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A subjective comparison of two lingual bracket systems

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SUMMARY The purpose of this prospective, longitudinal study was to compare the influence of two lingual bracket systems on subjective oral comfort, speech, mastication and oral hygiene. Forty-two native speakers of standard German (32 females, 10 males; mean age 27.1 years, standard deviation 12.2) were enrolled and completed a standardized questionnaire directly before insertion of lingual brackets (T0), within 24 hours of bond-up (T1) and 3 months (± 1 week) later (T2). Eighteen of the patients were treated with prefabricated brackets (Ormco®, seventh generation) (PB group) and 24 with customized brackets (Incognito) (CB group).

While no significant intergroup differences were recorded at any of the times with respect to tongue position, conversation pattern, swallowing or oral hygiene, the CB group experienced significantly fewer tongue space restrictions, speech disturbances and impairments in chewing and biting than the PB group at T1 and T2. At T2, pressure sores, reddening or lesions to the tongue were recorded significantly less often in the CB group than in the PB group.

This enhanced patient comfort in the CB group was attributed to the smaller dimensions of the customized brackets. This aspect could play a role in attracting more patients to lingual orthodontics in the future. Information given to the patient on the duration and extent of the restrictions associated with lingual orthodontics must be differentiated according to the bracket system used.

Introduction

Recent years have seen the lingual technique in terms of practicality for the orthodontist; optimization of laboratory processes (Fillion, 1989, 1998; Fillion and Leclerc, 1991; Altounion and Fillion, 1997; Wiechmann, 1999a) and chair-side processes (Wiechmann, 2000a); computerized archwire fabrication and sophisticated materials (Wiechmann, 1999b, 2000b). However, these factors have not yet contributed significantly towards increased patient comfort.

Patient problems have been documented in numerous publications on the subject of lingual orthodontics. The reported restrictions include: speech dysfunction (Fujita, 1979, 1982; Sinclair *et al.*, 1986; Årtun, 1987; Fillion, 1997; Miyawaki *et al.*, 1999; Fritz *et al.*, 2002; Hohoff *et al.*, 2003a, b), restricted mastication (Fujita, 1982; Sinclair *et al.*, 1986; Miyawaki *et al.*, 1999; Fritz *et al.*, 2002; Hohoff *et al.*, 2003b), oral discomfort (Fujita, 1982; Sinclair *et al.*, 1986, Miyawaki *et al.*, 1999; Fritz *et al.*, 2002; Hohoff *et al.*, 2003b) and oral hygiene problems (Fujita, 1979; Årtun, 1987; Hohoff *et al.*, 2003b, c). All of the above restrictions have been reported solely in association with prefabricated lingual brackets.

Customized brackets (CB) are currently undergoing clinical testing (Wiechmann, 2002, 2003; Wiechmann and Wiechmann, 2003; Wiechmann *et al.*, 2003). These are produced after scanning the study model from various perspectives using a high-resolution three-dimensional scanner. The brackets are then designed individually by computer technology and subsequently fabricated by means of rapid prototyping. The bracket bases, which are 0.4 mm thick, are contoured to the lingual surfaces of the teeth, which also permits direct (re-)bonding.

The bracket bodies of the CB have a lower profile than currently available prefabricated lingual brackets (Figure 1).

The aim of the present study was to investigate whether these differences in profile between prefabricated and CB induce short- and/or long-term differences in oral comfort, speech, mastication and oral hygiene.

Subjects and methods

Forty-two native speakers of standard German (32 females, 10 males; mean age 27.1 years, standard deviation 12.2) were enrolled in this prospective longitudinal study. Exclusion criteria were clefts, dialects, a history of speech or hearing defects, and previous elocution training or speech therapy.

Using a standardized questionnaire, the patients were evaluated for subjective oral comfort, speech, mastication and oral hygiene at the following time points: directly before insertion of the lingual brackets (T0), within 24 hours of bond-up (T1) and 3 months (± 1 week) later (T2). Each question had five possible answers: 'No, not at all' (rating = 1); 'Slightly' (rating = 2); 'Yes, to some extent' (rating = 3); 'Yes, definitely' (rating = 4) and 'No evaluation possible' (rating = 'omitted').

Eighteen of the 42 patients were randomly allocated to a group treated with prefabricated Ormco® seventh generation lingual brackets (Ormco, Amersfoort, The Netherlands) (PB group; Figure 2a). The other 24 were treated with

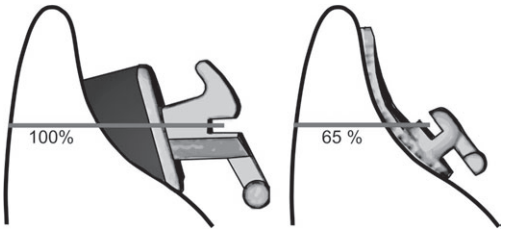

Figure 1 Diagrammatic comparison of the bracket types used in the present study. Left: prefabricated bracket (Ormco® seventh generation); right: customized bracket (Incognito).

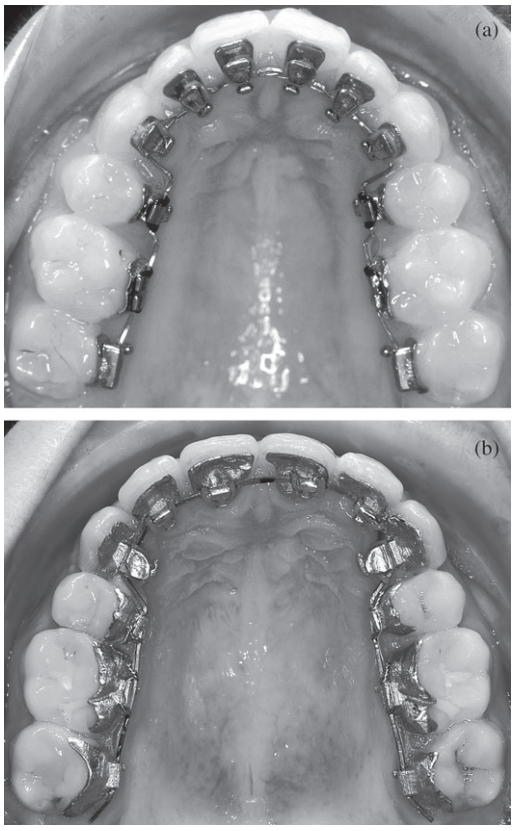

Figure 2 Intra-oral photograph of (a) a patient treated with Ormco seventh generation brackets (prefabricated brackets) and (b) a patient treated with Incognito brackets (customized brackets).

customized Incognito brackets (T.O.P. Service Ormco) (CB group; Figure 2b).

In the PB group, positioning of the lingual brackets on the model had been carried out with Phase II (Reliance Orthodontic Products, Itasca, Illinois, USA).

In the CB group, adhesive strength was enhanced by treating the dental aspect of the brackets with silane (Rocatec, 3M Espe, Seefeld, Germany) and coating it with a layer of Phase II.

After enamel etching the brackets were bonded with Maximum Cure (Reliance) in both groups. This was performed indirectly, using a tray system.

At T1, treatment was confined to the upper arch in both groups. At T2, 50 per cent of the patients in the PB group and 100 per cent of those in the CB group also had lingual brackets in the lower arch.

Statistical analysis

The statistical analysis was undertaken using SPSS 11.0 for Windows (SPSS, Chicago, Illinois, USA).

The Wilcoxon signed-rank test for related samples was used to verify any changes between T0, T1 and T2 in the PB and CB groups. Following Bonferroni adjustment for multiple testing, the significance level for the Wilcoxon signed-rank test was set at $P \leq 0.017$ according to the formula $1 - (1 - \alpha)^{1/n*}$ (Perneger, 1998) (*assuming the primary probability of error to be $\alpha = 0.05$ and the number of tests performed per investigated parameter to be $n = 3$).

The chi-square test was used to detect any inter-dependence between the different test parameters at T0, T1 and T2 in each of the two groups. The number of fields was adapted to the number of subjects by combining possible answers (1) and (2) and possible answers (3) and (4).

The Mann–Whitney *U* test for independent samples was applied to investigate any differences at the respective time points between the PB and CB groups.

For the chi-square and Mann–Whitney *U* tests, $P \leq 0.05$ was defined as significant.

Results

Subjects

The sample comprised 31.0 per cent students, 16.7 per cent academics and 47.6 per cent non-academics. Of the subjects, 4.7 per cent provided no information on their professional status. The PB and CB groups did not differ with respect to education, gender or age.

Answers to questions 1–10 at T0

At T0, no significant intergroup differences were recorded, with all patients in both groups answering questions 1–10 with 'No, not at all'.

Subjective oral comfort

Answers to question 1: 'Do you have a sense of your tongue space being restricted?' (Figure 3a).

The patients in both groups reported a significantly increased restriction of their tongue space from T0 to T1 ($P \leq 0.001$) and a significant improvement from T1 to T2 ($P \leq 0.001$). At T2, the tongue space was still significantly restricted in the PB group in relation to T0 ($P \leq 0.005$), while no significant difference was recorded in the CB group between T2 and T0.

At T1 ($P = 0.007$) and T2 ($P = 0.002$), the patients in the PB group reported significantly more tongue restriction than those in the CB group.

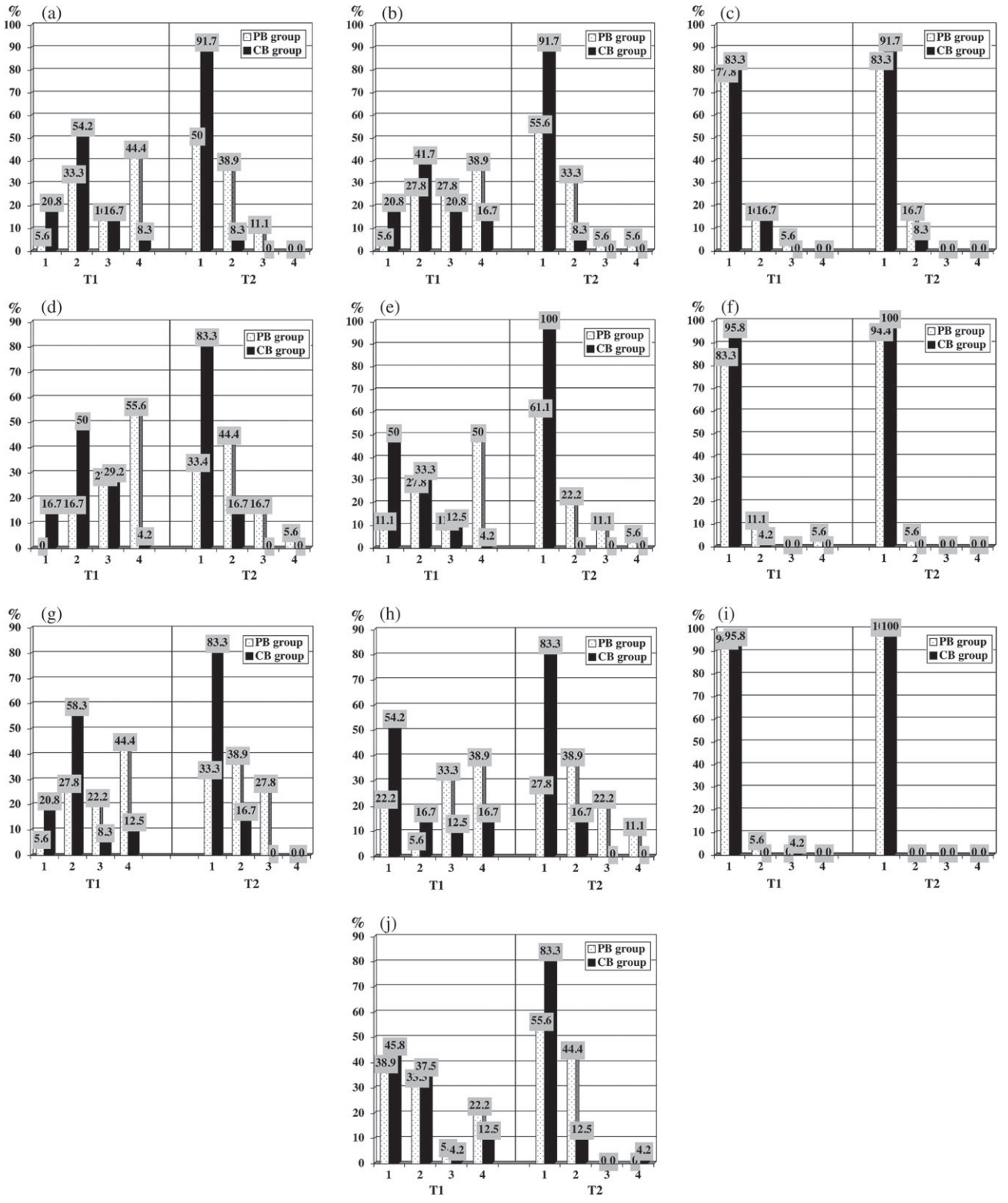

Figure 3 Answers to questions: (a) 1: 'Do you have a sense of your tongue space being restricted?', (b) 2: 'Have you noticed pressure sores, reddening or lesions to your tongue?', (c) 3: 'Has your tongue position changed?', (d) 4: 'Do you feel that your articulation has changed?', (e) 5: 'Has a change in your articulation been noticed in your social environment?', (f) 6: 'Do you avoid specific types of conversation (e.g. on the telephone?)', (g) 7: 'Do you have difficulty in chewing?', (h) 8: 'Do you have difficulty in biting?', (i) 9: 'Do you have difficulty in swallowing liquids?', (j) 10: 'Are lingual brackets an impediment to dental hygiene?'. Possible answers to questions 1–10: 1 = 'No, not at all'; 2 = 'Slightly'; 3 = 'Yes, to some extent'; 4 = 'Yes, definitely'. T1, within 24 hours after placement of lingual brackets; T2, 3 months (± 1 week) thereafter; PB group, patients with prefabricated brackets; CB group, patients with customized brackets.

Answers to question 2: 'Have you noticed pressure sores, reddening or lesions on your tongue?' (Figure 3b).

The patients in both groups reported a significant increase in pressure sores, reddening or lesions on the tongue between T0 and T1 ($P \leq 0.001$) with a significant improvement from T1 to T2 (PB group $P \leq 0.001$; CB group $P \leq 0.001$). At T2, the PB group still suffered significantly more from pressure sores, reddening or lesions than at T0 ($P \leq 0.008$), while no significant differences between T2 and T0 were recorded in the CB group.

At T1, significant intergroup differences with respect to pressure sores, reddening or lesions of the tongue were recorded ($P \leq 0.039$). At T2, some subjects in both groups suffered from pressure sores, reddening or lesions of the tongue, but the patients in the PB group were significantly more often affected than those in the CB group ($P = 0.006$).

Answers to question 3: 'Has your tongue position changed?' (Figure 3c).

There were no significant changes in tongue position reported in either of the groups between T0/T1, T1/T2 or T0/T2.

There were no significant intergroup differences with respect to tongue position at any of the study time points.

Speech

Answers to question 4: 'Do you feel that your articulation has changed?' (Figure 3d).

From T0 to T1 the patients in both groups reported a significant deterioration in their articulation ($P \leq 0.001$). From T1 to T2 articulation improved significantly in both groups ($P \leq 0.001$). At T2, articulation in the PB group was still given a significantly poorer rating than at T0 ($P = 0.002$), while no significant differences were recorded in the CB group.

At T1 ($P \leq 0.001$) and T2 ($P \leq 0.001$) the patients in the PB group gave their articulation a significantly poorer rating than those in the CB group.

Answers to question 5: 'Has a change in your articulation been noticed in your social environment?' (Figure 3e).

From T0 to T1 a significant deterioration in articulation was noticed in the social environment of the PB ($P \leq 0.001$) and CB ($P = 0.002$) groups. From T1 to T2 this improved significantly in both the PB ($P \leq 0.001$) and CB ($P = 0.002$) groups. At T2, however, articulation was still rated as significantly poorer in comparison with T0 in the PB group ($P = 0.016$), whereas no significant differences were recorded in the CB group.

At T1 ($P \leq 0.001$) and T2 ($P \leq 0.001$), a deterioration in the articulation of the PB group was noticed significantly more often than in the CB group.

Answers to question 6: 'Do you avoid specific types of conversation (e.g. on the telephone?)' (Figure 3f).

The conversation pattern of the two groups did not undergo a significant change during the study period, and at none of the study time points was a significant intergroup difference recorded.

Eating

Answers to question 7: 'Do you have difficulty in chewing?' (Figure 3g).

In both groups, mastication deteriorated significantly from T0 to T1 ($P \leq 0.001$). However, it improved significantly in both the PB ($P \leq 0.001$) and CB ($P \leq 0.001$) groups from T1 to T2. In the PB group, mastication was still significantly poorer at T2 than at T0 ($P = 0.002$), while no significant differences were reported in the CB group.

At T1 ($P = 0.004$) and T2 ($P \leq 0.001$), mastication in the PB group was significantly poorer than in the CB group.

Answers to question 8: 'Do you have difficulty in biting?' (Figure 3h).

Ability to bite deteriorated significantly from T0 to T1 in the PB ($P \leq 0.001$) and CB ($P = 0.003$) groups and improved significantly from T1 to T2 in the PB ($P = 0.006$) and CB ($P = 0.003$) groups. At T2, biting was significantly poorer than at baseline (T0) in the PB group ($P \leq 0.001$), while no significant differences were recorded in the CB group.

At T1 ($P = 0.016$) and T2 ($P \leq 0.001$) biting function was significantly poorer in the PB group than in the CB group.

Answers to question 9: 'Do you have difficulty in swallowing liquids?' (Figure 3i).

Within the groups, ability to swallow did not change significantly during the study period. No significant intergroup differences were registered at any time point.

Oral hygiene

Answers to question 10: 'Are lingual brackets an impediment to dental hygiene?' (Figure 3j).

In comparison with T0, oral hygiene was reported to be significantly restricted in both the PB ($P = 0.003$) and CB ($P \leq 0.001$) groups at T1. This assessment improved in the PB ($P = 0.010$) and CB ($P \leq 0.001$) groups from T1 to T2. In comparison with T0, oral hygiene was reported to be significantly impaired only in the PB group ($P \leq 0.005$). There were no significant intergroup differences at any of the registration time points.

Interdependencies between individual parameters (Table 1)

In both groups, interdependencies were recorded between subjective oral comfort and articulation and between subjective oral comfort and mastication.

Discussion

Patients

The majority of patients enrolled in the present study were females less than 40 years of age, typical of the age and gender distribution of lingual orthodontic patients (Fritz *et al.*, 2002; Hohoff *et al.*, 2003e).

In comparison with the PB group, significantly more patients in the CB group were being treated with lingual brackets in both arches at T2. Greater restrictions in respect of all investigated parameters would thus have been expected in the CB group. However, this was not confirmed by the results. It has been reported in the literature that the adaptation period is approximately the same for both arches (Fillion, 1997) and that the amount of tongue soreness and speech difficulty caused by upper lingual bracket application is almost equal to that induced by lower lingual bracket application (Miyawaki *et al.*, 1999).

Subjective oral comfort

Differences in the thickness of the same lingual appliances due to different positioning techniques have been found to have a significant impact on tongue space restrictions and lesions of the tongue (Hohoff *et al.*, 2004). A controlled short-term study showed that the smaller a lingual appliance is in the sagittal dimension, the less pronounced the induced irritations of the tongue (Hohoff *et al.*, 2003d). Accordingly, the flatter customized brackets in the present study induced significantly fewer cases of tongue space restriction, pressure sores, reddening or lesions to the tongue in the long term than the PB with the higher profile. This finding is in agreement with a study of 20 patients who had PB inserted in one dental arch and CB in the other. All 20 patients found the CB considerably more comfortable and reported fewer problems and shorter adaptation times in the arch concerned (Wiechmann, 2002).

The adaptation times quoted by Fillion (1997) and Fritz *et al.* (2002) after the application of prefabricated brackets are shorter than those recorded in the present investigation for the patients in the PB group. This may be due to the possible answers being more detailed or to the prospective design of the present study. The retrospective study by Miyawaki *et al.* (1999), however, documented tongue soreness in 20 per cent of their patients until debonding.

In the present investigation, no significant intergroup differences were found with respect to a changed tongue position. This result can be interpreted in three ways: this parameter was not influenced by the differences in the labiolingual dimension of the tested bracket systems; the patients were unable to quantify the amount of change; or this parameter was subject to a 'yes/no' decision.

Speech

The CB caused significantly fewer speech disturbances than the PB. This is in accordance with the results of a recent study where analysis by speech professionals was applied (Hohoff *et al.*, 2003d).

The agreement in the rating of articulation by the patients themselves in both groups (question 4) as compared with the rating by other persons (question 5) confirms that the changes perceived by the patients were not an outcome of excessive attention being paid to speech-related changes, but had indeed occurred. Prospective studies report good agreement between subjective, semi-objective and objective computerized methods of sonagraphy and auditive analysis with reference to /s/-articulation (Sinclair *et al.*, 1986; Hohoff *et al.*, 2003a), but not to vowel formation (Fujita, 1979). As the latter involves no contact with the teeth, no changes are to be expected *a priori*.

Neither group felt significantly restricted in the ability to converse. Fillion (1997) reported that approximately 6 per cent of patients with lingual brackets felt impaired by this treatment in their social activity, and approximately

Table 1 Prefabricated brackets (PB) group versus customized brackets (CB) group: interdependencies between parameters at different time points. See text and Figure 3 for questions.

Time point	Questions	Parameter + parameter		PB group χ^2 *P* value	CB group χ^2 *P* value
T1	3 + 6	Change of tongue position	Avoidance of conversations	0.000	NS
T2	1 + 4	Tongue space restriction	Articulation, subjective	0.005	NS
T2	1 + 5	Tongue space restriction	Articulation, semi-objective	0.001	NS
T2	2 + 8	Lesions to tongue	Biting	0.016	NS
T1	1 + 4	Tongue space restriction	Articulation, subjective	NS	0.046
T1	2 + 8	Lesions to tongue	Biting	NS	0.028
T1	4 + 8	Articulation, subjective	Biting	NS	0.011

T1, within 24 hours after insertion of lingual brackets; T2, 3 months (± 1 week) later; NS, not significant.

12 per cent in their professional activity. According to Nezhat *et al.* (2003), 8.1 per cent of 51 patients with lingual brackets still rated their ability to speak as notably restricted after 6 months of therapy. Unfortunately, neither the bracket type nor the bonding technique was specified by the authors.

In contrast to the investigation by Sinclair *et al.* (1986), positive interdependencies were established in the present study between lesions of the tongue and speech impairments (Table 1).

Eating

After a 3 month adaptation period, chewing and biting were significantly more impaired in patients with PB than in those with CB.

At T2, the percentage of patients with chewing and biting problems in the CB group (16.7 per cent) was comparable with that reported by Sinclair *et al.* (1986) of 17 per cent. However, the latter study covered only a 1 month period and provided no data on the brackets used. At T2, the percentage of patients with chewing (66.7 per cent) and biting (72.2 per cent) problems in the PB group was higher than that reported previously (Sinclair *et al.*, 1986; Fillion, 1997; Miyawaki *et al.*, 1999; Fritz *et al.*, 2002). This might be due to patients having been interviewed at different time points and to variations in possible ratings for the complaints.

Oral hygiene

No significant intergroup differences were recorded with respect to oral hygiene as assessed subjectively. Clinical studies using an objective rating of oral hygiene in patients with prefabricated lingual brackets show a significant increase in the plaque index after insertion of the appliance (Sinclair *et al.*, 1986). Visible plaque accumulations on the appliance and gingivitis persisting to the end of orthodontic treatment have been reported in up to 70 per cent of patients (Årtun, 1987). However, instruction and motivation can also lead to excellent oral hygiene in lingual patients (Hohoff *et al.*, 2003c).

Conclusions

Patients considering therapy with lingual brackets should be informed of potential restrictions in oral comfort, articulation, mastication and oral hygiene, irrespective of the bracket system. Briefing on the duration and extent of the restrictions to be expected must, however, be differentiated according to the bracket system used. CB with smaller dimensions result, in both the short- and long-term in significantly fewer tongue space restrictions, changes in articulation and difficulties in mastication than PB, and in the long-term induce significantly fewer pressure spots, reddening or lesions to the tongue than the latter.

CB thus make a major contribution to enhanced patient comfort in lingual orthodontics. However, despite their notable advantages, lingual brackets still induce discomfort in a certain proportion of patients, but it is impossible to predict who will be affected.

As changes in the speech of all patients with customized brackets were no longer perceived after 3 months of therapy, this type of bracket seems to be a good treatment tool for patients with ‘speech-intensive’ occupations, who have previously rejected the aesthetically favourable lingual technique for fear of impaired articulation. A controlled study with speech ratings by speech pathologists should be conducted in order to verify the subjective and semi-objective ratings of speech used in the present study.

Clinical studies investigating oral hygiene after insertion of the customized appliance with reference to indices and further results from the clinical testing phase of the brackets have yet to be published.

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