiene with Aligners

Orthodontic treatment with aligners facilitates oral hygiene, making it an optimal alternative for adolescents and patients at risk of developing periodontal disease (Elaouame et al., 2023). Clear aligner therapy favors reduction of plaque accumulation minimizing periodontal tissue damage (Paolo Caccianiga et al., 2022). Sauer et al., (2023), coincide as fixed multibracket therapy increases the risk of gingivitis and enamel demineralization. Moreover, removable aligners like Invisalign® Teen result in lower plaque accumulation and better periodontal health compared to fixed orthodontic appliances.

Clear aligner therapy is more hygienic than fixed orthodontic appliances. However, the potential for bacterial growth and tooth and gum damage is increased as patients must wear aligners for 22 hours a day, leaving little time for cleaning (Bichu et al., 2023). Additionally, the use of aligners in orthodontic treatment can improve oral hygiene by allowing easier access to all tooth surfaces and reducing the need for additional flossing. Nonetheless, aligners can hinder the natural cleansing and protective functions of saliva and the mechanical actions of the tongue and cheeks, leading to the potential buildup of plaque on both enamel and aligner surfaces (Moshiri et al., 2013).

Advancements in clear aligner therapy have incorporated cellulose based materials that carry essential oils, such as cinnamaldehyde demonstrated to have antimicrobial properties against Staphylococcus epidermidis, *S.* mutans and *S. miti*s. Cinnamaldehyde has proven to be effective in reducing microbial growth and biofilm formation for a 120 hour period (Worreth et al., 2021).

Moshiri et al. (2013), strongly highlight the need to completely avoid consuming certain acids, sucrose, and other sugars, particularly sports/energy drinks, sodas, and juices, during aligner wear. Their study concluded that bacteria and biofilm can still be present on thermoplastic orthodontic appliances despite proper oral hygiene practices. Recommended hygiene practices for using aligners include brushing the inside of the aligners with water and toothpaste, posterior tooth brushing focusing particularly on the cusp-tip areas and attachment wells. Additionally, suggesting eluding denture cleaners to avoid potential allergic reactions to persulfate. Rouzi et al., (2023), found that brushing with sodium carbonate and sulfate resulted in the most effective cleaning method. Moreover, aligners create a closed environment on the teeth, and increase the abundance of Streptococcus bacteria. Clear aligners have inherent imperfections like grooves, ridges, and microcracks that promote bacterial adhesion and the development of plaque biofilm. This suggests a potential risk for tooth decay in patients using clear aligner therapy (Rouzi et al., 2023).

2.6 Pain and Oral Impacts in Aligner Therapy

The International Association for the Study of Pain (IASP) defines pain as an unpleasant sensory and emotional experience associated with actual or potential tissue damage.

According to a study by Antonio-Zancajo et al. (2020), 90% of patients undergoing orthodontic treatment report pain and discomfort as the primary challenges associated with compliance. In general, pain negatively affects patients' quality of life (Fujiyama et al., 2014). Pain in the use of CAT the first week of treatment has been similarly compared with that of fixed orthodontic appliances (Weir, 2017). However, a

study conducted by Jaber et al., (2022), suggests patients using clear aligner experienced more pain during the first week of treatment compared to those using fixed appliances. AlSeraidi et al. (2021) differed, stating that pain levels were higher with fixed appliances compared to clear aligners in the early stages of treatment. Furthermore, Almasound 2018, also concurred as patients using Invisalign® aligners experienced less pain during the initial week of orthodontic treatment compared to those using fixed appliances. Flores-Mir et al., 2018, validate that Invisalign® users reported superior comfort and satisfaction when eating and chewing was concerned although patients undergoing both bracket based and invisalign orthodontic treatment reported similar satisfaction outcomes posterior treatment.

Regarding oral symptoms, clear aligner users experience fewer oral symptoms compared to those using fixed orthodontic appliances. This suggests that clear aligners cause less interference with intraoral soft tissues during functional movements, leading to fewer functional limitations (Jaber et al., 2022). Invisalign renders lower pain levels than the edgewise appliance (Fujiyama et al., 2014). Suggesting Invisalign® requires fewer painkillers compared to conventional fixed brackets (White et al., 2017). However, careful monitoring of tray deformation during CAT use is necessary to prevent future discomfort in patients (Fujiyama et al., 2014).

Orthodontic appliances can negatively impact dental anatomy, oral cavity space, tongue movement, and speech production. Patients using fixed orthodontic appliances experience more pronunciation difficulties compared to those using clear aligners in the first six months of treatment. Clear aligners can be temporarily removed during social situations, potentially reducing pronunciation disturbances (Damasceno Melo et al., 2021).

2.7 Aesthetics in Aligners

The attractiveness of a face is heavily influenced by the appearance of the smile, leading patients to prioritize aesthetic concerns when requesting clear aligner therapy (Weir, 2017). Aligners are gaining popularity due to their attractive appearance and comfortable fit. However, patients tend to favor aligners without attachments for their

perceived aesthetic benefits (Figure 11) (Putrino et al., 2023). Shortcomings of additional attachments detract CAT from its overall aesthetic appeal (Figure 12) (Thai et al., 2020).

Figure 11- *Clear aligners, devoid of any attachments*

Figure 12- *Clear aligners with anterior and posterior attachments*

Source: (Putrino et al., 2023)

Irregular tooth position or interarch relationship can negatively impact attractiveness and well-being. People seek orthodontic care due to the claimed psychosocial effects of dental esthetics (Livas et al., 2023). Furthermore, clear aligner therapy has been found to have positive esthetic effects on the lower third facial aging in adult patients with dental crowding malocclusions (Patini et al., 2018). Clear aligner systems receive positive responses in terms of visibility, attractiveness, and acceptability (Livas et al., 2023). Nevertheless, aligners can become discolored due to interactions with beverages and staining substances in the mouth, and this can negatively impact their visual appeal (Ganta et al., 2021).

Materials of clear aligners ensure transparency and prevent surface damage, resulting in improved aesthetics and a lack of white lesions after treatment, unlike fixed orthodontic appliances (Galluccio, 2021). Clear aligner technologies have greatly improved orthodontic treatment, offering patients a more imperceptible treatment option (Hennessy & Al-Awadhi, 2016).

2.8 Self-esteem, self confidence and anxiety with Aligners

The concept of self-esteem relates to an individual ability to acknowledge self worth and is shaped by various factors such as family ties, surroundings, and interactions with others. Adolescence is a critical period for the development of social identity and self-image, and appearance plays a significant role in emotional well-being. The satisfaction and acceptance of one's body image, particularly related to facial and overall appearance, have a direct impact on the quality of life and self-esteem of individuals (Muniz Júnior et al., 2023).

The arrangement of teeth plays an important role in facial aesthetics (Sari et al., 2020). A healthy and attractive smile is seen as an indicator of good health and confidence (Putrino et al., 2023). Patients with physical anomalies, particularly those affecting their facial appearance, experience psychological and social consequences that often cause significant stress for both patients and their loved ones. Among the esthetic-conscious society, aesthetic regard throughout orthodontic treatment has led to growing popularity in aligner treatment (Vaida et al., 2015). Clear aligners, according to a study by AlSeraidi et al. (2021), offer aesthetic advantages that alleviate the social anxiety associated with orthodontic treatment. These findings demonstrate the positive impact of clear aligners on patients' overall well-being and confidence during orthodontic care.

Xu et al. (2023), suggest that females have more anxiety, sensitivity, and concern about appearance. Severe dental misalignment can cause significant psychological distress. Even minor misalignment can affect female confidence. However, the impact varies depending on an individual's level of extroversion or emotional stability, with outgoing individuals experiencing less severe psychosocial consequences compared to emotionally unstable individuals. Personality significantly influences the psychosocial impact of dental aesthetics. Understanding the relationship between psychosocial health, personality traits, and dental esthetics is crucial in the field of orthodontics.

2.8.1 Patient Perception, Satisfaction and OHRQOL with aligners

Malocclusion, although not classified as a disease or life-threatening, significantly impacts an individual's quality of life, encompassing social, psychological, and physical effects. Dental health, according to the World Health Organization, encompasses more than just the absence of oral problems. It also includes positive psychosocial well-being and self-satisfaction (Xu et al., 2023).

According to previous assessments, correlation between lower impacts and fewer functional limitations, reduces pain, physical disability and psychological discomfort. Aligners are a user-friendly alternative to traditional orthodontic treatment, helping minimize the emotional stress commonly associated with the approach (Ganta et al., 2021).

Research has demonstrated that patients undergoing clear aligner therapy experience a significantly lower impact on their oral health compared to those using fixed orthodontic appliances, reporting less difficulty sleeping, less soreness on tongue and cheeks, and reduced food debris accumulation. Patients under this study completed a self-administered questionnaire concerning appliance experience that included daily routines, food consumptions, and oral symptoms. The relationship between the data variables from the questionnaire was analyzed using the chi-square test and Fisher's exact tests. Correspondingly, Likert scale and visual analog scale (VAS) were used to measure responses (Baseer et al., 2021). Likert scale is described as a rating scale used to measure opinions, attitudes, and behaviors, followed by multiple answer options (Bhandari, 2020). The 5 point likers scale used to measure patients responses included the following; 1 = never affected, 2 = less than once a month, 3 = once or twice a month, 4 = once or twice a week, and 5= 3–4 times a week/nearly every day. Furthermore, pain was assessed on a VAS scale consisting of a 10cm line, with two end points representing 0 as "no pain" and 10 as "pain as bad as it could possibly be". Accordingly, questionnaire scores indicated that clear aligner therapy users reported greater overall oral health-related quality of life compared to those using fixed appliances (Baseer et al., 2021).

Moreover, studies examining the impact of pain and oral quality of life in patients with different orthodontic appliances concurred and found that aligner patients experience less pain and improved quality of life (Antonio-Zancajo et al. 2020). Researchers employed a modified McGill questionnaire, a reliable tool to track severe pain levels and evaluate the effectiveness of interventions. Additionally, pain intensity was measured using VAS, and functional limitations, discomfort and disabilities attributed to oral conditions were measured using the Oral Health Impact Profile-14 questionnaire (OHIP-14), a 14-question questionnaire used to measure oral health related quality of life (Mary, 2017).

Alami et al. (2022), validate that patients treated with CAT report higher satisfaction levels when compared to those treated with traditional braces. The ability to remove the aligners during meals and oral hygiene routines was cited as a significant advantage, considerably reducing dietary restrictions and simplifying oral hygiene practices. Over 91% of patients expressed satisfaction with the outcomes of clear aligner therapy. However, aesthetic satisfaction was always highly influenced by attachment use. Results were obtained through a survey using a 4-point Likert scale and multiple-choice questions. Data was further analyzed using statistical product and service solution software, with results indicating patients were highly satisfied with the invisible aligner treatment, highlighting the invisibility of the treatment as the major advantage which was primarily driven by the desire to enhance self-confidence. Zhang et al. (2020), concur as their systematic review observed fewer eating disturbances in patients with CAT compared to those using fixed appliances.

Clear aligner therapy is a preferred treatment option for patients with severe crowding, as it offers various benefits including improved oral health-related quality of life and a better overall perception. Findings suggest that clear aligners are more satisfying in terms of eating and chewing. Correspondly, nearly 50% of clear aligner users reported 100% satisfaction, while only 24% in the fixed appliances users reported the same level of satisfaction. Patients seeking orthodontic treatment with minimal impact on their daily lives favor clear aligner therapy, during the first year of treatment as confirmed through the OHIP-14, and a 5-point likert scale (Jaber et al., 2022). Livas et al. (2018), established that viewers on YouTube are actively seeking information

about Invisalign aligners, with comments expressing predominantly positive emotions in regards to treatment use.

Studies conducted on adults undergoing orthodontic treatment with CAT and traditional fixed appliances explored pain perception, anxiety, and OHRQoL. The investigation was assessed through VAS, OHIP-14, the State-Trait Anxiety Inventory (STAI), and two-way analysis of variance (ANOVA). Accordingly, the study concluded that those using clear aligners experienced less pain, anxiety and higher levels of satisfaction with their oral health-related quality of life (Gao et al., 2020).

Correspondingly, choosing aligners for orthodontic treatment has been validated to experience fewer limitations on oral health-related quality of life and oral hygiene following one year of treatment. Clinical outcomes in this study were evaluated through OHIP-14, Quigley-Hein Plaque Index (TMQH), and the Psychosocial Impact of Dental Aesthetic Questionnaire (PIDAQ). PIDAQ refers to 23 statements of subscales: referring to "dental self-confidence," "social impairment," "psychological impairment," and "aesthetic concern". Research findings suggest psychosocial well-being increases throughout the course of aligner treatment with no clinical evidence suggesting increased dental plaque accumulation (Sauer et al., 2023); Comparisons of clear aligners treatment with conventional labially placed, metal, fixed orthodontic appliances, considered clear aligners, were linked to a better OHRQoL (Kaklamanos et al., 2023).

Aligners are praised for their effectiveness but also criticized for their negative environmental impact (Imazato et al., 2014). Bichu et al. (2023), discovered that orthodontic treatment using plastic aligners is causing a significant environmental burden and is a potential health risk due to the lack of recycling options.

Disposing of aligners requires careful consideration due to their potential for environmental contamination and risk of cross-infection (Imazato et al., 2014). The plastic waste from aligners affects the oceans, marine life, climate change, and our overall health. Microplastics have been found in seafood, emphasizing the need for increased awareness and responsibility among aligner manufacturers, clinicians, and users to promote sustainability (Bichu et al., 2023).

Bisphenol-A (BPA) is commonly used in the production of various orthodontic materials, including resin composites, esthetic brackets, elastomeric ligatures, and aligner or retainer systems (Eliades, 2017). A study published in Environmental Health Perspective revealed that even small amounts of BPA can lead to diseases such as immune system changes, prostate enlargement, diabetes, hyperactivity, infertility, obesity, precocious puberty, and breast cancer affecting the overall health related quality of life (Freitas, 2021). Limited evidence from an in vitro study suggests that three different clear aligner materials may leach BPA, indicating potential risks (Peter et al., 2023).

Clear aligners have been associated with various adverse effects such as pain, soft-tissue issues, oral dysfunctions, speech impairment, lip swelling, dry mouth, difficulty breathing and tooth damage, which may be due to the potential effects of low doses of BPA. These concerns highlight the need for further research and consideration of the risks associated with clear aligners (Yazdi, et al., 2023).

2.9 Advantages and Disadvantages with Aligner systems

Clear aligner technologies have transformed orthodontics by providing patients with a more discreet and comfortable alternative to traditional braces (Hennessy & Al-Awadhi, 2016). Nonetheless, the major drawback in the use of aligner therapy is lack of patient cooperation, consequently becoming the most important obstacle to getting the desired treatment correction. In patients with poor disposition, treatment times increase, and the outcome may be compromised (Bacci, 2022). According to Ganta et al. (2021), clear aligners have shortcomings such as potential delays in tooth movement caused by their removable nature and negative impact on clear aligner aesthetics produced by color staining substances present in the oral cavity .

Clear aligners are suitable for patients with thin gingival biotypes, limiting the risk of gingival recession. Aligner therapy is as valuable as traditional fixed treatments for resolving malocclusion, with the added benefit of being able to perform isolated tooth movements, and presenting shorter treatment duration (Ke et al., 2019).

Additionally, clear aligner applications provide benefits like enhanced oral hygiene, convenient removal during meals, pain reduction, and the ability to visualize treatment outcomes using computer aided software. On the other hand, these aligners have limitations including less control over root movement, and intermaxillary correction. Limitations also include challenges in achieving adequate occlusal contact and vertical intrusion and extrusion within the 0.5mm limit (Pithon et al., 2019). Furthermore patients treated with clear aligners relapsed more than those treated with fixed orthodontic appliance after retention forces we no longer applied (Ke et al., 2019).

Fixed orthodontic appliances have been associated with root resorption as a side effect. However, a recent study by Kundal and Shokeen (2020), found no evidence of root resorption when using CAT technique. This suggests that CAT may be a suitable alternative for individuals who are concerned about the potential risks of root resorption associated with traditional fixed orthodontic appliances. Additional benefits of clear aligner therapy include fewer clinical emergencies, and reduced chairside time (Weir, 2017). The advancement of digital technology enables the clinician to establish treatment sequence, individual tooth movement, and pace of movement during orthodontic treatment (Shi et al., 2022).

Recent studies confirm that clear aligner therapy (CAT) has a harmful environmental impact. Plastic waste from aligners is damaging oceans, marine life, and contributing to climate change. Furthermore, there is a need for further research into the potential risks associated with aligners, particularly concerning low doses of BPA. These findings highlight the significance of evaluating the environmental and health implications of CAT.

2.9.1 Limitations

Clear aligners were proven to be not as competent as braces in attaining adequate occlusal contacts, controlling dental torque, and retention (Ke, Y., Zhu, et al., 2019). Additional pitfalls with CAT use include unpredicted tooth movements including extrusion and rotations of round teeth (Weir, 2017). Clear aligners are effective for

aligning and adjusting upper molars, although achieving movements like torque can be challenging (Inchingolo et al., 2023). Fixed appliances have been found to be more effective in improving buccolingual inclination, occlusal contacts, and reducing overjet compared to other treatment options (Hennessy and Al-Awadhi 2016).

The study by Pithon et al. (2019), identified limitations with Invisalign® orthodontic treatment, such as teeth shifting, improper occlusal contact alignment, and undesired rotations in canines and premolars. Kassam & Stoops (2020), concur demonstrating Invisalign presents challenges in achieving buccolingual inclination, and vertical tooth movements. Hartshorne & Wertheimer (2022), revealed 37% of patients have been linked to needing supplementary aligners after Invisalign use.

Aligner systems are not effective for treating orthodontic problems in patients with class II and class III skeletal conditions (Ganta et al., 2021). A study by Kaur et al. (2021), concludes that Invisalign® aligners should be avoided for patients with clenching or grinding habits. Additionally, it has been established that the cost of clear aligner therapy is higher compared to other treatment options (Kundal & Shokeen, 2020).

Temperature, humidity, salivary enzymes, and elasticity have an impact on the properties of clear aligners. Additionally, environmental factors can cause variations in the mechanical behavior of these devices and it has been observed that stiffness increases after intraoral use, likely due to changes in the polymer material (Bucci et al., 2019). Furthermore, cooperation is essential for the success of aligner therapy as it is necessary to advance from one aligner to the next (Galluccio, 2021).

3 CONCLUSION

This narrative review on the perception, satisfaction, and quality of life in patients treated with aligners has shed light on several important aspects of orthodontic treatment using this innovative approach. Patients are attracted to clear aligner orthodontics due to the advertised benefits of improved comfort, flexibility, and aesthetic appeal over traditional braces. However, the success of aligner therapy is heavily dependent on patient compliance, posing a significant obstacle to achieving desired treatment outcomes. Patients must commit to wearing aligners for 20-22 hours daily to ensure successful treatment progression. Additionally, despite their benefits, aligners are prone to tray deformation and discoloration due to interactions with beverages and staining substances, resulting in compromised visual appeal.

The findings of this review suggest clear aligner therapy displays greater acceptance, satisfaction, comfort and aesthetics when compared to fixed orthodontic appliances. The use of invisible aligners allows the patient to effortlessly integrate the system into their daily lives without influencing their self-confidence and social relationships, reporting less functional limitations and improving their Oral health-related quality of life (OHRQoL). Patients who opt for aligner treatment often report feeling more confident and satisfied with their smile compared to those undergoing traditional braces. This improvement in self-perception and satisfaction can have a significant impact on the overall quality of life, as a positive self-image is closely linked to psychological well-being and social interactions.

This narrative review provides valuable insights into the perception, satisfaction, and quality of life in patients treated with aligners, although research is warranted to validate and expand upon these findings. Long-term follow-up studies can help assess the durability and stability of aligner therapy outcomes, as well as explore potential variations in patient perception and satisfaction based on treatment complexity and specific case factors.

4 BIBLIOGRAPHY

Abbing, A., Koretsi, V., Eliades, T., & Papageorgiou, S. N. (2020). Duration of orthodontic treatment with fixed appliances in adolescents and adults: a systematic review with meta-analysis. *Progress in orthodontics,* 21(1), 37.

Adobes-Martin, M., Montoya-Morcillo, M. L., Zhou-Wu, A., & Garcovich, D. (2021). Invisalign treatment from the patient perspective: A Twitter content analysis. *Journal of clinical and experimental dentistry,* 13(4), e376–e382.

Alajmi, S., Shaban, A., & Al-Azemi, R. (2020). Comparison of Short-Term Oral Impacts Experienced by Patients Treated with Invisalign or Conventional Fixed Orthodontic Appliances. *Medical principles and practice : international journal of the Kuwait University, Health Science Centre,* 29(4), 382–388.

Alami, S., Sahim, S., Hilal, F., Essamlali, A. and El Quars, F. (2022) Perception and Satisfaction of Patients Treated with Orthodontic Clear Aligners. *Open Access Library Journal,* 9: e9300.

Alansari, R. A. (2020). Youth Perception of Different Orthodontic Appliances. *Patient Preference and Adherence, Volume* 14, 1011–1019.

Alessandro, C. (2022). Recovery of craniofacial proportions using the Nuvola Op System protocol. *Journal of Oral Health and Craniofacial Science,* 7(2), 022–026.

Almasoud, N. N. (2018). Pain perception among patients treated with passive self-ligating fixed appliances and Invisalign® aligners during the first week of orthodontic treatment. *The Korean Journal of Orthodontics,* 48(5), 326.

Alrejaye, N., Pober, R., & Giordano Ii, R. (2017). Torsional strength of computer-aided design/computer-aided manufacturing-fabricated esthetic orthodontic brackets. *The Angle orthodontist,* 87(1), 125–130.

AlSeraidi, M., Hansa, I., Dhaval, F., Ferguson, D. J., & Vaid, N. R. (2021). The effect of vestibular, lingual, and aligner appliances on the quality of life of adult patients during the initial stages of orthodontic treatment. *Progress in Orthodontics,* 22(1).

Antonio-Zancajo, L., Montero, J., Albaladejo, A., Oteo-Calatayud, M. D., & Alvarado-Lorenzo, A. (2020). Pain and Oral-Health-Related Quality of Life in Orthodontic Patients During Initial Therapy with Conventional, Low-Friction, and Lingual Brackets and Aligners (Invisalign): A Prospective Clinical Study. *Journal of Clinical Medicine,* 9(7), 2088.

Bacci, H. (2022). Hybrid and "Invisible" treatment of class I malocclusion in patient with low grade of cooperation. *Journal of Dental Health, Oral Disorders & Therapy,* 13(3), 44–46.

Basavaraj Subhashchandra Phulari. (2013). History of orthodontics a glance at an exciting path, the oldest specialty of dentistry has treaded so far ... *New Delhi Jaypee Brothers. Med. Publ, 14-16.*

Baseer, M. A., Almayah, N. A., Alqahtani, K. M., Alshaye, M. I., & Aldhahri, M. M. (2021). Oral Impacts Experienced by Orthodontic Patients Undergoing Fixed or Removable Appliances Therapy in Saudi Arabia: A Cross-Sectional Study. *Patient preference and adherence,* 15, 2683–2691.

Bhandari, P. (2020, July 3). Designing and Analyzing a Likert Scale | What, Why and How. *Scribbr, 1.*

Bichu, Y. M., Alwafi, A., Liu, X., Andrews, J., Ludwig, B., Bichu, A. Y., & Zou, B. (2023). Advances in orthodontic clear aligner materials. *Bioactive Materials,* 22, 384–403.

Bruno, G., Gracco, A., Barone, M., Mutinelli, S., & De Stefani, A. (2021). Invisalign® vs. SparkTM Template: Which Is the Most Effective in the

Attachment Bonding Procedure? A Randomized Controlled Trial. *Applied Sciences,* 11(15), 6716.

Bucci, R., Rongo, R., Levatè, C., Michelotti, A., Barone, S., Razionale, A. V., & D'Antò, V. (2019). Thickness of orthodontic clear aligners after thermoforming and after 10 days of intraoral exposure: a prospective clinical study. *Progress in Orthodontics,* 20(1).

Čalušić Šarac, M., Anić Milošević, S., Matošić, Ž., & Lapter Varga, M. (2021). Oral Hygiene Behavior of Croatian Adolescents during Fixed Orthodontic Treatment: A Cross-sectional Study. *Acta stomatologica Croatica,* 55(4), 359–366.

Cardoso, P. C., Espinosa, D. G., Mecenas, P., Flores-Mir, C., & Normando, D. (2020). Pain level between clear aligners and fixed appliances: a systematic review. *Progress in orthodontics,* 21(1).

Cenzato, N., Nobili, A., & Maspero, C. (2021). Prevalence of Dental Malocclusions in Different Geographical Areas: Scoping Review. *Dentistry Journal*, *9*(10), 117.

Chan, K. (2022). Online aligners. *British Dental Journal,* 232(9), 589–589.

Chen, J., Wan, J., & You, L. (2017). Speech and orthodontic appliances: a systematic literature review. *European Journal of Orthodontics,* 40(1), 29–36.

Coppola, G., Christopoulou, I., Gkantidis, N., Verna, C., Pandis, N., & Kanavakis, G. (2023). The effect of orthodontic treatment on smile attractiveness: a systematic review. *Progress in Orthodontics,* 24(1).

Damasceno Melo, P. E., Bocato, J. R., de Castro Ferreira Conti, A. C., Siqueira de Souza, K. R., Freire Fernandes, T. M., de Almeida, M. R., & Pedron Oltramari, P. V. (2021). Effects of orthodontic treatment with aligners and fixed appliances on speech. *The Angle Orthodontist,* 91(6), 711–717.

Dasy, H., Dasy, A., Asatrian, G., Rózsa, N., Lee, H.-F., & Kwak, J. H. (2015). Effects of variable attachment shapes and aligner material on aligner retention. *The Angle Orthodontist*, 85(6), 934–940.

Dental chair upgrade offer extended. (2023). *British Dental Journal,* 235(1), 65–65.

Elaouame, A., Qaderi, M., Khamlich, K., Zahiri, M., & Alami, S. (2023). Effect of Orthodontic Treatments by Dental and Periodontal Health Aligners: A Literature Review. *Open Access Library Journal*, 10(6), 1–10.

Elekdag-Türk, S., & Yilmaz (née Huda Ebulkbash), H. (2019). Ceramic Brackets Revisited. *Current Approaches in Orthodontics, 2-13*.

Eliades, T. (2017). Bisphenol A and orthodontics: An update of evidence-based measures to minimize exposure for the orthodontic team and patients. *American Journal of Orthodontics and Dentofacial Orthopedics*, 152(4), 435–441.

Flores-Mir, C., Brandelli, J., & Pacheco-Pereira, C. (2018). Patient satisfaction and quality of life status after 2 treatment modalities: Invisalign and conventional fixed appliances. *American Journal of Orthodontics and Dentofacial Orthopedics,* 154(5), 639–644.

Freitas, A. O., Marquezan, M., Nojima, M.daC., Alviano, D. S., & Maia, L. C. (2014). The influence of orthodontic fixed appliances on the oral microbiota: a systematic review. *Dental press journal of orthodontics,* 19(2), 46–55.

Freitas, M. P. M. (2021). Aligners, Environmental Contamination, and The Role of Orthodontics. *The Angle Orthodontist,* 92(1), 148–149.

Fujiyama, K., Honjo, T., Suzuki, M., Matsuoka, S., & Deguchi, T. (2014). Analysis of pain level in cases treated with Invisalign aligner: comparison with fixed edgewise appliance therapy. *Progress in Orthodontics,* 15(1).

Gallegos-Delgado, Fernanda Eugenia, Schmuck-Villarroel, Alex Eduardo, Aguilera-Muñoz, Felipe Rodrigo, & Cornuy-Barozzi, María Antonieta. (2018). Satisfaction with the use of fixed orthodontic appliances in patients from Valdivia and Paillaco, 2017. Observational study. *Odontoestomatología,* 20(32), 54-61.

Galluccio, G. (2021). Is the use of clear aligners a real critical change in oral health prevention and treatment. *La Clinica Terapeutica*, 172(2).

Ganta, G. K., Cheruvu, K., Ravi, R. K., & Reddy, R. P. (2021, August 1). Clear aligners, the aesthetic solution: a review. *Social Science Research Network, 91-93.*

Gao, M., Yan, X., Zhao, R., Shan, Y., Chen, Y., Jian, F., Long, H., & Lai, W. (2021). Comparison of pain perception, anxiety, and impacts on oral health-related quality of life between patients receiving clear aligners and fixed appliances during the initial stage of orthodontic treatment. *European journal of orthodontics,* 43(3), 353–359.

Hartshorne, J., & Wertheimer, M. B. (2022). Emerging insights and new developments in clear aligner therapy: A review of the literature. *AJO-DO Clinical Companion,* 2(4), 311–324.

Haralur, S. B., Addas, M. K., Othman, H. I., Shah, F. K., El-Malki, A. I., & Al-Qahtani, M. A. (2014). Prevalence of malocclusion, its association with occlusal interferences and temporomandibular disorders among the Saudi sub-population. *Oral Health and Dental Management*, 13(2), 164–169.

Hennessy, J., & Al-Awadhi, E. A. (2016). Clear Aligners Generations and Orthodontic Tooth Movement. *Journal of Orthodontics,* 43(1), 68–76.

How To Reduce White Spots During Orthodontic Treatment | Dental News | *Trycare, UK. (n.d.), 1.*

Imazato, S., Ma, S., Chen, J., & Xu, H. H. K. (2014). Therapeutic polymers for dental adhesives: Loading resins with bio-active components. *Dental Materials*, 30(1), 97–104.

Inchingolo, A. M., Ceci, S., Coloccia, G., Azzollini, D., Malcangi, G., Mancini, A., Inchingolo, F., Trerotoli, P., Dipalma, G., & Patano, A. (2023). Predictability and Effectiveness of Nuvola® Aligners in Dentoalveolar Transverse Changes: A Retrospective Study. *Biomedicines,* 11(5), 1366.

Jaber, S. T., Hajeer, M. Y., Burhan, A. S., & Latifeh, Y. (2022). The Effect of Treatment With Clear Aligners Versus Fixed Appliances on Oral Health-Related Quality of Life in Patients With Severe Crowding: A One-Year Follow-Up Randomized Controlled Clinical Trial. *Cureus, 2-10.*

Javidi, H., Vettore, M., & Benson, P. E. (2017). Does orthodontic treatment before the age of 18 years improve oral health-related quality of life? A systematic review and meta-analysis. *American Journal of Orthodontics and Dentofacial Orthopedics,* 151(4), 644–655.

Johal, A., Alyaqoobi, I., Patel, R., & Cox, S. (2014). The impact of orthodontic treatment on quality of life and self-esteem in adult patients. *The European Journal of Orthodontics,* 37(3), 233–237.

Jung, M.-H. (2015). An evaluation of self-esteem and quality of life in orthodontic patients: Effects of crowding and protrusion. *The Angle Orthodontist,* 85(5), 812–819.

Kaklamanos, E. G., Makrygiannakis, M. A., & Athanasiou, A. E. (2023). Oral Health-Related Quality of Life throughout Treatment with Clear Aligners in Comparison to Conventional Metal Fixed Orthodontic Appliances: A Systematic Review. *International journal of environmental research and public health, 20(4), 3537.*

Kara-Boulad, J. M., Burhan, A. S., Hajeer, M. Y., Khattab, T. Z., Nawaya, F. R., & Al-Sabbagh, R. (2022). Treatment of Moderately Crowded Teeth Using Lingual Fixed Appliance Prepared by a Modified HIRO® Technique: A Case Report and Method Description. *Cureus,* 14(5), e25077.

Kassam, S. K., & Stoops, F. R. (2020). Are clear aligners as effective as conventional fixed appliances?. *Evidence-based dentistry,* 21(1), 30–31.

Kaur, G., Soni, S., & Singh, M. (2021). Invisalign. *International Journal of Health Sciences,* 46–52.

Ke, Y., Zhu, Y., & Zhu, M. (2019). A comparison of treatment effectiveness between clear aligner and fixed appliance therapies. *BMC oral health,* 19(1), 24.

Kim, H.-Y. (2017). Statistical notes for clinical researchers: Chi-squared test and Fisher's exact test. *Restorative Dentistry & Endodontics*, 42(2), 152.

Kundal, S., & Shokeen, T. (2020). Aligners: The Science of Clear Orthodontics. *International Journal of Dental and Medical Specialty, Vol 7, 8-41.*

Livas, C., Delli, K., & Pandis, N. (2018). "My Invisalign experience": content, metrics and comment sentiment analysis of the most popular patient testimonials on YouTube. *Progress in Orthodontics*, 19(1).

Livas, C., Pazhman, F. S., Ilbeyli, Z., & Pandis, N. (2023). Perceived esthetics and value of clear aligner therapy systems: A survey among dental school instructors and undergraduate students. *Dental Press Journal of Orthodontics*, 28(3).

Li, Y., Jacox, L. A., Little, S. H., & Ko, C.-C. (2018). Orthodontic tooth movement: The biology and clinical implications. *The Kaohsiung Journal of Medical Sciences,* 34(4), 207–214.

Lombardo, L., Arreghini, A., Maccarrone, R., Bianchi, A., Scalia, S., & Siciliani, G. (2015). Optical properties of orthodontic aligners—spectrophotometry analysis of three types before and after aging. *Progress in Orthodontics,* 16(1).

Long, H., Wang, Y., Jian, F., Liao, L. N., Yang, X., & Lai, W. L. (2016). Current advances in orthodontic pain. *International journal of oral science,* 8(2), 67–75.

Mampieri, G., Condò, R., Di Caccamo, G., Pirelli, P., & Giancotti, A. (2022). Clear Aligner Treatments in Orthoperio Patients. *Case Reports in Dentistry*, 2022, 8932770.

Mandava, P., Singaraju, G. S., Obili, S., Nettam, V., Vatturu, S., & Erugu, S. (2021). Impact of self-esteem on the relationship between orthodontic treatment and the oral health-related quality of life in patients after orthodontic treatment - a systematic review. *Medicine and Pharmacy Reports,* 94(2), 158–169.

Marincak Vrankova, Z., Rousi, M., Cvanova, M., Gachova, D., Ruzicka, F., Hola, V., Lochman, J., Izakovicova Holla, L., Brysova, A., & Borilova Linhartova, P. (2022). Effect of fixed orthodontic appliances on gingival status and oral microbiota: a pilot study. *BMC oral health*, 22(1), 455.

Mary, A. V. (2017). Assessing Quality of Life using the Oral Health Impact Profile (OHIP-14) in Subjects with and without Orthodontic Treatment need in Chennai, Tamil Nadu, India. *JOURNAL of CLINICAL and DIAGNOSTIC RESEARCH, VOL 11 (8).*

Martins, F. da S., Silva, M. F. da, Souza, D. S., Farias, R. R. S. de, & Ramos, P. F. C. (2021). Má oclusão e fonoaudiologia e fatores associados: revisão integrativa. *Research, Society and Development*, 10(1), e27610111714.

Marques, L. S., Paiva, S. M., Vieira-Andrade, R. G., Pereira, L. J., & Ramos-Jorge, M. L. (2014). Discomfort associated with fixed orthodontic appliances:

determinant factors and influence on quality of life. *Dental Press Journal of Orthodontics,* 19(3), 102–107.

Massimo Del Fabbro. (2022). Clinical Use of Aligners Associated with Nuvola® OP System for Transverse Maxillary Deficiency: A Retrospective Study on 100 Patients. *International Journal of Environmental Research and Public Health,* 19(9), 5751–5751.

Millett, D. T., Glenny, A. M., Mattick, R. C., Hickman, J., & Mandall, N. A. (2016). Adhesives for fixed orthodontic bands. *The Cochrane database of systematic reviews,* 10(10).

Moimaz, S. A. S. ., Gonçalves, C. S., Chiba, F. Y., Garbin, A. J. I., & Saliba, T. A. (2021). Malocclusion indices and their applications in public health: a review study. *ARCHIVES OF HEALTH INVESTIGATION,* 10(7), 1156–1163.

Morton, J., Derakhshan, M., Kaza, S., & Li, C. (2017). Design of the Invisalign system performance. *Seminars in Orthodontics*, *23*(1), 3–11.

Moshiri, M., Eckhart, J. E., McShane, P., & German, D. S. (2013). Consequences of poor oral hygiene during aligner therapy. *Journal of Clinical Orthodontics: JCO*, *47*(8), 494–498.

Muniz Júnior, A. B., Carneiro, D. P. A., Menezes, C. C. de, Degan, V. V., Vedovello, S. A. S., & Vedovello Filho, M. (2023). A Multivariate Analysis of the Psychosocial Impact of Malocclusion and Self-Esteem in Adolescents. *Pesquisa Brasileira Em Odontopediatria E Clínica Integrada*, 22, e200178.

Närhi, L., Tolvanen, M., Pirttiniemi, P., & Silvola, A. S. (2022). Malocclusion severity and its associations with oral health-related quality of life in an adult population. *European journal of orthodontics,* 44(4), 377–384.

Nucera, R., Dolci, C., Bellocchio, A. M., Costa, S., Barbera, S., Rustico, L., Farronato, M., Militi, A., & Portelli, M. (2022). Effects of Composite

Attachments on Orthodontic Clear Aligners Therapy: A Systematic Review. *Materials,* 15(2), 533.

Olteanu, C. D., Bucur, S.-M., Chibelean, M., Bud, E. S., Păcurar, M., & Feştilă, D. G. (2022). Pain Perception during Orthodontic Treatment with Fixed Appliances. *Applied Sciences,* 12(13), 6389.

Paolo Caccianiga, Nota, A., Tecco, S., Saverio Ceraulo, & Gianluigi Caccianiga. (2022). Efficacy of Home Oral-Hygiene Protocols during Orthodontic Treatment with Multibrackets and Clear Aligners: Microbiological Analysis with Phase-Contrast Microscope. *Healthcare,* 10(11), 2255–2255.

Patini, R., Gallenzi, P., Meuli, S., Paoloni, V., & Cordaro, M. (2018). Clear aligners effects on aesthetics: evaluation of facial wrinkles. *Journal of Clinical and Experimental Dentistry, 696-701.*

Perillo, L., Esposito, M., Caprioglio, A., Attanasio, S., Santini, A. C., & Carotenuto, M. (2014). Orthodontic treatment need for adolescents in the Campania region: the malocclusion impact on self-concept. *Patient preference and adherence,* 8, 353–359.

Peter, E., Monisha J, & Suja Ani George. (2023). Bisphenol-A release from thermoplastic clear aligner materials: A systematic review. *Journal of Orthodontics,* 146531252311605-146531252311605.

Pithon, M. M., Baião, F. C. S., Sant Anna, L. I. D. A., Paranhos, L. R., & Cople Maia, L. (2019). Assessment of the effectiveness of invisible aligners compared with conventional appliance in aesthetic and functional orthodontic treatment: A systematic review. *Journal of investigative and clinical dentistry,* 10(4), e12455.

Putrino, A., Abed, M.-R., & Lilli, C. (2022). Clear aligners with differentiated thickness and without attachments – A case report. *Journal of Clinical and Experimental Dentistry,* e514–e519.

Putrino, A., Marinelli, E., Raso, M., Calace, V., & Zaami, S. (2023). Clear Aligners and Smart Eye Tracking Technology as a New Communication Strategy between Ethical and Legal Issues. *Life,* 13(2), 297.

Rooz, D. (2022, May 1). The 2023 Ultimate-Mega Comparison Guide of 12 Different Types of Braces and Clear Aligners. *Modern Orthodontic Clinic in Sammamish & Bellevue, 1.*

Rouzi, M., Zhang, X., Jiang, Q., Long, H., Lai, W., & Li, X. (2023). Impact of Clear Aligners on Oral Health and Oral Microbiome During Orthodontic Treatment. *International Dental Journal*.73(5):603-611

Saini, R., Thakur, N., Jindal Goyal, R., Sharma Rai, K., Bagde, H., & Dhopte, A. (2022). Analysis of Smile Aesthetic Changes With Fixed Orthodontic Treatment. *Cureus, 16;14(12).*

Saloom, H. F., Mohammed-Salih, H. S., & Rasheed, S. F. (2013). The influence of different types of fixed orthodontic appliance on the growth and adherence of microorganisms (in vitro study). *Journal of clinical and experimental dentistry,* 5(1), e36–e41.

Samsonyanová, L., & Broukal, Z. (2014). A Systematic Review of Individual Motivational Factors in Orthodontic Treatment: Facial Attractiveness as the Main Motivational Factor in Orthodontic Treatment. *International Journal of Dentistry,* 2014, 1–7.

Sari, C. N., Jazaldi, F., & Ismah, N. (2020). Association Between Psychosocial Status and Orthodontic Treatment Needs in Indonesian High School Students. *Pesquisa Brasileira Em Odontopediatria E Clínica Integrada*, 20.

Sauer, M. K., Drechsler, T., Peron, P. F., Schmidtmann, I., Ohlendorf, D., Wehrbein, H., & Erbe, C. (2023). Aligner therapy in adolescents: first-year results on the

impact of therapy on oral health-related quality of life and oral hygiene. *Clinical Oral Investigations*, 27(1), 369–375.

Sharma, R., Drummond, R., Wiltshire, W., Schroth, R., Lekic, M., Bertone, M., & Tate, R. (2021). Quality of life in an adolescent orthodontic population. *The Angle orthodontist,* 91(6), 718–724.

Shi, C. X., Feng, Y., Hsiao, Y.-C., Julia Meri Smith, Jin, C., Farella, M., & Li, M. (2022). Clear aligners brands and marketing claims: An overview of available information on the web. *Australasian Orthodontic Journal,* 38(2), 252–262.

Telatar, G. Y., & Telatar, B. C. (2021). Oral Health Status After Orthodontic Treatment: a Retrospective Study. Odovtos - *International Journal of Dental Sciences,* 441–448.

Tepedino, M., Paoloni, V., Cozza, P., & Chimenti, C. (2018). Movement of anterior teeth using clear aligners: a three-dimensional, retrospective evaluation. *Progress in Orthodontics,* 19(1).

Thai, J. K., Araujo, E., McCray, J., Schneider, P. P., & Kim, K. B. (2020). Esthetic perception of clear aligner therapy attachments using eye-tracking technology. *American Journal of Orthodontics and Dentofacial Orthopedics: Official Publication of the American Association of Orthodontists, Its Constituent Societies, and the American Board of Orthodontics*, *158*(3), 400–409.

Vaida, L., Todor, B. I., Bertossi, D., & Corega, C. (2015). Correlations between Stress, Anxiety and Coping Mechanisms in Orthodontic Patients. *Iranian journal of public health,* 44(1), 147–149.

Weir, T. (2017). Clear aligners in orthodontic treatment. *Australian Dental Journal,* 62(S1), 58–62.

Wexler, A., Nagappan, A., Beswerchij, A., & Choi, R. (2020). Direct-to-consumer orthodontics: surveying the user experience. *The Journal of the American Dental Association,* 151(8), 625-636.e4.

White, D. W., Julien, K. C., Jacob, H., Campbell, P. M., & Buschang, P. H. (2017). Discomfort associated with Invisalign and traditional brackets: A randomized, prospective trial. *The Angle Orthodontist,* 87(6), 801–808.

Worreth, S., Bieger, V., Rohr, N., Astasov-Frauenhoffer, M., Tino Töpper, Osmani, B., & Olivier Braissant. (2021). Cinnamaldehyde as antimicrobial in cellulose‐based dental appliances. *Journal of Applied Microbiology,* 132(2), 1018–1024.

Xu,L.,Li,H.,Mei,L.,Li,Y.,Wo,P. & Li,Y.[Yu].(2022).Aligner treatment: patient experience and influencing factors. *Australasian Orthodontic Journal*, 38(1) 88-95.

Xu, Q., Du, W., & Lin, F. (2023). What impact do personality traits have on self-perception of dental aesthetics?. *Head & Face Medicine*, *19*(1).

Yassir, Y. A., McIntyre, G. T., & Bearn, D. R. (2019). The impact of labial fixed appliance orthodontic treatment on patient expectation, experience, and satisfaction: an overview of systematic reviews. *European Journal of Orthodontics, 42(3):223-230.*

Yazdi, M., Daryanavard, H., Ashtiani, A. H., Moradinejad, M., & Rakhshan, V. (2023). A systematic review of biocompatibility and safety of orthodontic clear aligners and transparent vacuum-formed thermoplastic retainers: Bisphenol-A release, adverse effects, cytotoxicity, and estrogenic effects. *Dental research journal*, *20*, 41.

Zhang, B., Huang, X., Huo, S., Zhang, C., Zhao, S., Cen, X., & Zhao, Z. (2020). Effect of clear aligners on oral health‐related quality of life: A systematic review. *Orthodontics & Craniofacial Research,* 23(4), 363–370.