A comparative assessment of acceptance of different types of functional appliances

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SUMMARY Patients' acceptance of an orthodontic appliance may influence compliance and thus contribute to a successful outcome of treatment. The aim of this study was to assess the influence of shape and design of different types of functional appliances on their acceptance by patients. For each of 10 adult volunteer subjects employed in the study eight different functional appliances were fabricated which had a varying extension of the resin base and amount of interocclusal opening. Effects of appliances on speech, initial acceptance, and acceptance after wearing were assessed by means of standardized tests. Amongst the appliances tested the bionator, functional corrector FR-I and elastic open activator showed the highest acceptance by the test subjects. The results of the study indicate that there is a considerable difference in acceptance of various types of functional appliances.

Introduction

Treatment effects of removable orthodontic appliances irrespective of their particular individual therapeutic intention and mode of action largely depend on the patient's co-operation. The motivation of patients undergoing orthodontic treatment to wear a removable appliance is determined by a number of personality characteristics such as discipline, tolerance of frustration, stamina, attitude towards treatment and parental control (Sergl *et al.*, 1987). Although the clinician has the ability to influence a patient's motivation (Holst and Ek, 1988), the efficacy of such influence is limited as the patient's relevant personality features mainly depend on his/her individual environment and education, and lie outside the sphere of interactions between the clinician and the patient (Sergl and Schmalfuß, 1973; Oppenheim *et al.*, 1987; Sergl, 1994).

It is known that removable appliances may cause discomfort including unpleasant tactile sensations, pressure on mucosa, stretching of soft tissues, and displacement of the tongue. They may also induce functional impediment of speech, deglutition and breathing, or affect aesthetics (Sergl *et al.*, 1981, 1993; Sergl and Furk, 1982a,b,c; Oliver and Knappman 1985; Ngan *et al.*, 1989). These side-effects of appliance-wear act as adverse stimuli disturbing the process of adaptation and affecting acceptance of the appliance (Sergl *et al.*, 1981, 1993, 1998; Sergl and Furk, 1982a,b,c; Oliver and Knappman, 1985). The results of a recent study indicate that acceptance of orthodontic appliances and treatment, in general, may be predicted by the amount of initial pain and discomfort experienced after insertion of the first appliance (Sergl *et al.*, 1998). It would appear, therefore, that clinicians might improve appliance acceptance by selecting an appliance design which would allow comfortable wear and facilitate adaptation to the appliance (Gosney, 1985; Ngan *et al.*, 1989; Sergl *et al.*, 1998).

Functional appliances which are an established mode of treatment of modern clinical orthodontics show a remarkable diversity of design. It appears from clinical experience that patients do not readily adapt to these appliances because of their large size and unfixed position in the oral cavity, and that patients' adaptation might vary with regard to different functional appliance types (Graber and Neumann, 1977). Although functional appliances seem to cause more pain and

discomfort than, for instance, removable plates (Sergl *et al.*, 1998) the issue of the influence of various types of functional appliances on patients' adaptation has hitherto not been investigated.

The purpose of the present work was to evaluate the influence of shape and design of various functional appliances on their acceptance by patients. This was undertaken by comparing initial acceptance of different types of appliances including Balters' bionator (Balters, 1973), Klammt's elastic open activator (Klammt, 1984), Karwetzky's horizontal split activator (Karwetzky, 1967), Fränkel's FR-I appliance (Fränkel, 1969) and the classical activator (Andresen *et al.*, 1957). In addition, different designs of the classical activator were tested by varying the extension of the resin base and amount of interocclusal opening (IO). In the absence of a suitable model for a controlled clinical study on real orthodontic patients, appliance acceptance was tested under laboratory conditions involving adult test subjects who did not undergo actual orthodontic treatment.

Subjects and methods

Ten adult volunteers (five males, five females, age 18–32 years) with marked Class II division 1 malocclusions and not familiar with orthodontic appliances were selected as test subjects. Impressions for working casts were taken and construction bites were prepared for the fabrication of eight functional appliances of various designs for each individual test subject. These appliances had the following design variations (Figure 1):

(1) medium-size activator with extensive IO;
(2) large activator with moderate IO;
(3) small activator with moderate IO;
(4) functional corrector FR-I;
(5) medium-size activator with minimal IO;
(6) small horizontally split activator with flexible mandibular guidance and moderate IO;
(7) medium-size elastic open activator with moderate IO;
(8) small bionator with minimal IO.

The resin base of all appliances was of a uniform thickness of 2.0 mm. The IO was determined by the distance between the upper and lower first molars in the construction bite. Depending on individual occlusions of the test subjects the amount of IO ranged in the appliances with little IO from 2.0 to 5.0 mm, in those with moderate IO from 5.0 to 7.5 mm, and in those with extensive IO from 8.0 to 11.5 mm. When different appliances with the same type of IO were fabricated for an individual subject, its amount remained constant.

The size of appliances, that is small, medium, or large, was related to the size of appliance base, especially to the extension of the lingual flanges. The extension of lingual flanges from the occlusal plane in the bionator appliances was 7.0 and 5.0 mm upwards and downwards, respectively. In the small-size activators it measured 8.0 and 6.0 mm upwards and downwards, respectively. In the medium-size appliances these measurements amounted to 11.0 and 7.0 mm, and in the large-size activators 14.0 and 8.0 mm upwards and downwards, respectively. The amount of mandibular advancement in the sagittal plane varied according to the subject's individual extent of sagittal discrepancy from 2.0 to 6.0 mm and remained constant for each subject irrespective of the appliance type. The volume of each appliance was measured by placing the appliances in a water-filled measuring cylinder. Initial acceptance of the above appliances by the test subjects was assessed in a series of standardized tests as follows.

Test 1: effects on speech

The subjects were given a standardized written text and instructed to read it out, first, without an appliance, then with eight appliances inserted into the mouth one after another in a randomized order. Between changing the appliances, the subjects were allowed a 1-minute pause, after the insertion they had 10 seconds to become accustomed to the new appliance before attending to the text. The reading out of the text was recorded on a tape recorder and later evaluated by a group of assessors including a school teacher, a speech therapist, a theatre instructor, an orthodontist, and a dental surgery assistant. The text read without an appliance was listened to
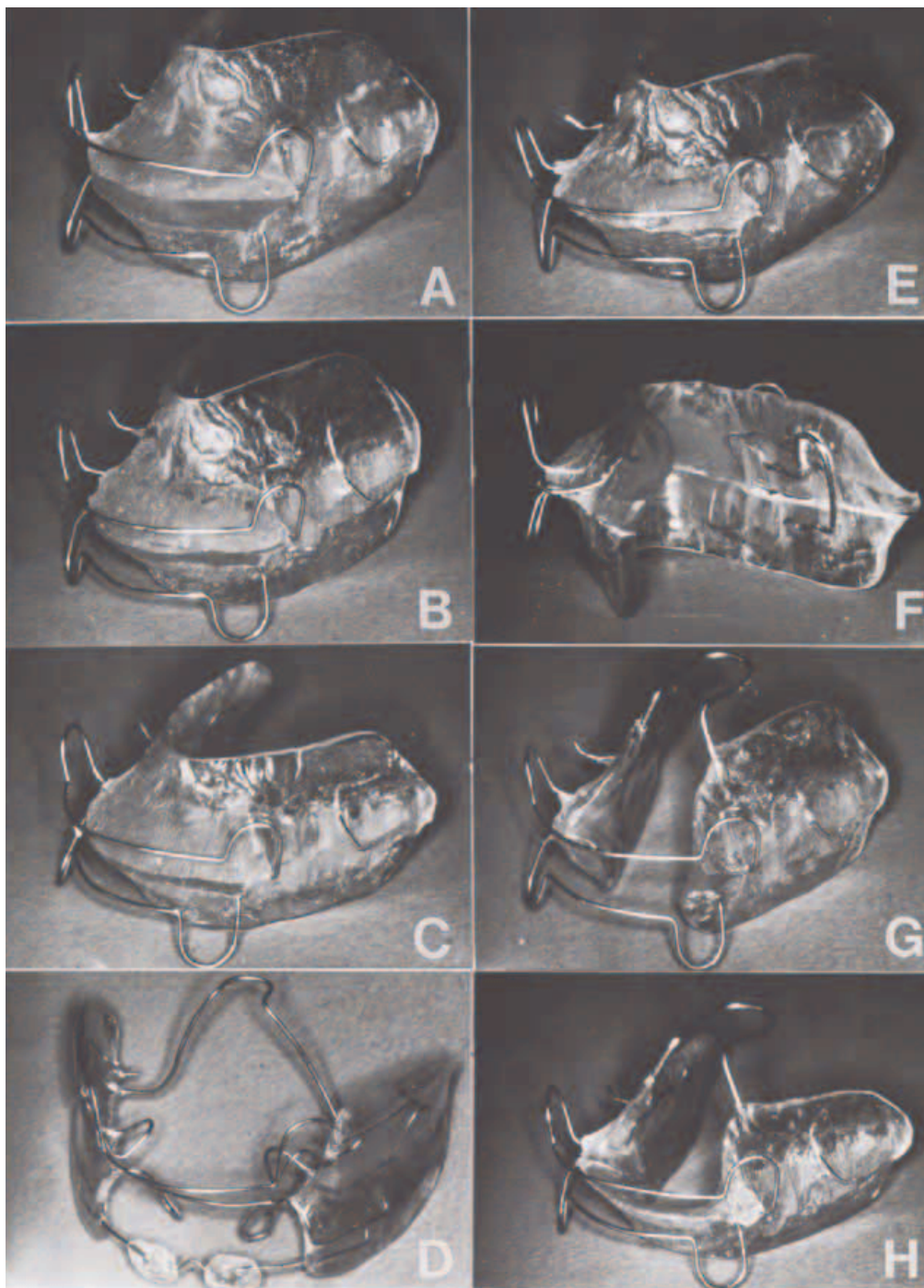
Figure 1 Appliances shown in declining order of their average volume: (A) medium-size activator with extensive interocclusal opening; (B) large activator with moderate interocclusal opening; (C) small activator with moderate interocclusal opening; (D) functional corrector FR-I; (E) medium-size activator with little interocclusal opening; (F) small horizontally split activator with flexible mandibular guidance and moderate interocclusal opening; (G) medium-size elastic open activator with moderate interocclusal opening; (H) small bionator with little interocclusal opening.

first and used as a reference in assessment of eight other recordings from each test subject. Each assessor independently rated the subject's pronunciation on a 5-point rating scale, rating 1 given for the clearest pronunciation.

Test 2: initial acceptance

In this test the subjects were asked to report on the basis of the first spontaneous impression how comfortable the individual appliances felt when inserted into the oral cavity. The subjects were blindfolded in order to exclude potential confounding effects of visual perception and presented the eight appliances in pairs (Figure 2), a total of 56 pairs for each test subject. They were instructed to insert the appliances into the mouth and each time state the preference which of the two was more comfortable to wear. The subjects were allowed brief periods of rest between each time in order to minimize potential fatigue.

Test 3: acceptance after wearing

The test subjects were instructed to wear the appliances one day each, 12 hours per day, in a random order which was different for each subject. Subsequently, the subjects were requested to grade the comfort of each appliance on a 6-point rating scale, rating 1 given to the most comfortable appliance.

Figure 2 Testing of initial acceptance. The test subjects were blindfolded, presented eight appliances in pairs (altogether 56 pairs for each subject) and requested each time to state their preference as to which of the two was more comfortable to wear.

Statistical analysis

In each test the mean ratings and numbers of preferences were calculated for each individual appliance and the differences tested for statistical significance using Friedman two-way ANOVA with the appliance types and the test subjects as sources of variance. This was followed by Student–Neuman–Keuls all pairwise comparison procedure. The null hypothesis tested was that there were no differences between the performance of the various individual types of appliances in each test, was rejected when the values of χ_r^2 (Friedman test) and q (Student–Neuman–Keuls test) corresponded to the values given under the significance level of $P = 0.05$.

Results

The average volumes of appliances were, in declining order, 10.6 ml for the medium-size activator with extensive IO, 9.4 ml for the large activator with moderate IO, 8.7 ml for the small activator with moderate IO, 8.3 ml for the FR-I, 8.0 ml for the medium-size activator with little IO, 8.0 ml for the horizontally split activator, 7.4 ml for the elastic open activator and 6.0 ml for the bionator. In order to facilitate visual presentation of the results the appliances are listed in the illustrations in declining order of their average volumes.

As shown by the ANOVA there were statistically significant differences between the ratings given by the assessors in test 1 (Figure 3) with regard to the appliance type ($P < 0.001$). The results of the pairwise comparison disclosed that the ratings for the FR-I appliance, elastic open activator and bionator significantly differed from those for all other appliances ($P < 0.01$). Amongst all appliances tested the clearest pronunciation was attained with the FR-I appliance followed by the elastic open activator and the bionator (Figure 3) and the difference between the FR-I and either of both the latter was statistically significant ($P < 0.05$). The worst pronunciation was achieved with the medium-size activator with extensive IO and the large activator with moderate IO as revealed by the mean ratings presented in Figure 3. These ratings were,
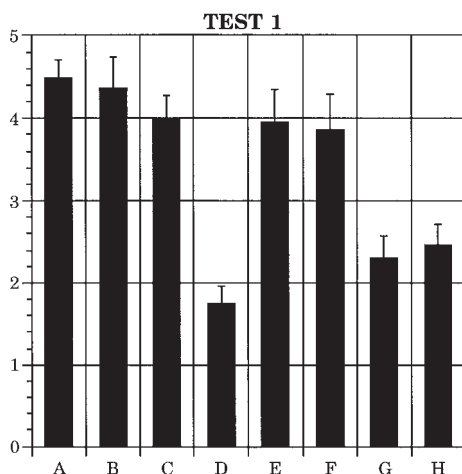
Figure 3 Results of testing of effects on speech expressed as mean ratings and standard deviations (*y*-axis) given by five assessors (rating 1 given for the clearest pronunciation) to each type of appliance. The appliances A–H are recorded on the *x*-axis in declining order of their average volume.

however, not significantly different from the values obtained for the medium-size activator with little IO and the horizontally split activator.

In the test of initial acceptance (test 2, Figure 4) the highest number of preferences was given to the bionator, closely followed by the FR-I
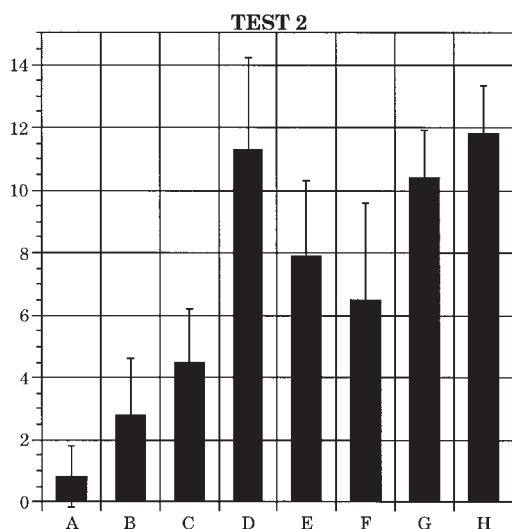

Figure 4 Results of testing of initial acceptance expressed as mean number of preferences and standard deviations (*y*-axis) stated for the individual appliance types. The appliances A–H are recorded on the *x*-axis in declining order of their average volume.

and the elastic open activator, whilst the medium-size activator with extensive IO was classified as the least comfortable appliance. The differences were substantial ranging from 11.8 preferences stated on average for the most comfortable, to 0.8 for the least comfortable appliance, and were statistically significant in the ANOVA test ($P < 0.001$). As shown by the pairwise comparison the values obtained for the FR-I, the bionator and the elastic open activator were significantly higher than those for the medium-size activator with little IO and the horizontally split activator ($P < 0.05$), as well as those obtained for the remaining appliances ($P < 0.01$). The differences between the preferences stated for the FR-I, the bionator, and the elastic open activator were not statistically significant.

No statistically significant differences were revealed between the medium-size activator with little IO and the horizontally split activator, whilst the values obtained for either of these appliances were significantly higher ($P < 0.01$) compared with the medium-size activator with extensive IO, the large activator with moderate IO and the small activator with moderate IO. Amongst the latter three the medium-size activator with extensive IO received the lowest number of preferences ($P < 0.05$).

In the testing of appliance acceptance after wearing (test 3, Figure 5) the bionator attained the best rating amongst all appliances tested, followed by the FR-I and the elastic open activator. The appliance type was the statistically significant source of variance as revealed by the ANOVA ($P < 0.001$). Further testing by the pairwise comparison demonstrated that the ratings obtained for the bionator, FR-I, and elastic open activator differed significantly from those of the medium-size activator with little IO and the horizontally split activator ($P < 0.01$), as well as from the values obtained for the remaining appliances ($P < 0.05$).

There were no statistically significant differences between the values calculated for the bionator, FR-I and elastic open activator. The medium-size activator with little IO and the horizontally split activator did not differ from each other. However, they had, in turn, significantly better ratings when compared with
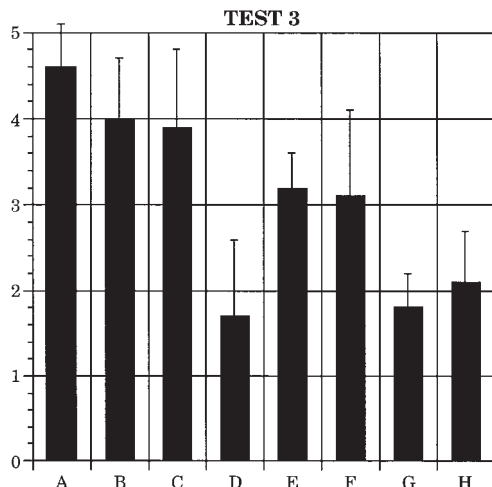
Figure 5 Results of testing of acceptance after wearing expressed as mean ratings and standard deviations (*y*-axis) given to the individual appliance types on a 6-point scale (rating 1 given to the most comfortable appliance). The appliances A–H are recorded on the *x*-axis in declining order of their average volume.

the medium-size activator with extensive IO, the large activator with moderate IO and the small activator with moderate IO ($P < 0.05$). The pairwise comparison between the values obtained for the latter three showed no statistically significant differences.

Discussion

The methods used in the present study are established tools of psychological research usually employed for comparative assessment of personal preferences. Despite some inherent disadvantages, these methods were chosen as no other known methods would readily lend themselves to an objective quantification of essentially subjective judgments. Non-parametric statistical tests were used as no normal data distribution and equidistance between individual points on the rating scales could be assumed. In test 2 an extremely laborious pair comparison test was employed in order to simplify the experimental task for each test subject and to draw inferences from data derived from an extensive number of single judgments.

The purpose of this work was to evaluate the influence of the design of an appliance on its

acceptance by patients. It is recognized that selection of a small group of adult test subjects not undergoing actual treatment, as well as evaluation of initial effects of appliances on speech and comfort, represent a gross simplification of undeniably more complex events occurring in a real clinical situation. A clinical study of longer duration involving a larger number of patients would most certainly increase the validity of the results. However, in the absence of a feasible clinical experimental model which, without ethical objections and disruption of treatment allows a controlled intra-individual comparison of simultaneous or consecutive use of various appliances in real patients, the simplified study design as employed here seems to be entirely reasonable. In addition, the employment of adult volunteer subjects in a short-term study excluded the potential confounding effects of treatment motivation and different powers of tolerance and adaptation which are exhibited to a varying degree in real patients, and thus allowed a more controlled evaluation of the appliance design.

As a whole, the results obtained in all three tests were remarkably consistent. Visual inspection of the graphs in Figures 3–5 indicates that the differences in rankings obtained for the individual appliance types cannot be explained merely on the basis of their total volume. Although, on one hand, the medium-size activator with extensive IO, that is the appliance with the largest total volume, appears to be the worst performing one in all three tests, the acceptance amongst the four variations of the classical activator tested here clearly improves as its total volume decreases. On the other hand, the general trend is not confirmed when the three best-performing appliances are considered. FR-I, for instance, which with regard to the total volume was the fourth largest appliance, showed the best or second best performance in the tests. This would suggest that the best-performing appliances are the ones which occupy very little space in the mouth interior as most of FR-I elements are located in the vestibule and both the bionator and open activator are substantially reduced with regard to acrylic coverage (Figure 1).

It further appears from the results obtained under the conditions of the present study that

the influence of the amount of IO on appliance acceptance is unlikely beyond its role as a contributor to the overall volume of the appliance. It may be of interest in this respect that test subjects reported dislike of appliances with extensive IO because of stretched soft tissues and restrained lip closure, whereas appliances with little IO and widely extended flanges tended to increase discomfort by constraining the tongue.

With the exception of the positions of the bionator and FR-I the order in which the appliances were preferred in test 2 (Figure 4) is almost a mirror image of the order in which they appeared to affect speech (test 1, Figure 3) implying that the more uncomfortable an appliance feels to the patient the more likely it is to cause speech impediment. Likewise, the performance of the appliances in test 3 (Figure 5), that is their acceptance after wearing for 1 day is, apart from the positions of the bionator and the FR-I, in accordance with the order in which they were ranked in test 1. Such noticeable reproduction of the discomfort associated with the first insertion of an appliance in its acceptance after an initial period of wearing might be of significance for long term clinical events. This would be in accord with the general experience in life that first personal impressions and observations of a particular event or object have a long-lasting impact on one's attitude towards it.

The results of the present study show that there is a remarkable difference in the initial acceptance of various types of functional appliances. It is not intended here to advocate or oppose prescription of a particular type of functional appliance merely on the basis of comfort since clinical decisions about the appliance design usually involve a more complex approach. The results of the present study suggest, however, that factors influencing the initial acceptance of an appliance should whenever possible be considered, especially as the amount of discomfort occurring during treatment may have substantial effects on a patient's acceptance of the treatment on the whole and his/her future compliance (Sergl *et al.*, 1998). Whether and to what extent a patient would reliably wear an appliance has a vital influence on outcome of treatment, and it seems likely that a more acceptable appliance would be more readily worn by the patient contributing to successful treatment.

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