

Review

# Factors Influencing Appliance Wearing Time during Orthodontic Treatments: A Literature Review

Ferruccio Torsello <sup>1,†</sup> , Giorgia D'Amico <sup>2,†</sup>, Edoardo Staderini <sup>1,\*</sup> , Luca Marigo <sup>1,3</sup> , Massimo Cordaro <sup>1,3</sup> and Raffaella Castagnola <sup>1,3</sup> 

- <sup>1</sup> Postgraduate School of Orthodontics, Università Cattolica del Sacro Cuore, Largo Agostino Gemelli 8, 00168 Rome, Italy; ferruccio.torsello@gmail.com (F.T.); luca.marigo@unicatt.it (L.M.); massimo.cordaro@unicatt.it (M.C.); raffaella.castagnola@unicatt.it (R.C.)
  - <sup>2</sup> School of Dentistry and Prosthodontics, Università Cattolica del Sacro Cuore, Largo Agostino Gemelli 8, 00168 Rome, Italy; giorgiadamico24@gmail.com
  - <sup>3</sup> UOC Odontoiatria Generale e Ortodonzia, Dipartimento di Testa-Collo e organi di senso, Fondazione Policlinico Universitario "A. Gemelli" IRCCS, Largo Agostino Gemelli 8, 00168 Rome, Italy
- \* Correspondence: edoardo.staderini@unicatt.it  
† These authors contributed equally to this work.

**Abstract:** This review aims to analyze the multiple factors affecting patients' level of compliance (how much they wear removable devices/clear aligners) during orthodontic treatments and to investigate the available methods and devices to monitor the appliance wearing time and to improve it. A literature search was conducted on electronic databases (Pubmed, Scopus, and Google Scholar). The results of the present study suggest that compliance indicators may misestimate the intraoral wearing time. Compliance is affected by patient-related factors (age, personality traits, the importance of personal appearance, self-perception of malocclusion), appliance-related factors (visibility, pain/discomfort), and clinician-related factors (trust, clear and complete communication, motivation). The motivation of pre-pubertal patients is mostly external, while adolescents/young adults have intrinsic motivation for orthodontic treatment. Patients' self-reports tend to overestimate the appliance wearing time. Even if there is a lack of evidence, teledentistry might improve patients' awareness of being monitored, thus increasing the time for which orthodontic devices are worn. Compliance is a key factor for clear aligner treatments, but high-quality studies focusing on this aspect are missing. Further studies should focus on how to handle the lack of cooperation and how to increase compliance in order to maximize the treatment's results.

**Keywords:** patient compliance; orthodontic appliances; removable; cooperation; clear aligners; compliance indicator



**Citation:** Torsello, F.; D'Amico, G.; Staderini, E.; Marigo, L.; Cordaro, M.; Castagnola, R. Factors Influencing Appliance Wearing Time during Orthodontic Treatments: A Literature Review. *Appl. Sci.* **2022**, *12*, 7807. <https://doi.org/10.3390/app12157807>

Academic Editors: Andrea Deregibus, Gabriele Rossini and Simone Parrini

Received: 12 June 2022

Accepted: 25 July 2022

Published: 3 August 2022

**Publisher's Note:** MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



**Copyright:** © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

## 1. Introduction

Awareness of the importance of facial and dental appearance has led to an increased perception among laypeople of the malocclusions and irregularities of their teeth. The demand for orthodontic treatment for "aesthetic reasons" has been widespread, from both young and adult patients [1].

In order to achieve successful treatment outcomes, clinicians have to obtain patients' compliance [2].

Compliance (or adherence) is defined as "the extent to which a person's behavior coincides with medical or health advice" [3,4].

In orthodontics, patients' cooperation is required throughout every phase of the therapy [5,6]; patients' adherence to treatment is composed of multiple variables strictly correlated with their motivation: respecting appointments, maintaining a good oral hygiene, and wearing orthodontic appliances for as long as required [5].

A lack of compliance may affect treatment results with both fixed [7] and removable appliances [7]: poor oral hygiene during fixed orthodontic treatment could lead to caries and plaque-related or periodontal diseases [8]. Disregarding the wearing time of a removable appliance could lead to treatment delays, thus slowing the treatment process [9,10] and compromising the achievement of the treatment goals [5]. In particular, clear aligners should be worn 22 h per day and changed sequentially every 7, 10, 14 days. If this wearing time is not respected, the treatment outcome may be compromised. All these situations will result in patients' frustration and the further loss of motivation [11].

Compliance represents an essential concept in orthodontics, so its understanding is a key issue for clinicians, starting from the factors involved.

## 2. Aim and Objectives

The aim of this review was to identify the multiple factors affecting compliance in orthodontic treatments with removable devices, that is, how much patients wear them (wearing time), since an in-depth awareness of these aspects might be helpful to understand the reasons behind a poor motivation and to handle a lack of compliance. A secondary aim was to analyze the available indicators that could provide an objective assessment of the appliance wearing time. Finally, solutions to improve the adherence of patients to the orthodontic treatment were considered.

## 3. Methods

A literature search of relevant articles was conducted on electronic databases (Pubmed, Scopus, and Google Scholar) from 1990 up to December 2021. The following keywords were selected for the search string: "patient compliance", "orthodontic appliances, removable", "cooperation", "clear aligners", and "compliance indicators". The eligibility criteria were the following: studies (case reports, case-series, longitudinal studies, randomized clinical trials) on adults and adolescents without any health or mental disease undergoing orthodontic treatment (functional, clear aligners) which discussed the level of compliance during the therapy.

The methodological characteristics of the search strategy were summarized according to the PICO approach:

- 'P' (patients/problem/population)—young and adult patients
- 'I' (intervention)—orthodontic treatment
- 'C' (comparison)—clear aligners, fixed multibracket, functional removable appliance
- 'O' (outcome)—evaluation of patient compliance (appliance wearing time).

The following search strings were developed for Scopus:

((("compliance indicator") OR ("cooperation") OR ("adherence") OR ("wear")) AND ((("orthodontics") OR ("clear AND aligners") OR ("removable AND appliance")) OR ("orthodontic AND appliance"))

The following search strings were developed for Pubmed and adapted for Google Scholar:

((("patient compliance") OR (Treatment Adherence and Compliance)) OR ("compliance indicator") OR ("cooperation")) AND ((Orthodontic Appliances, Removable) OR (Orthodontics) OR (Orthodontic Appliances))

The titles and abstracts of the papers were pre-screened to identify their consistency with the topic of the present review; then, relevant papers were retrieved for full-text analysis. Additionally, the reference list of the included studies was assessed for potentially eligible articles.

### *Assessment of Relevance, Validity, and Data Extraction*

An overall assessment of methodological quality was undertaken for each included trial using six key methodological criteria: parameters such as setting (I), participant characteristics (II), sample size (III), dependent and independent variables (IV), outcome data (V), and statistical analyses (VI). For each of these parameters, there was a dichotomous

issue: positive (+) or negative (−). Relying on the assessment of these six parameters, the available score for each of the included studies varied from 0 to 6.

#### 4. Results and Discussion

A total of 253 papers were found in the electronic databases. A total of 18 papers were found by a hand search taking other records from the list of references of selected full texts.

Literature screening was performed by two researchers (G.D.A. and E.S.); in case of divergence, a third author was consulted (F.T.).

Duplicate and irrelevant papers were left out, and then a title-abstract screening was conducted: the titles and abstracts of 165 papers were assessed; 39 papers were selected for full text examination after removing studies that were not focused on the topics of the present review. Studies that presented a quality score < 3 were also excluded (four papers). 35 papers were finally included in the review.

The flowchart reported in Figure 1 shows the entire study selection process.

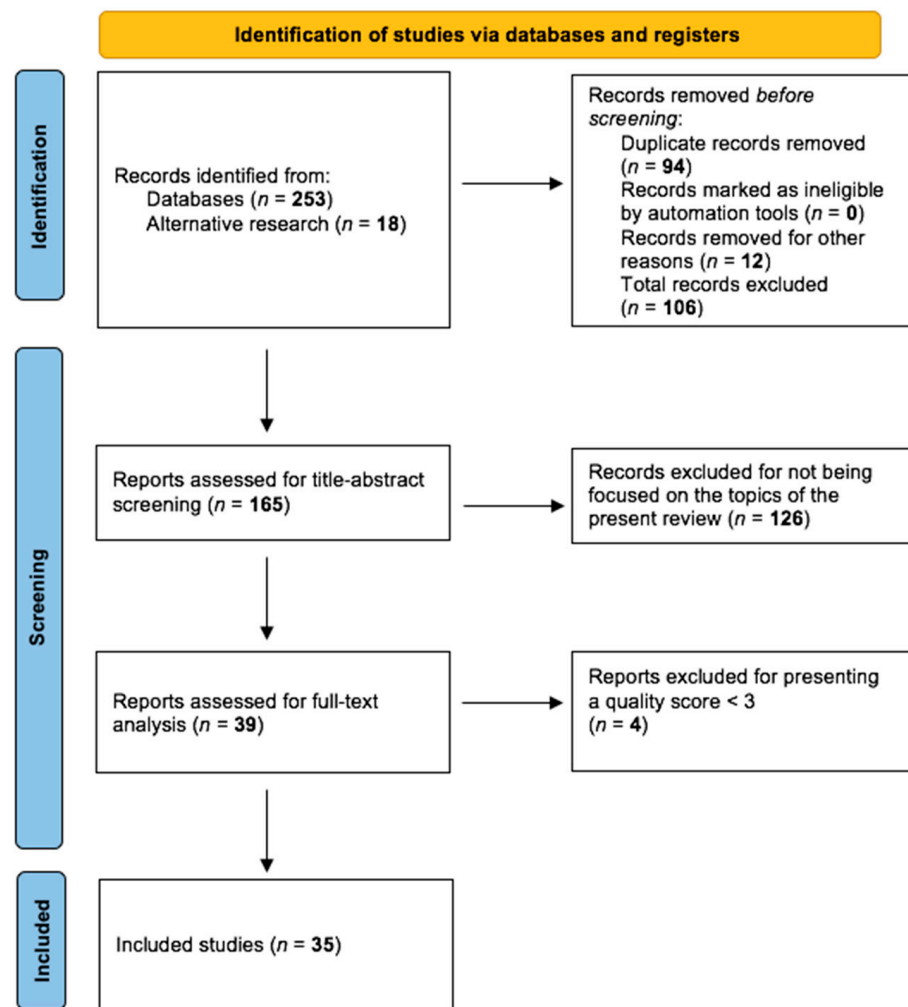


Figure 1. Literature search flowchart (PRISMA 2020).

Following a detailed assessment, 11 included studies satisfied at least 3 methodological criteria, 9 satisfied 4 criteria, and 15 fulfilled 5–6 criteria (Tables 1 and 2).

**Table 1.** Methodological assessment of the included studies.

Study	Setting Description	Description of the Participants	Sample Size	Variables	Outcome Data	Statistical Analysis	Overall Quality (0–6)
Arreghini et al., 2016 [12]	+	+	+	+	–	–	4
Bartsch et al., 1993 [3]	–	+	+	–	+	+	4
Beckwith et al., 1999 [9]	+	+	+	–	–	–	3
Bos et al., 2005 [13]	–	–	–	+	+	+	3
Bos et al., 2007 [14]	+	+	+	+	+	–	5
Brandao et al., 2006 [15]	+	+	+	+	+	–	5
Brierley et al., 2017 [16]	+	+	+	+	+	–	5
Casutt et al., 2007 [4]	+	+	–	–	+	+	4
Cucalon et al., 1990 [17]	+	+	+	–	+	+	5
Dalessandri et al., 2021 [18]	+	–	+	–	+	+	4
Doll et al., 2000 [19]	+	+	+	+	+	+	6
Egolf et al., 1990 [20]	+	+	+	–	–	–	3
El-Huni et al., 2019 [8]	+	+	–	–	–	–	2
Flores-Mir et al., 2018 [21]	–	–	+	+	+	+	4
Gao et al., 2021 [22]	+	–	+	–	+	+	4
Gatto et al., 2019 [23]	+	+	+	–	+	–	4
Hansa et al., 2020 [24]	+	–	+	+	+	+	5
Hansa et al., 2021 [25]	+	–	+	+	+	+	5
Hyun et al., 2015 [26]	–	+	–	+	+	–	3
Lee et al., 2008 [27]	+	+	–	–	–	–	2
Li et al., 2015 [28]	+	+	+	+	+	+	6
Lin et al., 2016 [29]	+	+	+	+	–	+	5
Masood et al., 2013 [30]	+	+	+	+	–	–	4
Nanda et al., 1992 [1]	+	+	+	–	+	+	5
Nedwed et al., 2005 [31]	+	+	+	–	+	+	5
Oliver et al., 1985 [32]	+	+	–	–	+	–	3
Pabari et al., 2011 [33]	+	+	+	+	+	–	5
Pauls et al., 2013 [34]	–	+	–	–	+	+	3
Prabakaran et al., 2012 [7]	+	+	+	–	+	+	5
Richter et al., 1998 [35]	–	–	–	+	–	+	2
Schafer et al., 2005 [11]	+	+	–	–	+	+	4
Schott et al., 2010 [36]	–	+	–	–	–	+	2
Sergl et al., 1998 [37]	+	+	+	–	–	–	3
Skidmore et al., 2006 [10]	+	+	+	–	+	+	5
Spalj et al., 2016 [38]	–	–	–	+	+	+	3
Timm et al., 2021 [39]	+	+	+	+	+	+	6
Tsomos et al., 2014 [40]	–	–	–	+	+	+	3
Tuncay et al., 2009 [41]	–	+	–	–	+	–	3
Zotti et al., 2014 [42]	+	+	+	–	–	–	3

**Table 2.** Summary of included studies.

Authors	Year	Country	Type of Study	Sample	Conclusions
Arreghini et al. [12]	2016	Italy	Prospective cohort study	30 patients	Monitoring systems may be a valuable means of providing a dentist with objective information regarding their patients' compliance.
Bartsch et al. [3]	1993	Germany	Prospective cohort study	77 patients	Better compliance was found in patients who felt accepted and comfortable during the treatment session.
Beckwith et al. [9]	1999	USA	Retrospective cross-sectional study	140 patients	Developing an objective assessment of factors that influence orthodontic treatment duration may be important for increasing the understanding of treatment time variation.

Table 2. Cont.

Authors	Year	Country	Type of Study	Sample	Conclusions
Bos et al. [13]	2005	Netherlands	Prospective cross-sectional study	466 patients	Previously treated patients were found to have a significantly more positive attitude towards orthodontists than untreated patients.
Bos et al. [14]	2007	Netherlands	Prospective study	56 patients	Patients tend to overestimate their compliance.
Brandao et al. [15]	2006	Brazil	Prospective study	21 patients	Patients overreport compliance. Patient compliance increases from 57 to 63% with a monitoring system.
Brierley et al. [16]	2017	UK	Prospective pilot study	5 patients	The adjustment of the TheraMon <sup>®</sup> microsensor software parameters would improve accuracy.
Casutt et al. [4]	2007	Germany	Retrospective multicenter study	222 patients	The success of early orthodontic treatment with removable appliances is highly dependent on patient compliance.
Cucalon et al. [17]	1990	USA	Prospective study	252 patients	Higher compliance was found among females, those with a higher self-esteem, and more optimistic patients.
Dalessandri et al. [18]	2021	Italy	Prospective cross-sectional study	160 patients	Both patients and doctors judged telemonitoring positively, considering it a technologically advanced tool capable of increasing the perception of the quality and accuracy of the treatment.
Doll et al. [19]	2000	Germany	Prospective cohort study	67 patients	Appliance acceptance is determined by both attitude and discomfort.
Egolf et al. [20]	1990	USA	Prospective cross-sectional study	100 patients	Combinations of personality type, negative motives (pain, inconvenience, dysfunction), and positive motives (general health awareness, specific dental knowledge, personal oral embarrassment) were found to be factors correlated with compliance.
Flores-Mir et al. [21]	2018	Canada	Prospective cross-sectional study	122 patients	Patients treated with Invisalign reported more satisfaction than those treated with brackets.
Gao et al. [22]	2021	China	Prospective clinical trial	110 patients	Patients treated with clear aligners experienced lower pain levels, less anxiety and a higher OHRQoL compared to those receiving fixed appliances.
Gatto et al. [23]	2019	Brazil	Prospective cross-sectional study	815 patients	The need for orthodontic treatment was not associated with OHRQoL.
Hansa et al. [24]	2020	Australia	Retrospective study	215 patients	Monitoring decreases treatment duration and in-office appointments.
Hansa et al. [25]	2021	Australia	Retrospective study	90 patients	Monitoring decreases treatment duration and in-office appointments.
Hyun et al. [26]	2015	USA	Prospective pilot study	22 patients	Patients aware of themselves being monitored were more compliant.
Li et al. [28]	2015	China	Randomized controlled	240 patients	Messaging apps increase compliance and decrease treatment duration.
Lin et al. [29]	2016	China	Prospective clinical trial	393 patients	The psychosocial impact of dental aesthetics plays an important role in the decision-making process of adults seeking orthodontic treatment.
Masood et al. [30]	2013	Malaysia	Prospective cross-sectional study	323 patients	Malocclusion has a negative impact on OHRQoL.
Nanda et al. [1]	1992	USA	Prospective cohort study	100 patients	Improving communication is important to salvage a potentially uncooperative patient.
Nedwed et al. [31]	2005	Germany	Prospective cohort study	54 patients	If the indication has been correctly established, Invisalign therapy can be a source of great satisfaction for both the patient and physician.
Oliver et al. [32]	1985	Wales	Prospective cross-sectional study	100 patients	Pain from the appliances and its appearance are the main discouraging features during orthodontic treatment.

Table 2. Cont.

Authors	Year	Country	Type of Study	Sample	Conclusions
Pabari et al. [33]	2011	UK	Prospective cohort study	172 patients	Self-esteem and facial body image scores were higher among patients who had completed treatment than among those who had not.
Pauls et al. [34]	2013	Germany	Retrospective cohort study	32 patients	Patients tend to overestimate their wear times but become more realistic once they know wear time is being monitored.
Prabakaran et al. [7]	2012	UK	Prospective cohort study	60 patients	Most parents placed a high importance on seeking treatment for their child while he or she was still growing to prevent future problems.
Schafer et al. [11]	2015	Germany	Prospective cross-sectional study	141 patients	The daily wear time of removable appliances during the active phase of orthodontic therapy can be quantified using integrated microelectronic sensors.
Sergl et al.	1998	Germany	Prospective cohort study	84 patients	The acceptance of orthodontic treatment in general may be predicted by the amount of initial pain and discomfort experienced.
Skidmore et al. [10]	2006	New Zealand	Retrospective cross-sectional study	366 patients	It is possible to predict the estimated treatment time for a patient by using a small number of personal characteristics and treatment decisions.
Spalj et al. [38]	2016	Croatia	Prospective cross-sectional study	252 patients	Adolescents and young adults with lower agreeableness and conscientiousness seem to be less affected by the increased severity of self-perceived malocclusion, as demonstrated in the reporting of some psychosocial impacts.
Timm et al. [39]	2021	Germany	Retrospective cross-sectional study	2644 patients	A total of 36% of the patients were fully compliant, 38.3% of them showed fair compliance, and 25.7% showed poor compliance.
Tsomos et al. [40]	2014	Switzerland	Prospective cohort study	45 patients	Objective measures are necessary to assess compliance with removable orthodontic appliances, since patient compliance is a highly variable issue.
Tuncay et al. [41]	2009	USA	Prospective cohort study	14 patients	The color compliance indicator has considerable promise for improving the efficiency and effectiveness of orthodontic treatment with clear aligners.
Zotti et al. [42]	2014	Italy	Prospective cohort study	80 patients	The weekly sharing of selfies of patients' smiles in a WhatsApp-based chat room contest is an effective and long-lasting way to improve oral hygiene compliance among adolescent orthodontic patients.

The literature reported many factors that may have an influence on how much patients wear orthodontic removable appliances, and they are commonly thought to be exclusively patient-dependent [40,43]. However, compliance seems to be a multifactorial concept: the type of appliance selected for the treatment and the relationship with the orthodontist play a significant role in determining the level of compliance [2,40]. In order to simplify the discussion on factors affecting patients' compliance, the authors arbitrarily divided them in three groups: "appliance-related", "patient-related", and "clinician-patient relationship-related" factors (Table 3).

Table 3. Factors influencing compliance.

"Appliance-Related"	"Patient-Related"	"Clinician-Related"
Type of appliance (poor/good aesthetic; visible/invisible) [19]	Age [3,40]	Trust, honesty, and loyalty [5,35]
Level of pain and discomfort [20,32]	Personality traits [3]	Complete and clear communication [5]
-	Importance of aesthetics [44]	Motivation [33]
-	Perception of malocclusion [23]	-

Among the selected articles, seven of them deal with clear aligner therapy, but no prospective studies assessing patient compliance with this treatment option were retrieved.

#### 4.1. "Appliance-Related" Factors

Orthodontic treatment certainly improves both dental and facial appearances, but there are annoying and uncomfortable side effects that may lead to a decrease in patients' compliance [19,20]. This regards therapies with both fixed and removable appliances on aesthetic and functional levels.

For example, fixed appliances are associated with poor aesthetics (such as metallic brackets), and they are therefore less accepted than more aesthetic solutions [19]. These types of appliances can be a source of pain and discomfort, but patients cannot remove them. In the case of fixed appliances, a decrease in cooperation is usually associated with oral hygiene and with the use of additional auxiliaries such as elastics and headgear [20,32].

Removable appliances are generally considered more comfortable, as, in rare cases of pain or discomfort, patients may remove them. Unfortunately, studies show that removable appliances are worn less than required [45]. Some reports show that compliance with removable appliances is suboptimal: patients wear the appliances five hours less than indicated by the clinician [2].

Pain, discomfort, and functional restrictions that are caused by orthodontic appliances seem to be the most annoying side effects of the treatment. According to the literature, patients' discomfort represents one of patients' main reasons for not cooperating with the orthodontic treatment [2,5,19].

Clear aligners (CA) are well-tolerated removable appliances, and they are thus accepted by patients since they are invisible and do not compromise the facial appearance. They cause minimal trauma or irritation thanks to their smooth surface. Patients experience slight alterations of pronunciation, especially in the first period, until they get used to it. This issue is generally considered as the most annoying part of the aligners' therapy, and it could influence compliance levels. However, patients become accustomed to CA very quickly and do not suffer much impairment, as a study on 54 patients showed that 83% of patients got used to the appliance within 1 week and 93% of them felt so secure wearing CA that they felt no inhibition while talking [31].

Clear aligners are designed to exert appropriate, precise, and calibrated forces on the teeth according to the type of malocclusion. Thus, patients are not subjected to heavy forces that may cause "useless" and deleterious aches and pains. Patients wearing CA report lower levels of pain, less stress and social anxiety, and higher Oral Health Related Quality of Life (OHRQoL) measurements. As a consequence, patients wearing clear aligners demonstrate a superior attitude during the treatment [22,46].

A comparison between clear aligners and fixed appliances after the completion of orthodontic treatment assessed patients' satisfaction and OHRQoL. Similar satisfaction levels were found for the two treatment modalities, except for eating and chewing. CA significantly performed better for these activities compared to fixed appliances [21].

Compliance for CAT is required to be high, since aligners are meant to be changed regularly, and they need to be worn almost all day [39].

Timm et al. [39] investigated several factors influencing compliance in clear aligner therapy in a large sample of 2644 individuals using a mobile application for the self-reporting of aligner wear. The results showed that 36% of the patients were fully compliant, 38.3% of them showed fair compliance, and 25.7% showed poor compliance. These findings are particularly relevant as one out of four patients demonstrated insufficient collaboration, which may jeopardize the therapeutic outcome.

The effectiveness of clear aligner therapy, compared to the conventional fixed appliances, is widely discussed in the literature. The improvements introduced over the past few years regarding clear aligner therapy have made this approach comparable with fixed conventional treatments in selected cases (such as the intrusion and rotation of incisors, lingual crown tip, the distalization of upper molars, dental cross-bite, etc.) [47–49]. It has been

recently reported that complex and even surgical treatments can be successfully completed with clear aligners, but more studies are needed to retrieve solid conclusions [50].

A very good compliance is necessary to obtain successful results with clear aligner therapy [36,41], as the appliances should be worn 22 h per day and changed sequentially every 7, 10, 14 days [51]. An insufficient compliance may increase the treatment time and therefore may compromise the treatment outcome [35].

In order to improve the efficiency of the treatment, it is important for the clinician to understand the optimal aligner wear protocol: Al-Nadawi et al. [51], in 2021, evaluated the efficacy of tooth movement with aligner wear protocols of 7, 10, and 14 days. They found out that a 7-day protocol reduces the treatment duration and is generally enough, as there is not a clinically significant difference compared with a 10-day or 14-day protocol. A 14-day protocol showed a statistically greater accuracy for complex posterior movements such as maxillary intrusion, distal-crown tip, buccal-crown torque, and mandibular intrusion and extrusion [51].

The compliance issue is critical to obtain results and to select accelerated wearing schedules. It should be carefully evaluated by the clinician and thoroughly discussed with the patient and/or with the parents when talking about kids' treatment. If the patient shows a good approach and the adherence to the treatment is foreseen, the clear aligners are an excellent treatment option with effective results, even in difficult cases. A fair compliance could be sufficient in mild malocclusions, but certainly not in complex cases. A poor compliance may cause the failure of any treatment.

#### 4.2. "Patient-Related" Factors

Psychological studies have shown how individuals cope with any general discomfort, including pain caused during orthodontic treatments, as influenced by personal values, personality, and the attitude towards the therapy's phases [5,35].

Therefore, it is essential, helpful, and interesting to discuss the psychological dimension behind the patients and the related factors that may influence the adherence to the treatment and how much they wear the devices. Orthodontic treatments usually last several years and are often undertaken in the middle of skeletal growth; thus, orthodontic patients are generally people who are in the pubertal phase. This implies that cooperation is influenced by developmental factors [3], including the patient's age and personality. In the past, it was believed that gender could influence cooperation [17,52], but more recent studies have not recognized it as a significant influential factor [13,40].

Patients with different ages can face the treatment in different ways: it seems that there is a compliance reduction with the increase in age—from middle childhood to early adulthood [40]. It has been observed that patients in middle childhood (6–8 years) are more compliant than adolescents (12–15 years) and early adults [12]. Compliance is influenced by different factors in each of these life periods: during middle childhood, the "parent-child" bond is central and has a strong impact on treatment motivation [1]. Since a child is not aware enough of his/her appearance, parents and caregivers pay attention to the patients' needs, including orthodontic treatment [1]; during adolescence and adulthood, self-perception, self-esteem, and social feedback deeply influence motivation and adherence to the treatment [53].

It has been observed how the psychological dynamics underlying the level of collaboration and adherence to the rules in any situation of everyday life are regulated by the "effect" that they have on the quality of people's life: if positive, the level of compliance would be high [45]; on the contrary, if negative, it would be low. People are strongly motivated to take medications that relieve pain and promote healing because they have a positive effect on their quality of life. In orthodontics, the treatment represents a transitory phase in which it is possible to experience pain or discomfort, negatively affecting patients' compliance [37,45]; however, in the long term, the treatment would lead to an improvement in aesthetics and quality of life.



Psychological “patient-related” factors include the self-perception of facial appearance, attitude towards the treatment, pain, and discomfort threshold. Facial appearance determines how a person feels about himself/herself and how society feels about people’s appearances [44]. If someone is particularly concerned about their physical appearance and has a high self-esteem, when malocclusions or irregularities of the teeth are noticed, the person is strongly motivated to resolve them to gain or maintain acceptance and compliments from other people [23]. Subjects with a good self-esteem who are emotionally stable and have a tendency to observe the rules and understand the importance of constantly wearing the orthodontic device will be highly collaborative. On the contrary, subjects with a confused lifestyle or an attitude of distrust towards their own therapy management skills tend to be unpredictable in terms of collaboration, as their personality makes them nervous and whiny about pain and discomfort when experiencing the treatment [38].

The perception of malocclusions is another important factor that influence the wearing time of orthodontic devices. Masood et al. showed that dental irregularities are perceived in a different way based on two opposite patient personalities: subjects with slight defects are excessively alarmed, while subjects with severe malocclusions are fine with their appearance. The reaction is not always in line with reality, as it is strictly related to the self-awareness of dental and facial appearance [29,30]. Generally, the more severe the malocclusion is perceived to be, the higher the level of compliance will be. However, if the patient is not fully aware of how serious the problem is, he/she will tend to underestimate the situation and not accurately comply with the treatment.

Therefore, the patient’s perception of his/her own malocclusion can be a predictor of cooperation [12]. As patients’ self-esteem is considered a major predictor of adherence to treatment, the clinicians should illustrate the treatment plan with the support of the patient’s documentation (pictures, radiographs, 3D facial scans, dental models).

#### 4.3. “Clinician-Related” Factors

The ways clinicians interact with their patients directly influence how much they cooperate during the treatment [5,35].

Developing a healthy relationship with patients represents a real challenge that requires attention regarding some essential aspects such as the communication and awareness of psychological issues and the dynamics involved with orthodontic treatment [5]. Clinicians should build a mutually beneficial relationship based on trust, honesty, and loyalty. The orthodontist should speak to the patients to introduce them to the treatment, to give advice, or to satisfy a request by using clear and coherent words. The purpose is to make the patients aware of every aspect of the treatment, such as the benefits, risks, costs, and uncomfortable effects. Moreover, the case discussion has the role of reducing the possibility of dissatisfaction or premature “drops-out” [54]. As patients’ self-esteem is considered a major predictor of the adherence to treatment, the clinicians should illustrate the treatment plan with the support of the patient’s documentation (pictures, radiographs, 3D facial scans, dental models). The use of patients’ documentation is of twofold importance: firstly, it demonstrates a successful outcome that can be attained if the patient adheres to the appliance’s wearing instruction during every phase of the treatment; secondly, it shows that the therapeutic outcomes would outweigh any experienced discomfort [54].

It has been observed that patients will choose to be treated only if the “positive” motivation (keeping in mind the desired results) is stronger than the “negative” motivation (the pain and discomfort of the treatment) [54]. Furthermore, the level of cooperation is optimal if the “positive” motivation is kept high [7]. The motivation through an orthodontic process can be “internal” or “external” [33], and the role of the orthodontists’ communication is crucial in both. The “internal” motivation is influenced by the awareness among patients about their personal orthodontic situation combined with the desire to achieve good results (aspects that should be explained and clarified by the orthodontist). The motivation of younger patients is mostly external; teenagers who seek orthodontic treatment are usually motivated by intrinsic factors. Indeed, the “external” motivation is generally increased

by other people such as family, friends, partners, and schoolmates, but also by orthodontists who have to constantly encourage the patients [33]. The influence of both types of motivation makes the clinician–patient relationship mutually beneficial.

#### 4.4. Self-Reported Patient Compliance: Myths and Facts

Since “orthodontic compliance” does not involve a single general aspect of compliance [27], (i.e., a patient who keeps high levels of oral hygiene does not necessarily wear the appliance for the required time, and vice versa), conducting accurate measurements of the patients’ level of adherence to the treatment represents a very challenging task [27,40]. Compliance can be subjectively assessed with self-reported questionnaires filled by patients or parents; however, many authors suggest that subjective evaluations are usually unreliable [14,15,27,34].

In fact, patients are often unrealistic about the wear-time of the removable appliances: they tend to overestimate their wear-time [15,34] by one-third when they do not know that it is monitored [34].

In the past decades, the introduction of several devices and monitoring tools has helped to overcome these limitations and has provided an objective evaluation of the level of patient compliance [3].

#### 4.5. Compliance Monitoring: Physical Devices and Chemical Indicators

Pauls et al. reported that, to achieve an orthodontic treatment goal, functional appliances should be worn at least 12.8 h per day, and active plates should be worn for 13.9 h per day [34]. The literature agrees on the fact that compliance never exceeds 7 to 9 h of the prescribed 8 to 15 h per day [11,12,34]. It is very poor at 65% of the 13 h prescribed and is likely to compromise the efficacy of the orthodontic treatment [12].

Patients are used to cheating, declaring that they wear orthodontic appliances for more hours than the real time of wearing [15]. The awareness of being monitored by monitoring devices leads patients to be more realistic about their wear-time. When confronted with the objective and real measurement of the wear-time of the removable appliances, patients start to provide more accurate subjective estimations, with better transparency about their behavior, which may help in understanding possible failures of the treatment [34,55].

Yet, the evidence reported that wear-time monitoring by clinicians and caregivers does not necessarily boost compliance or increase the general amount of time spent wearing removable appliances [12]: if patients are informed that their wear-time is recorded, they tend to be more compliant but still wear the appliances for a shorter period than that prescribed by the given instructions [14,36].

Physical compliance devices have been developed to associate the wear-time with intraoral environmental factors (e.g., pressure, body temperature) [56]. The first timing device was a piece of headgear introduced by Northcutt (1974) which was activated by pressure switches on the neckstrap, but it was easy to cheat by just activating the timer by placing heavy objects on the pressure switch [57]. A timer monitor designed by Savage (1982) used a soluble controlled-release glass timing disc incorporated into the removable appliance [58], and Cureton et al. (1991) developed a device with a small quartz calendar wristwatch [59].

These devices were innovative, but they never spread for clinical purposes, not even for research, because of the inadequate characteristics such as the elevated costs, the complicated use, and the uncomfortable size affecting the acceptance among patients and orthodontists [26,40,56,60]. Low reliability and poor accuracy in the measurements were also reported [40,60].

More recently, environmental microsensors which can be embedded in appliances and automatically measure and record temperature changes between the oral cavity and surrounding area were introduced.

The TheraMon<sup>®</sup> System (Handelsagentur Gschlady, Hargelsberg, Austria or Forestadent, Pforzheim, Germany) is a small device (13 × 9 × 4.5 mm) that measures the intraoral wear-

time: it works as a recording thermometer by measuring the temperature of the surrounding area of the patient's orthodontic appliance. The system is a useful tool to briefly ascertain the time for which patients wear removable appliances, but it does not allow for the objectification of the effective wear-time due to the several confounders (starting from temperature variations in an individual's mouth) that affect the data recordings [16,61].

The Smart Retainer<sup>®</sup> (Scientific Compliance, Atlanta, GA, USA) gathers several pieces of data from the environment (light, vibration, temperature) and consists of a button-size environmental microsensor that can be easily embedded into many types of orthodontic devices. At preset intervals, the microsensors automatically monitor any change in the environmental surroundings and store the data in an encrypted form. When the retainer is plugged in the proprietary USB-powered Smart Reader, the data are analyzed using proprietary algorithms for trends and use pattern periods [26].

Chemical indicators were also introduced to monitor the wear-time of clear aligners by Align Technology [41]. The compliance indicators are made of a colorful food dye (Erioglaucine disodium salt) encapsulated in the aligner. When the clear aligner is in contact with saliva or oral fluids, the dye is released from the appliance; if the aligner is worn over the 300–400 h of recommended wear for 14 days, the color of the compliance indicator turns from dark to clear blue. Indeed, the color-fade indicates of the quantity of dye loss, which will correspond to the amount of time that the patient wore the aligner, referring to how the appliance was in contact with the saliva (there are two different formulations of yeasts to account for patients' individual dissolution rates of saliva) [41].

Evidence of the clinical efficacy of chemical compliance indicators in clear aligners therapy is lacking. It is reported that chemical indicators have several flaws, since patients can easily manipulate the color changes (on purpose or without intention) and affect the results. The color chart can be biased if the patient leaves the aligners in his/her mouth while drinking or uses inappropriate cleaning-tablets containing oxidizing agents or dishwasher [41].

#### *4.6. How to Improve Compliance? Teledentistry Could Be an Answer*

High levels of compliance (such as better attendance, accurate appliance wear-times, and good oral hygiene) are associated with the increased efficacy and effectiveness of orthodontic treatment. Li et al. reported that messaging apps such as WhatsApp (WhatsApp Inc., Mountain View, CA, USA) and WeChat (Tencent Holdings Limited, Shenzhen, China) have an impact on improving patients' compliance, especially among adolescents, and on reducing the duration of orthodontic treatment (DOT) [28].

Smartphones and tablets have been widely used in health areas (to improve education and to facilitate the patient's management). "Telecommunication" is a method of communication between people (the clinician and the patients) who are physically separated: the distance does not inhibit the clinical process but is empowered by the frequent sharing of photos and information, which allows for an increased access to oral care and for remote but strict monitoring of the evolution of a treatment [62]. Recently, the Association of American Medical Colleges coined the term "Teledentistry"—the use of digital tools (diagnostic imaging, software, and devices) for diagnosis, follow-ups, and telecommunications in dentistry. Sharing digital information, data, graphics, and photos for clinical care using technology (computers, smartphones, apps) represents an alternative and very innovative method to deliver dental care [18,42,62].

Telecommunication in dentistry is a valid tool for the clinician, who can better educate and guide the patient through the therapy with advice, warnings, and reminders for hygiene or time wearing. Additionally, it constantly controls the integrity of appliances, making earlier diagnoses of vestibular cavities (the evidence suggested the effectiveness of this approach in decreasing the incidence of white spot lesions during the first year of treatment with multibracket appliances) [2]. It can also detect irregularities and mistakes in the treatment process. It is also a valid tool for patients, who can solve some doubts by simply sending a WhatsApp message to consult the dentist. Teledentistry is positively

judged by both patients and dentists, who consider it as a valid method to increase the accuracy of the treatment [63], and has been an effective aid during the COVID-19 pandemic, which made it possible for a lot of clinicians to monitor the course of orthodontic treatments during the lockdown periods [24,64].

WhatsApp, WeChat, or any other chat platforms represent an effective way to improve the wearing time of orthodontic devices: it is reported that the DOT is shortened by 7.3 weeks on average [28]. In dentistry, the evidence shows that attendance can be incentivized by simply sending a reminder of any type before the appointments [28].

Dental Monitoring<sup>TM</sup> (DM, Dental Monitoring, Montreal, France) is a further step in Teledentistry. It is a digital system with three integrated platforms (a teeth movement-tracking algorithm, an app for the patient, and a web-based Doctor Dashboard) designed to conduct orthodontic follow-ups at a distance [18]. The dedicated app makes the patient's smartphone a "remote intraoral scanner" (the patients themselves can make an intraoral video which is processed by DM) by which orthodontists can control teeth movement and the integrity of the appliances and make assessments about the patient's treatment progress. The DM receives the patient's pretreatment photographs and a 3D model in stereolithography file format (.stl). An artificial intelligence-based algorithm compares pictures taken by the patient's smartphone with the .stl file of the initial scan. With the pictures at the beginning of the therapy, it calculates the tooth positions, the overjet, the overbite, and the interarch relationships, realizing a "multidimensional information map" of the teeth (uploaded to the Doctor Dashboard), which provides the clinician with automatically generated information regarding the course of the treatment [18,63]. Hansa et al., in 2021 [64], compared the effects of clear aligner treatment with and without DM in terms of the duration of the treatment, the number of appointments, refinements, and refinement aligners, and the achievement of predicted tooth positions: the results suggested that DM leads to a reduction of appointments by 3.5 visits (33.1%) over the treatment duration, which obviously allows for an increase in office efficiency. DM seems to require 4–5 h per week to manage 275 active patients: 30 min per week with the doctor, 1 min per patient per week for the staff, and a few seconds per week for the orthodontist. Reduced appointments also represent a benefit for the patients by reducing travel costs and allowing them to not leave work or school; so, generally, DM is well received and appreciated by patients [24]. DM also reduces the first refinement time by 1.7 months when DM refinements are performed earlier (due to the more frequent and proactive monitoring). The treatment's efficacy may also be improved by this system, which offers the possibility of identifying mistakes and problems at an early stage, such as debonded brackets, non-tracking aligners, and broken ligatures [25,65,66].

These promising technologies, however, need sound scientific evaluation and cannot yet be considered validated [67,68]. Based on our knowledge, all these devices may integrate the clinical examination and may reduce the frequency of visits, but they cannot totally replace in-person appointments.

#### *4.7. Limitations of the Study*

The present review has methodological limitations (the small number of electronic databases, PROSPERO registration) due to its "narrative" purpose: the absence of scientific evidence on the topic of compliance and clear aligners leads to a move away from a rigorous, systematic approach. This study seeks to satisfy the need for "ground knowledge" on this topic and to offer practical hints for developing further investigations.

### **5. Conclusions**

Compliance is a multifactorial issue: the wearing time of removable appliances is influenced by patient-related factors (age, personality traits, the importance of personal appearance, the self-perception of malocclusions), appliance-related factors (visibility, pain/discomfort), and clinician-related factors (trust, clear and complete communication, motivation).

Compliance is a key factor for clear aligner treatments, but high-quality studies focusing on this aspect are missing. Patients tend to overestimate appliance wearing time, and poor compliance is a very frequent problem (25%) in clear aligner therapies. Evidence is lacking on the clinical efficiency of compliance indicators. Teledentistry (communication by messaging apps such as WeChat (Tencent, Shenzhen, China) and WhatsApp (Meta Platforms, Inc., Cambridge, MA, USA) can improve patients' adherence. More sophisticated monitoring apps based on artificial intelligence might increase patients' compliance, but they still need to be scientifically validated. Further studies should focus on how to handle the lack of cooperation and how to increase compliance in order to maximize the treatment's results.

**Author Contributions:** Conceptualization, F.T., E.S. and G.D.; methodology, F.T., E.S. and G.D.; software, E.S. and G.D.; validation, E.S., G.D. and F.T.; formal analysis, E.S., G.D. and F.T.; investigation, E.S., G.D. and F.T.; resources, M.C., L.M. and R.C.; data curation, E.S. and G.D. writing—original draft preparation, E.S. and G.D.; writing—review and editing, E.S., G.D. and F.T.; visualization, E.S. and G.D.; supervision, M.C., L.M. and R.C.; project administration, M.C., L.M. and R.C.; funding acquisition, M.C., L.M. and R.C. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Not applicable.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

- Nanda, R.S.; Kierl, M.J. Prediction of cooperation in orthodontic treatment. *Am. J. Orthod. Dentofacial. Orthop.* **1992**, *102*, 15–21. [[CrossRef](#)]
- Al-Moghrabi, D.; Salazar, F.C.; Pandis, N.; Fleming, P.S. Compliance with removable orthodontic appliances and adjuncts: A systematic review and meta-analysis. *Am. J. Orthod. Dentofacial. Orthop.* **2017**, *152*, 17–32. [[CrossRef](#)]
- Bartsch, A.; Witt, E.; Sahm, G.; Schneider, S. Correlates of objective patient compliance with removable appliance wear. *Am. J. Orthod. Dentofacial. Orthop.* **1993**, *104*, 378–386. [[CrossRef](#)]
- Casutt, C.; Pancherz, H.; Gawora, M.; Ruf, S. Success rate and efficiency of activator treatment. *Eur. J. Orthod.* **2007**, *26*, 614–621. [[CrossRef](#)] [[PubMed](#)]
- Ukra, A.; Bennani, F.; Farella, M. Psychological aspects of orthodontics in clinical practice. Part one: Treatment-specific variables. *Prog. Orthod.* **2011**, *12*, 143–148. [[CrossRef](#)] [[PubMed](#)]
- Monaco, A.; Tepedino, M.; Sabetti, L.; Petrucci, A.; Sgolastra, F. An adolescent treated with rapid maxillary expansion presenting with strabismus: A case report. *J. Med. Case Rep.* **2013**, *23*, 222. [[CrossRef](#)] [[PubMed](#)]
- Prabakaran, R.; Seymour, S.; Moles, D.R.; Cunningham, S.J. Motivation for orthodontic treatment investigated with Q-methodology: Patients' and parents' perspectives. *Am. J. Orthod. Dentofacial. Orthop.* **2012**, *142*, 213–220. [[CrossRef](#)]
- El-Huni, A.; Colonio Salazar, F.B.; Sharma, P.K.; Fleming, P.S. Understanding factors influencing compliance with removable functional appliances: A qualitative study. *Am. J. Orthod. Dentofacial. Orthop.* **2019**, *155*, 173–181. [[CrossRef](#)]
- Beckwith, F.R.; Ackerman, R.J., Jr.; Cobb, C.M.; Tira, D.E. An evaluation of factors affecting duration of orthodontic treatment. *Am. J. Orthod. Dentofacial. Orthop.* **1999**, *115*, 439–447. [[CrossRef](#)]
- Skidmore, K.J.; Brook, K.J.; Thomson, W.M.; Harding, W.J. Factors influencing treatment time in orthodontic patients. *Am. J. Orthod. Dentofacial. Orthop.* **2006**, *129*, 230–238. [[CrossRef](#)] [[PubMed](#)]
- Schafer, K.; Ludwig, B.; Meyer-Gutknecht, H.; Schott, T.C. Quantifying patient adherence during active orthodontic treatment with removable appliances using microelectronic wear-time documentation. *Eur. J. Orthod.* **2015**, *37*, 73–80. [[CrossRef](#)] [[PubMed](#)]
- Arreghini, A.; Trigila, S.; Lombardo, L.; Siciliani, G. Objective assessment of compliance with intra- and extraoral removable appliances. *Angle Orthod.* **2016**, *87*, 88–95. [[CrossRef](#)]
- Bos, A.; Hoogstraten, J.; Prah-Andersen, B. Attitudes towards orthodontic treatment: A comparison of treated and untreated subjects. *Eur. J. Orthod.* **2005**, *27*, 148–154. [[CrossRef](#)]
- Bos, A.; Kleverlaan, C.J.; Hoogstraten, J.; Prah-Andersen, B.; Kuitert, R. Comparing subjective and objective measures of headgear compliance. *Am. J. Orthod. Dentofacial. Orthop.* **2007**, *132*, 801–805. [[CrossRef](#)]
- Brandao, M.; Pinho, H.S.; Urias, D. Clinical and quantitative assessment of headgear compliance: A pilot study. *Am. J. Orthod. Dentofacial. Orthop.* **2006**, *129*, 239–244. [[CrossRef](#)] [[PubMed](#)]

16. Brierley, C.A.; Benson, P.E.; Sandler, J. How accurate are Theramon microsensors at measuring intraoral wear-time? Recorded vs. actual wear times in five volunteers. *J. Orthod.* **2017**, *44*, 241–248. [[CrossRef](#)]
17. Cucalon, A.T.; Smith, R.J. Relationship between compliance by adolescent orthodontic patients and performance on psychological tests. *Angle Orthod.* **1990**, *60*, 107–114.
18. Dalessandri, D.; Sangalli, L.; Tonni, I.; Laffranchi, L.; Bonetti, S.; Visconti, L.; Signoroni, A.; Paganelli, C. Attitude towards Telemonitoring in Orthodontists and Orthodontic Patients. *Dent. J.* **2021**, *9*, 47. [[CrossRef](#)]
19. Doll, G.M.; Zentner, A.; Klages, U.; Sergl, H.G. Relationship between Patient Discomfort, Appliance Acceptance and Compliance in Orthodontic Therapy. *J. Orofac. Orthop.* **2000**, *61*, 398–413. [[CrossRef](#)]
20. Egolf, R.J.; Begole, E.A.; Upshaw, H.S. Factors associated with orthodontic patient compliance of intraoral elastic and headgear wear. *Am. J. Orthod. Dentofacial. Orthop.* **1990**, *97*, 336–348. [[CrossRef](#)]
21. Flores-Mir, C.; Brandelli, J.; Pacheco-Pereira, C. Patient satisfaction and quality of life status after 2 treatment modalities: Invisalign and conventional fixed appliances. *Am. J. Orthod. Dentofacial. Orthop.* **2018**, *154*, 639–644. [[CrossRef](#)]
22. Gao, M.; Yan, X.; Zhao, R.; Shan, Y.; Chen, Y.; Jian, H.; Long, W. 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. *Eur. J. Orthod.* **2021**, *43*, 353–359. [[CrossRef](#)] [[PubMed](#)]
23. Gatto, R.C.; Garbin, J.; Corrente, E.; Garbin, C. The relationship between oral health related quality of life, the need for orthodontic treatment and bullying, among Brazilian teenagers. *Dent. Press J. Orthod.* **2019**, *20*, 73–80. [[CrossRef](#)] [[PubMed](#)]
24. Hansa, I.; Semaan, S.J.; Vaid, N.R. Clinical outcomes and patient perspectives of Dental Monitoring GoLive with Invisalign—A retrospective cohort study. *Prog. Orthod.* **2020**, *21*, 16. [[CrossRef](#)] [[PubMed](#)]
25. Hansa, I.; Semaan, S.J.; Vaid, N.R.; Ferguson, D.J. Remote monitoring and “Tele-orthodontics”: Concept, scope and applications. *Semin. Orthod.* **2018**, *24*, 470–481. [[CrossRef](#)]
26. Hyun, P.; Preston, C.B.; Al-Jewair, T.S.; Park-Hyun, E.; Tabbaa, S. Patient compliance with Hawley retainers fitted with the SMART<sup>®</sup> sensor: A prospective clinical pilot study. *Angle Orthod.* **2015**, *85*, 263–269. [[CrossRef](#)]
27. Lee, S.-J.; Ahn, S.-J.; Kim, T.-W. Patient compliance and locus of control in orthodontic treatment: A prospective study. *Am. J. Orthod. Dentofacial. Orthop.* **2008**, *133*, 354–358. [[CrossRef](#)]
28. Li, X.; Xu, Z.-R.; Tang, N.; Ye, C.; Zhu, X.-L. Effect of intervention using a messaging app on compliance and duration of treatment in orthodontic patients. *Clin. Oral Investig.* **2015**, *20*, 1849–1859. [[CrossRef](#)]
29. Lin, F.; Ren, M.; Yao, L.; Yan, H.; Guo, J.; Ye, Q. Psychosocial impact of dental esthetics regulates motivation to seek orthodontic treatment. *Am. J. Orthod. Dentofacial. Orthop.* **2016**, *150*, 476–482. [[CrossRef](#)]
30. Masood, Y.; Masood, M.; Zainul, N.; Araby, N.; Newton, T. Impact of malocclusion and adolescents’ dissatisfaction with dental appearance and oral functions. *Angle Orthod.* **2013**, *11*, 25.
31. Nedwed, V.; Miethke, R.R. Motivation, acceptance and problems of Invisalign. *J. Orofac. Orthop.* **2005**, *66*, 162–173. [[CrossRef](#)] [[PubMed](#)]
32. Oliver, R.G.; Knapman, Y.M. Attitudes to orthodontic treatment. *Br. J. Orthod.* **1985**, *12*, 133–138. [[CrossRef](#)] [[PubMed](#)]
33. Pabari, S.; Moles, D.R.; Cunningham, S.J. Assessment of motivation and psychological characteristics of adult orthodontic patients. *Am. J. Orthod. Dentofacial. Orthop.* **2011**, *140*, 263–272. [[CrossRef](#)] [[PubMed](#)]
34. Pauls, A.; Nienkemper, M.; Panayotidis, A.; Wilmes, B.; Drescher, D. Effects of wear time recording on the patient’s compliance. *Angle Orthod.* **2013**, *83*, 1002–1008. [[CrossRef](#)]
35. Richter, D.D.; Nanda, R.S.; Sinha, P.K.; Smith, D.W.; Currier, G.F. Effect of behavior modification on patient compliance in orthodontics. *Angle Orthod.* **1998**, *68*, 123–132.
36. Schott, T.C.; Goz, G. Color fading of the blue compliance indicator encapsulated in removable clear Invisalign Teen aligners. *Angle Orthod.* **2011**, *81*, 185–191. [[CrossRef](#)]
37. Sergl, H.G.; Klages, Y.; Zentner, A. Pain and discomfort during orthodontic treatment: Causative factors and effects on compliance. *Am. J. Orthod. Dentofacial. Orthop.* **1998**, *114*, 684–691. [[CrossRef](#)]
38. Spalj, S.; Noxsak, A.; Bilobrk, P.; Katic, V.; Zrinski, M.T.; Pavlic, A. Mediation and moderation effect of the big five personality traits on the relationship between self-perceived malocclusion and psychosocial impact of dental esthetics. *Angle Orthod.* **2016**, *86*, 413–420. [[CrossRef](#)]
39. Timm, L.H.; Farrag, G.; Baxmann, M.; Schwendicke, F. Factors Influencing Patient Compliance during Clear Aligner Therapy: A Retrospective Cohort Study. *J. Clin. Med.* **2021**, *10*, 3103. [[CrossRef](#)] [[PubMed](#)]
40. Tsomos, G.; Ludwig, B.; Grossen, J.; Pazera, P.; Gkantidis, N. Objective assessment of patient compliance with removable orthodontic appliances. A cross-sectional cohort study. *Angle Orthod.* **2014**, *84*, 56–61. [[CrossRef](#)] [[PubMed](#)]
41. Tuncay, O.C.; Bowman, S.J.; Nicozisis, J.L.; Amy, B.D. Effectiveness of a compliance indicator for clear aligners. *J. Clin. Orthod.* **2009**, *43*, 263–268. [[PubMed](#)]
42. Zotti, F.; Dalessandri, D.; Salgarello, S.; Piancino, M.; Bonetti, S.; Visconti, L.; Paganelli, C. Usefulness of an app in improving oral hygiene compliance in adolescent orthodontic patients. *Angle Orthod.* **2014**, *86*, 101–107. [[CrossRef](#)]
43. Fleming, P.S.; Scott, P.; DiBiase, A.T. Compliance: Getting the Most from your Orthodontic Patient. *Dent. Update* **2007**, *34*, 565–572. [[CrossRef](#)]
44. Alley, T.R. *Social and Applied Aspects of Perceiving Faces*; Lawrence Erlbaum Associates: Hillsdale, NJ, USA, 1982.

45. Gross, A.M.; Samson, G.; Dierkes, M. Patient cooperation in treatment with removable appliances: A model of patient noncompliance with treatment implications. *Am. J. Orthod.* **1985**, *87*, 392–397. [[CrossRef](#)]
46. Azaripour, A.; Weusmann, J.; Mahmoodi, B.; Peppas, A.; Gerhold-Ay, A.; Noorden, C.J.F.; Willershausen, B. Braces versus Invisalign: Gingival parameters and patients' satisfaction during treatment: A cross sectional study. *BMC Oral Health* **2015**, *15*, 69. [[CrossRef](#)]
47. Borda, A.F.; Garfinkle, J.S.; Covell, D.A.; Wang, M.; Doyle, L.; Sedgley, C.M. Outcome assessment of orthodontic clear aligner vs fixed appliance treatment in a teenage population with mild malocclusions. *Angle Orthod.* **2020**, *90*, 485–490. [[CrossRef](#)] [[PubMed](#)]
48. Lanteri, V.; Farronato, G.; Lanteri, C.; Caravita, R.; Cossellu, G. The efficacy of orthodontic treatments for anterior crowding with Invisalign compared with fixed appliances using the Peer Assessment Rating Index. *Quintessence Int.* **2018**, *49*, 581–587. [[PubMed](#)]
49. Tepedino, M.; Iancu-Potrubacz, M.; Ciavarella, D.; Masedu, F.; Marchione, L.; Chimenti, C. Expansion of permanent first molars with rapid maxillary expansion appliance anchored on primary second molars. *J. Clin. Exp. Dent.* **2018**, *10*, e241–e247. [[CrossRef](#)]
50. Kankam, H.; Madari, S.; Sawh-Martinez, R.; Bruckman, K.C.; Steinbacher, D.M. Comparing Outcomes in Orthognatic Surgery Using Clear Aligners Versus Conventional Fixed Appliances. *J. Craniofac. Surg.* **2019**, *30*, 1488–1491. [[CrossRef](#)]
51. Al-Nadawi, M.; Kravitz, N.D.; Hansa, I.; Makki, L.; Ferguson, D.J.; Vaid, N.R. Effect of clear aligner wear protocol on the efficacy of tooth movement: A randomized clinical trial. *Angle Orthod.* **2021**, *91*, 157–163. [[CrossRef](#)]
52. Schott, T.C.; Goz, G. Young patients' attitudes towards removable appliance wear times, wear-time instructions and electronic wear-time measurements-results of a questionnaire study. *J. Orofac. Orthop.* **2010**, *71*, 108–116. [[CrossRef](#)] [[PubMed](#)]
53. Weiss, J.; Diserens, D. Health behavior of dental professionals. *Clin. Prev. Dent.* **1980**, *2*, 5–8.
54. Yassir, A.; McIntyre, G.T.; Bearn, D.R. The impact of labial fixed appliance orthodontic treatment on patient expectation, experience, and satisfaction: An overview of systematic reviews. *Eur. J. Orthod.* **2020**, *42*, 223–230. [[CrossRef](#)]
55. Witt, E.; Bartsch, A.; Sahm, G. Recommended times for wearing removable appliances- the results of a survey. *J. Orofac. Orthop.* **1992**, *53*, 124–130.
56. Kyriacou, P.A.; Jones, D.P. Compliance monitor for use with removable orthodontic headgear appliances. *Med. Biol. Eng. Comput.* **1997**, *35*, 57–60. [[CrossRef](#)]
57. Di Palma, E.; di Giuseppe, B.; Tepedino, M.; Chimenti, C. Orthodontic management of bilateral maxillary canine-first premolar transposition and bilateral agenesis of maxillary lateral incisors: A case report. *Dental Press J. Orthod.* **2015**, *20*, 100–109. [[CrossRef](#)] [[PubMed](#)]
58. Savage, M. A preliminary report into the development and use of soluble controlled-release glass timing discs implanted into orthodontic appliances. *Br. J. Orthod.* **1982**, *9*, 190–193. [[CrossRef](#)] [[PubMed](#)]
59. Cureton, S.L.; Regennitter, F.; Orbell, M.G. An accurate, inexpensive headgear timer. *J. Clin. Orthod.* **1991**, *25*, 749–754.
60. Schott, T.C.; Goz, G. Applicative Characteristics of New Microelectronic Sensors Smart Retainer<sup>®</sup> and TheraMon<sup>®</sup> for Measuring Wear Time. *J. Orofac. Orthop.* **2010**, *71*, 339–347. [[CrossRef](#)]
61. Ackerman, M.B.; McRae, M.S.; Longley, W.H. Microsensor technology to help monitor removable appliance wear. *Am. J. Orthod. Dentofacial. Orthop.* **2009**, *135*, 549–551. [[CrossRef](#)]
62. Jampani, N.D.; Nutalapati, R.; Dontula, B.S.K.; Boyapati, R. Applications of teledentistry: A literature review and update. *J. Int. Soc. Prev. Community Dent.* **2011**, *1*, 37–44. [[PubMed](#)]
63. Park, J.H.; Rogowski, L.; Kim, J.H.; Al Shami, S.; Howell, S.E.I. Teledentistry platforms for orthodontics. *J. Clin. Pediatr. Dent.* **2021**, *45*, 48–53. [[CrossRef](#)]
64. Hansa, I.; Katyal, V.; Ferguson, D.J.; Vaid, N. Outcomes of clear aligner treatment with and without Dental Monitoring: A retrospective cohort study. *Am. J. Orthod. Dentofacial. Orthop.* **2021**, *4*, 453–459. [[CrossRef](#)]
65. Maspero, C.; Abate, A.; Cavagnetto, D.; El Morsi, M.; Fama, A.; Farronato, M. Available Technologies, Applications and Benefits of Teleorthodontics. A Literature Review and Possible Applications during the COVID-19 Pandemic. *J. Clin. Med.* **2020**, *9*, 1891. [[CrossRef](#)] [[PubMed](#)]
66. Lombardo, G.; Vena, F.; Negri, P.; Pagano, S.; Barilotti, C.; Paglia, L.; Colombo, S.; Orso, M.; Cianetti, S. Worldwide Prevalence of malocclusion in the different stages of dentition: A systematic review and meta-analysis. *Eur. J. Paediatr. Dent.* **2020**, *21*, 115–122.
67. Occasi, F.; Perri, L.; Saccucci, M.; di Carlo, G.; Ierardo, G.; Luzzi, V.; de Castro, G.; Brindisi, G.; Loffredo, L.; Duse, M.; et al. Malocclusion and rhinitis in children: An easy-going relationship or a yet to be resolved paradox? A systematic literature revision. *Ital. J. Pediatr.* **2018**, *22*, 44. [[CrossRef](#)] [[PubMed](#)]
68. De Felice, F.; Di Carlo, G.; Saccucci, M.; Tombolini, V.; Polimeni, A. Dental Cone Beam Computed Tomography in Children: Clinical Effectiveness and Cancer Risk due to Radiation Exposure. *Oncology* **2019**, *4*, 173–178. [[CrossRef](#)] [[PubMed](#)]