Improving the Speech Function of Maxillary Complete Dentures: A Pilot Study

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Purpose: The aim of this pilot study was to investigate a universal and easy method for improving the speech function of complete maxillary dentures. Specifically, it was analyzed whether sandblasting could improve speech performance, since this process increases the tactile surface area in the region of tongue-to-denture contact. ***Materials and Methods:*** Fourteen volunteers with complete maxillary dentures in a geriatric rehabilitation center (7 men, 7 women, mean age 81.2) were recruited. Speech samples (normal conversation, logopedic standard text, and a word list) were recorded for all subjects. In 11 cases, a specific area of the denture was sandblasted, while the remaining 3 cases served as controls. After 1 week of service, the same speech samples were recorded again. The rating of the speech samples was performed by 2 experienced speech therapists. The rater did not know whether the sample was a control case or whether it was before or after intervention. ***Results:*** The speech therapists found no difference between the 2 speech samples in all 3 cases in the control group. For 8 of 11 subjects, the speech sample after sandblasting was rated better by both therapists ($P = .002$). In 2 subjects, no difference was observed, and deterioration was found in only 1 subject by 1 speech therapist. ***Conclusion:*** Taking into account the limited number of subjects, the results show that sandblasting may lead to moderate improvements in speech performance in most cases. Deterioration is not expected, but in such cases, it is easy to restore the denture with simple polishing. *Int J Prosthodont 2006;19:499–503.*

Human speech is a combination of phonation and articulation.[1] The phonation and production of the voice takes place in the larynx and is a result of oscillations of the vocal cords caused by an air stream. The pitch is primarily determined by the tension of the vocal cords, which are influenced by the muscles of the larynx. After leaving the glottis, the air stream reaches the mouth and throat tract, where articulation takes place. Articulation is the result of changes in variable structures, such as the lips, tongue, mandible, and velum, which lead to changes in the resonance space through which the air stream passes. Consonants can be divided into 3 groups: *(1)* the stops /b, p, d, t, g, k/; *(2)* the fricatives /w, f, s, j, sch/; and *(3)* the nasals /m, n, ng/.[1] Consonants are formed in 3 articulation zones: *(1)* the labial (eg, bilabial /b/, labial-dental /w/); *(2)* the dentals (eg, lingulo-alveolar /s, d/); and *(3)* the gutturals (eg, /g/, lingulo-guttural /j/). If the vocal cords oscillate while forming the consonants, they are called voiced (eg, /w/); if not, they are called voiceless (eg, /f/).[1,2] Vowels are always formed with voiced articulation. When dentures are worn, the action of structures involved in articulation and resonance space are affected,[3,4] which was discussed in the literature as early as 1864.[5] Speech problems are frequently reported after denture placement[6–8]—mainly expressed as problems with consonants, especially a distorted /s/ sound[9,10]—and may remain for years. In the case of implant-retained fixed dentures, the gap between the

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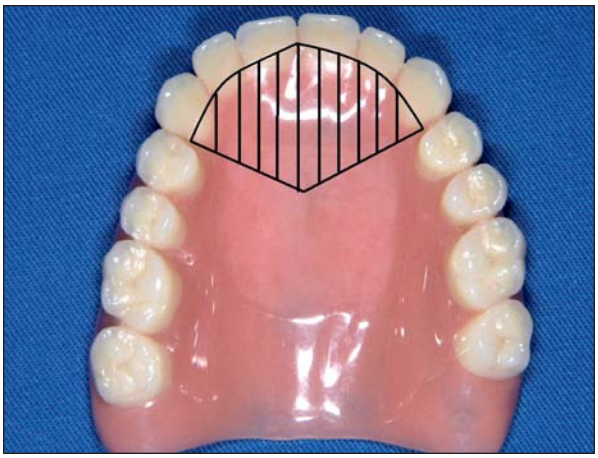

Fig 1 The sandblasted area.

mucosa and the fixed prosthesis is thought to be primarily responsible for speech problems. However, any covering of the palate—including complete dentures or covered dentures supported by teeth or implants—causes alterations in speech.[6,11,12] The contact areas between the palate resin, anterior teeth, first premolars, and tongue are important, as was shown using palatograms.[4,13] The importance of the region between the tubercula of the canines, incisors, and midpalate for articulation has been demonstrated.[14] There have been attempts in the past to describe the factors influencing speech function, and efforts have been made to improve the speech function of maxillary complete dentures. The anterior and molar reverse curve of the resin body,[15,16] a thin palate resin,[17,18] the correct vertical dimension,[4,18,19] and frontal overbite are thought to be important factors for speech function and correct pronunciation of the /s/ sound. Attempts to rebuild the rugae palatinae are controversial.[14,20,21] It was suggested that the tongue needs surfaces with greater tactile stimulation, in analogy to the anatomic structures, such as the rugae palatinae, nonanatomic papilla, or areas with different grades of polishing.[17] The German Oral Health Study demonstrated that there is still a remarkable demand for removable complete dentures, as 25% of the German population between 65 and 74 years of age were found to be edentulous.[22,23] Therefore, the aim of this pilot study was to investigate a universal and easy method for improving the speech function of complete maxillary dentures. Specifically, it was analyzed whether sandblasting could improve speech performance, as this process increases the tactile surface area in the anterior region of tongue-to-denture contact.

Materials and Methods

Subjects

Fourteen volunteers (7 men, 7 women; mean age 81.2 years, range 75 to 85) in a short-term geriatric rehabilitation center with complete or covered maxillary dentures were recruited for this investigation. The subjects gave informed consent. The dentures had been worn for more than 2 years in every case. No subject reported spontaneous loosening of the denture. All dentures had 3 mm or less of anterior resin thickness and an anterior horizontal and vertical overbite of 1 to 3 mm (except for 1 case with a vertical overbite of only 0.5 mm). The subjects did not have dementia or a recent stroke with limitations of speech function. None of the volunteers were in speech therapy.

Design and Procedure

This pilot study was designed as a prospective, double-blind investigation with random distribution of subjects to the control group (3 subjects) or intervention group (11 subjects). Prior to the investigation, the subjects were asked which function of their denture—chewing function, esthetics, speech, or a combination of these—was most important. In addition, the subjects were asked if they had never, rarely, or always had problems with speech. After the questionnaire was completed, speech samples were recorded from all participants (microphone: Sennheiser 500; amplifier: Vivanco MX 510, Sonic Digital Audio Tape 650). Subjects sat in front of the microphone at a distance of about 40 cm. With the help of the amplifier, the optimal setting for the loudness amplitude was obtained. Three speech samples were recorded. First, subjects were led in about 1 minute of normal conversation (half-structured interview) with the investigator. Next, subjects were asked to read a speech therapy standard text with many difficult combinations of consonants. Finally, subjects were given a list of words to read with the sibilants /z/, /s/, and /sch/ at the beginning, intermediate, and end of the word (/z/: "Zeit, Katze, Metz"; /s/: "Summe, Nase, Guss"; /sch/: "Schloss, naschen, lasch"). These sibilants were chosen because of their importance in speech function.

Dentures were then taken into a separate room, and in 11 cases, the palate area between the tubercula of the canines, incisors, and the midpalate was sandblasted (Airsonic Mini-Blaster, Hager & Werken) with aluminum oxide particles with a size of 90 µm, to provide a slightly rough surface (intervention group). The sandblasted area is shown in Fig 1. This area was chosen because an important part of tongue-to-denture contact takes places in this region, and the normal

anatomy of this area shows unevenness. The other areas of the denture were masked. Sandblasting was performed until the surface began to appear dull. The average surface roughness before and after sandblasting was not measured. The 3 dentures used as controls were returned to the subjects without modification. The blindness of the subjects to the intervention was relative, because the rough surface is visibly duller. One week later, all speech samples were recorded again, and the subjects were asked if they had observed a change in speech or tongue sensation.

Speech Therapist Ratings

The speech samples before and after sandblasting were played for 2 experienced speech therapists in random sequence. The speech therapists did not know whether the speech samples were from the control or sandblasted group, or whether speech samples were obtained before or after sandblasting. The speech therapists were played both samples for each subject, and asked to rate whether one of the samples showed better speech performance. They were also asked to rate if this difference was low, intermediate, or obvious. The speech therapists described the difference between the samples in terms of overall speech performance and especially regarding articulation of the sibilants.

Statistical Ratings

Descriptive analysis was performed and the Wilcoxon exact test for dependent samples was used to evaluate the difference between the groups before and after intervention. Because the results from both speech therapists were pooled, a significance level of $P \leq .025$ was chosen (5% probability of error from each rater). In addition, the level of agreement between the 2 speech therapists was calculated using the κ statistic, disregarding possible empty categories. Values above 0.4 were considered "acceptable," and values above 0.6 considered "good."[24] The statistical ratings, except for the κ values,[25] were performed with the aid of SPSS 13.0.1 for Windows (SPSS).

Results

Eight of 14 subjects reported placing an equal level of importance on chewing function, esthetics, and speech, while 5 placed the most importance on chewing function, and 1 emphasized chewing function and speech. All subjects stated that they had never or only rarely had problems with speech. No subjects reported a change in speech function or a difference in tongue sensation after the sandblasting. A higher degree of plaque in the sandblasted areas was not observed after the 1-week period.

Speech Therapist Ratings

The speech performance of 4 of the 14 subjects was rated as "good" by both speech therapists. All other subjects exhibited deficits in articulation or in preciseness of speech. This is in contrast to the fact that 100% of the subjects stated having no problems with speech.

Speech therapists 1 and 2 found no difference between the 2 speech samples in any of the 3 control cases. In 19 of 22 single ratings (11 ratings for both speech therapists) and in concordance, for 8 of 11 subjects, the speech sample after sandblasting was rated better by both therapists ($P < .001$ for single ratings, $P = .002$ for subjects). In 2 single ratings, no difference was found, and deterioration was found in only 1 single rating. There were no cases judged by both speech therapists as deteriorating after sandblasting. In 5 cases, the improvement after sandblasting was judged as intermediate or obvious (by both speech therapists in 3 cases). The single ratings of both speech therapists are shown in Table 1.

For subjects with "good" speech performance, there were only low changes observed after sandblasting. In 1 case, 1 speech therapist rated the speech sample before intervention as better.

The speech therapists' specific comments on the cases, which show better ratings for the intervention group from both speech therapists, are shown in Table 2.

The κ value between the speech therapists' ratings was 0.53 when grouping the specific ratings "low, intermediate, and obvious better/worse" together with the more general "better or worse." When these specific characteristics were considered, the κ value was 0.41. Both values showed an acceptable level of agreement.

Discussion

Limitations of the Study

Because of the sample size, this investigation must be interpreted as a pilot study. The blindness of the raters with respect to the intervention groups and time of intervention was established. The blindness of the subjects with respect to therapy was relative. Although subjects did not know if sandblasting was performed for their denture, the rough surface is duller than the polished areas and could be identified. Alteration of the palatal area of controls, for example with pigmentation, may minimize this problem for further studies on this topic. Considering the age of the subjects, it is possible that speech performance may differ over a 1-week period, independent of the intervention. However, this is qualified, as the 3 control cases were identified by both speech therapists. The average surface roughness of polished and sandblasted areas was not measured.

Table 1 Ratings by the Speech Therapists for the Intervention Group (n = 11)*

	Speech therapist 1				
	SB low worse	No difference	SB low better	SB intermediate better	SB obvious better
Speech therapist 2					
SB low worse	0	0	1	0	0
No difference	0	0	1	0	0
SB low better	0	1	3	1	0
SB intermediate better	0	0	1	0	0
SB obvious better	0	0	0	1	2

*There were no judgments of "SB intermediate worse" or "SB obvious worse" from either speech therapist.
SB = sandblasted.

Table 2 Specific Comments on Subjects from the Intervention Group Who Had Better Ratings After Intervention from Both Speech Therapists (n = 8)

Subject	Lowest rated difference	Comments
1	Obvious	Much more precise sibilants and /l, d, t, n/
2	Low	More precise /s, sch/
3	Obvious	Almost no more air frictional noise with sibilants
4	Low	More precise sibilants
5	Low	Less air frictional noise in sibilants
6	Low	Slightly more precise sibilants
7	Low	Slightly less lisping
8	Intermediate	No more any air frictional noise and more precise articulation overall

Therefore, minor differences between prostheses in the grade of roughness may have occurred. However, it was assumed that the particle size of the material would primarily determine the roughness of the sandblasted areas, and that any minor differences in roughness would not lead to measurable changes in speech performance.

The importance of speech for patient satisfaction with new dentures has been described.[26] It has also been shown that incorporation of dentures affects speech, and familiarization may be a protracted process. In edentulous patients, speech performance without dentures is worse than with dentures, but new complete dentures are not always related to improvement compared to the old dentures.[12] Superior speech performance was found to be related to a denture with better fit, which was independent of whether the subject was satisfied or unsatisfied with the previous denture.[27] Even vocal parameters are influenced by dentures, and there may be unpredictable auditory changes in the voice, depending on the thickness and volume of the denture. It is recommended to inform patients about these possible changes.[18] One study showed that for 2 patients, even the material of the palatal area of complete dentures affected speech, with better intelligibility noted in the perception of listeners when using metal prostheses.[28] In addition, the position of the maxillary central incisors was shown to be important when forming the /s/ sound.[29] It was found that any change of position, especially a labial angulation, caused a poorer execution of the /s/ sound. One study has described a method for contouring the palatal vault to create individualized functional room for the tongue using wax impressions that are then rebuilt with acrylic resin.[15] This method was related to a significantly better speech performance in 80% of cases. The shape of the resin body,[15,16] rebuilding of the rugae palatinae,[14,20,21] and the use of various unpolished areas have been suggested as important for speech function. The aim of this study was to describe a method involving only minor changes to the dentures. In accordance with other studies, only 4 of 14 subjects were awarded a good rating for speech performance by the speech therapists. In contrast, all subjects stated that they had never or only seldom had problems with speech. This may be related to an impaired hearing ability.

Speech performance after sandblasting was rated as better in 8 of 11 subjects by both speech therapists, who were blinded to the intervention. The κ values of agreement between the therapists were acceptable, both for general decisions of better/worse and after the specific characteristics of the ratings were considered (low, intermediate, or obvious better/worse).

However, the difference observed was low in most cases. Only in 3 cases did both speech therapists observe an intermediate or obvious improvement.

Particularly for subjects with good speech performance, there was only a low difference between the samples. On the other hand, there was no rating by both speech therapists that showed deterioration in speech performance after sandblasting. Clearly, sandblasting cannot solve all problems related to speech function; however, the results showed moderate improvement in most cases. Stops and fricatives particularly improved after sandblasting. Future research should examine whether the roughness of the surface modifies this effect. A much rougher surface, using aluminum oxide particles greater than 90 µm, may further affect speech. However, a rougher surface will also increase problems with plaque accumulation, stain, and discoloration. These phenomena were not observed after the 1-week period of this study, but may occur over longer periods.

Conclusions

Taking into account the small sample size, sandblasting may lead to improvement in speech performance, and deterioration is not expected. However, if deterioration takes place, the denture can be easily restored by polishing the roughened surface. An interesting possibility for future research would be to investigate whether this method can reduce speech problems during familiarization with new dentures. There is a continuing need for basic research on speech performance and its relationship to prosthetic parameters.

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