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Functional impression and jaw registration: a single session procedure for the construction of complete dentures*

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SUMMARY **The conventional fabrication of complete dentures involves two separate clinical sessions for functional impression making and jaw registration. The presented method combines both procedures in one session.The aim of this study was to survey the three-dimensional tooth positions in complete dentures with reference to the ridges to establish arbitrary guideline values that could be used for the manufacturing of tooth-position analogue plastic rims on functional impression trays. New complete dentures were fabricated by supervised undergraduate students in the conventional manner for 104 edentulous patients. The position of the maxillary teeth was surveyed in the *horizontal* plane using the Schmuth 'vizor-measuring plate'. The *vertical* dimension of occlusion, represented as the distance between opposing ridge areas of the dentures in maximum intercuspation, was measured at different sites by means of a Gutowski gauge.The tooth positions on the dentures varied widely, e.g. the *horizontal* distances between the incisive papilla and the maxillary incisors was 7·1 ± 2·3 (3–14) mm. The *vertical* dimension of occlusion, which is most important in the jaw registration, varied equally with an anterior inter-alveolar distance between 12 and 33 (20·4 ± 4·0) mm. Arbitrary moulding of the tooth position-analogue plastic rims does not seems to be an ideal method of pre-shaping functional impression trays, because the individual anatomical variation is considerable. Alternatively, the horizontal and vertical tooth positions of functionally and aesthetically pleasing dentures should be measured to pre-shape the rims of functional impression trays in the maxillary and the mandibular jaw. Such trays are a valuable tool for functional impressions and an immediate preliminary jaw registration in the fabrication of new complete dentures. This method allows a first try-in of the full set-up in the third clinical visit without loosing precision.**

KEYWORDS: **complete dentures, functional impression, registration template, impression tray, wax rim, arbitrary tooth position**

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Introduction

In complete denture prosthetics the jaw registration presents a special challenge, because the position of the artificial teeth has to be determined with reference to the vertical dimension, the horizontal jaw relation, the occlusal plane and last but not least aesthetic aspects such as lip support and the smile line. To facilitate this complex and time consuming procedure many attempts were made to pre-shape wax rims or registration templates according to average values. The majority of studies surveyed plaster casts taken from fully dentate subjects (1–12). It was assumed that the ideal tooth position in a complete denture would be where the natural teeth had been. Only a small number of authors investigated the tooth position in complete dentures (7, 10, 13). Measurements of the position of the anterior teeth were taken with reference to the incisive papilla, the first pair of palatal rugae or the midline of the palate. For the mandibular jaw only 'vertical' average values, such as the distance from the incisal edge of the anterior teeth to the vestibule, are available.

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Pre-shaped and arbitrarily moulded denture-like wax rims have also been recommended to improve the quality of the functional impression of the edentulous jaws (14, 15). Gutowski (16), Besimo *et al.* (17), Palla (PRO-COR-technique) (18) and our own group went – with different intentions – one step further and performed a preliminary jaw registration using rim-shaped functional impressions. This technique seemed complicated at first, but proved to be clinically practicable. It is important to note that the described technique does not aim to duplicate the patient's existing denture. Duplicate-dentures have a special range of indications and are constructed accordingly (19–22). The technique described is used to construct *new* dentures in a more rational way by using functional impression trays equipped with tooth-position analogue plastic rims for a preliminary determination of the vertical dimension of occlusion and a final registration of the horizontal jaw relation. This single-session procedure for functional impression, jaw registration and face-bow transfer allows a first try-in of the full set-up in the third clinical visit, when the vertical dimension might be refined in the articulator. There is no loss in quality, in contrast this procedure increases the precision because the functional impression provides a perfect fit for the jaw registration. However, this method requires that acrylic rims are trimmed *on* the functional impressions. Guidelines for the manufacturing of the tooth-position analogue plastic rims might contribute to minimize chairside adjustments, but data available from the literature do not provide enough detail.

Aim

The aim of the present study was therefore to survey the tooth positions in complete dentures in three-dimensions in order to establish guideline values which could be used for the manufacturing of tooth-position analogue plastic rims on functional impression trays.

Materials and methods

A total of 104 edentulous patients consecutively attending the Department of Prosthetic Dentistry of the University of Bonn for new or replacement of complete dentures were included in the study. Exclusion criteria were an obvious jaw discrepancy or pre-prosthetic surgery. The patients consisted of 48 men and 56 women with an average age of 66·2 ± 9·5 (38–89) years and denture-wearing experience between 6 months and 48 years (average 14·6 ± 9·4 years). Undergraduate dental students provided all subjects with new complete dentures under close supervision by staff. All clinical treatment steps followed standard procedures with the exception that no spacer was used to relieve areas of reduced resilience; hence the incisive papilla was visible on the denture bases.

Fig. 1. Orthodontic 'vizor-measuring plate' by Schmuth, which is designed to compensate for parallax. The reading points on the upper denture were exaggerated for visibility.

Gauges

Some of the horizontal measurements were carried out by means of the orthodontic Schmuth (23) 'vizor-measuring plate' (Orthodontische Visiermessplatte nach Schmuth)[†]. This device has a seize of 6 × 1 cm and is designed to avoid misreadings caused by parallax (Fig. 1). In the early 1990s Gutowski and Meyding introduced a mechanical gauge (Präzisionsschieblehre nach Gutowski und Meyding)[‡] which was employed to measure horizontal and vertical distances with reference to the alveolar ridge (16) (Fig. 2). This device was further developed from the 'rim depth detector' by Schreinemakers by adding a vernier-scale (15). Both levers of the gauge are curved to allow vertical

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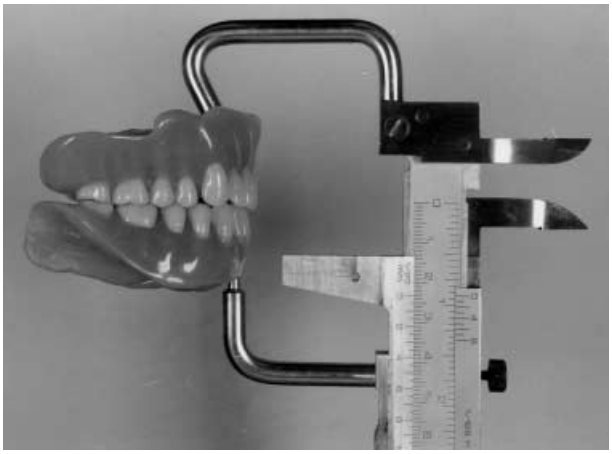

Fig. 2. The interalveolar distance is measured with the dentures in intercuspation using the Gutowski-gauge (incisive papilla to the crest of the mandibular alveolar ridge in the *anterior* area).

measurements from 'inside' the denture. A removable measuring table can be used to measure transversal tooth positions.

Protocol

One operator carried out the survey after the new dentures were remounted. A comprehensive clinical examination was performed including assessment of the interocclusal space between the first right premolars when pronouncing 'S' and when the mandible was in rest position. Furthermore, alveolar ridge resorption was assessed ('good', 'moderately resorbed', 'poor') and the previous and the new set of dentures were compared. Subsequently the dentures were surveyed.

Measurements on maxillary denture

The *horizontal* distances from the tip of the maxillary canines and the mesio-palatal cusps of the first maxillary molars to the palatal midline, which had been copied to the 'outside' of the denture's palate, were determined by means of the Schmuth-plate. Furthermore, the sagittal distances from the incisal edge of the right central incisor to the canine–canine line and the line between both maxillary molars were recorded (Fig. 1, see also Fig. 5).

The *sagittal* distance of the incisal edge of the central incisor from the incisive papilla was quantified by means of the removable measuring table of the Gutowski gauge (see also Fig. 3a).

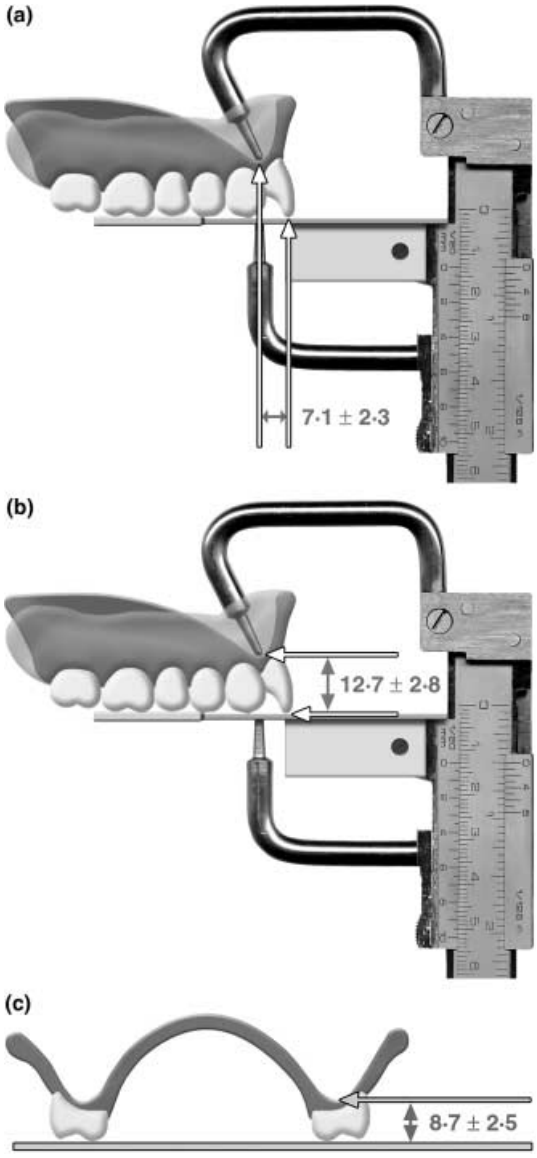

Fig. 3. (a) Sagittal distance of central incisor's incisal edge from the incisive papilla. (b) Vertical distance from the incisive papilla to the incisal edge of the right central incisor. (c) Vertical distance of the mesio-palatal cusp of the first *right* and *left* molars to the crest of maxillary alveolar ridge beneath.

The following *vertical* distances were surveyed on the maxillary dentures using the Gutowski gauge:

1. Incisive papilla to the incisal edge of right central incisor (see also Fig. 3b).
2. Top of denture flange 10 mm lateral of the frenular notch to the incisal edge of right central incisor.
3. Mesio-palatal cusp of the *right* and *left* first molar to the crest of maxillary alveolar ridge, as measured perpendicular under the respective reading point (see also Fig. 3c).

Measurements on mandibular denture

Measurements in the *horizontal* plane were performed using the removable measuring table of the Gutowski-gauge. The *sagittal* distance between the incisal edge of the left central mandibular incisor and the crest of the mandibular alveolar ridge was evaluated. With the measuring table removed the following *vertical* distances were surveyed:

1. Incisal edge of the left central incisor to the crest of the mandibular alveolar ridge (see also Fig. 4).
2. Bottom of denture flange 10 mm lateral to the approximal contact of central incisors to the height of incisal edges of right lateral incisor and mandibular canine.
3. Tip of mesio-vestibular cusp of first mandibular molars to the crest of the mandibular alveolar ridge (see also Fig. 4).

Measurements in maximum intercuspation

Using the previous reading points the following distances were measured with both dentures held in intercuspation:

1. Incisive papilla to the crest of the mandibular alveolar ridge in the *anterior* area (Fig. 2).
2. Top of flange of maxillary denture 10 mm lateral of the frenular notch to the bottom of flange of the mandibular denture 10 mm right of the approximal contact of central incisors.
3. Crest of maxillary alveolar ridge to the crest of mandibular alveolar ridge in *right* molar area.
4. Crest of maxillary alveolar ridge to the crest of mandibular alveolar ridge in *left* molar area.

Accuracy of measurements

To determine the accuracy of the measurements, 10 of the dentures were re-surveyed with 10 of the dentures at a later date, without knowing the first results.

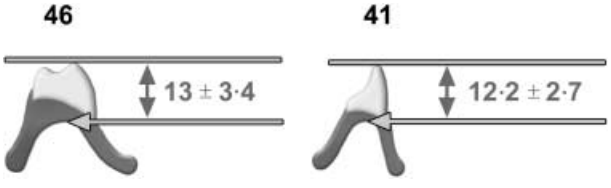

Fig. 4. Distance of mesio-buccal cusp of the first mandibular molar and of the incisal edge of the left central mandibular incisor respectively to the crest of the mandibular alveolar ridge beneath.

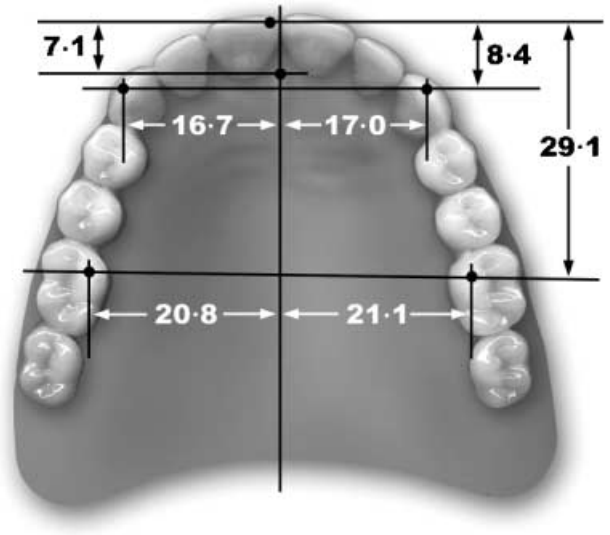

Fig. 5. *Horizontal* distances between the reading points on an upper complete denture measured by means of the vizor-measuring plate.

Statistical analysis

Data were stored in a spreadsheet (Excel Version 5.0, Fa)[§] and further processed in SPSS/PC (Version 6.1.2 for windows, SPSS GMbH)[¶]. Histograms and one-sample Kolmogorov–Smirnov tests were used to verify normal distribution. Accordingly either *t*-test or non-parametric Mann–Whitney *U*-test were used to test non-paired samples. The non-parametric *H*-test (Krukal–Wallis) or the Spearman's rank correlation were employed to reveal any correlations. Differences were considered significant at $P = 0{\cdot}05$ (24).

Results

The clinically estimated average interocclusal distance between the right premolars when pronouncing 'S' was 1·7 ± 1·0 (0·5–4·0) and 3·0 ± 1·5 (1·0–6·0) mm with the mandible in the rest position.

The repeated measurements on the 10 dentures revealed an accuracy of approximately 1 mm for the Schmuth vizor-measuring plate and 0·5 mm for the mechanical measuring gauge by Gutowski and Meyding.

[§]Microsoft, Unterschleißheim, Germany.
[¶]SPSS GMbH Software, München, Germany.

Table 1. Survey of maxillary dentures ($n = 104$)

From ⇔ to	Mean ± s.d.	Minimum	Maximum
Horizontal distances (Schmuth-plate/measuring table of Gutowski-gauge) [mm]			
Maxillary incisor ⇔ maxillary canine–canine line	8·4 ± 0·9	6	11
Maxillary incisor ⇔ maxillary molar–molar line	29·1 ± 1·7	20	34
Maxillary *right* canine ⇔ palatal midline	16·7 ± 1·6	8	20
Maxillary *left* canine ⇔ palatal midline	17·0 ± 1·6	8	20
Maxillary *right* molar ⇔ palatal midline	20·8 ± 3·0	16	31
Maxillary *left* molar ⇔ palatal midline	21·1 ± 3·3	16	32
Maxillary incisor ⇔ incisive papilla	7·1 ± 2·3	3	14
Vertical distances (Gutowski-gauge)			
Maxillary incisor ⇔ incisive papilla	12·7 ± 2·8	5	21
Maxillary *right* molar ⇔ maxillary alveolar ridge	8·7 ±2 ·5	2	16
Maxillary *left* molar ⇔ maxillary alveolar ridge	9·0 ± 2·3	4	15
Top of maxillary flange ⇔ maxillary incisor	23·1 ± 2·9	15	30

Table 2. Survey of mandibular dentures ($n = 104$)

From ⇔ to	Mean ± s.d.	Minimum	Maximum
Horizontal distances (measuring table of Gutowski-gauge) [mm]			
Mandibular incisor ⇔ mandibular alveolar ridge	3·0 ± 1·7	0	6
Vertical distances (Gutowski-gauge) [mm]			
Mandibular incisor ⇔ mandibular alveolar ridge	12·2 ± 2·7	7	19
Mandibular *right* molar ⇔ mandibular alveolar ridge	13·0 ± 3·4	6	20
Mandibular *left* molar ⇔ mandibular alveolar ridge	13·0 ± 3·3	5	20
Level of incisal edges of *right* mandibular lateral incisor and canine ⇔ mandibular flange	15·1 ± 2·1	9	21

Table 3. Survey with maxillary and mandibular dentures held in maximum intercuspation ($n = 104$)

From ⇔ to	Mean ± s.d.	Minimum	Maximum
Vertical distances (Gutowski-gauge) [mm]			
Incisive papilla ⇔ mandibular alveolar ridge *Anterior area*	20·4 ± 4·0	12	33
Maxillary alveolar ridge ⇔ mandibular alveolar ridge *Right first molar area*	20·5 ± 4·3	9	34
Maxillary alveolar ridge ⇔ mandibular alveolar ridge *Left first molar area*	20·7 ± 4·0	9	32
Maxillary flange ⇔ mandibular flange	35·4 ± 3·6	27	45
Relation of maxillary and mandibular front teeth (ruler) [mm]			
Vertical overlap	2·8 ± 1·1	0	8
Horizontal overlap	4·4 ± 1·8	1	11

Results from the survey are listed in Tables 1–3 and in Figs 3–5. Distances in men were found on average 1–2 mm longer than in women, a difference that proved significant for the following parameters:

1. Tip of *right* and *left* maxillary canine to the palatal midline (horizontal, $P < 0·01$).
2. Mesio-palatal cusp of *right* and *left* maxillary first molar to the palatal midline (horizontal, $P < 0·01$).
3. Distance from right and left mesio-palatal cusps of first maxillary molars to the incisal edge of maxillary right central incisor (horizontal, $P < 0·01$).
4. Incisive papilla to the incisal edge of maxillary right central incisor (vertical, $P < 0·05$).
5. Top of maxillary flange 10 mm lateral of the frenular notch to the bottom of mandibular flange 10 mm right of the approximal contact of central incisors (vertical, $P < 0·01$).

6. Crest of mandibular alveolar ridge to the incisal edge of mandibular left central incisor (vertical, $P < 0{\cdot}05$).

Neither the denture-wearing experience, the degree of ridge resorption, nor the age of the patient showed a consistently significant correlation to the width of the dental arch or the total height of the denture.

Discussion

Critique of method

The accuracy of mechanical measurements used in this study seems limited when compared with sophisticated optical or electronic recording methods. However, the precision of the vernier scale already seems to exceed the level of clinical relevance. Furthermore the method is easy to apply in clinical and/or laboratory use.

Flattened occlusal surfaces or a perpendicular deviation between tooth position and alveolar ridge, as caused by progressive ridge resorption, create difficulties with measurements.

In retrospect it would have been interesting to investigate the vertical distance of the occlusal plane in relation to the hamular notch and the retromolar pad. As the latter areas resorb very little they might have been valuable reference points contributing to a reduced variability of data. However, no studies on this matter are known, only recommendations have been published (18, 25).

Literature review

Early studies investigated large numbers of dentate subjects to determine average values for the purpose of fabricating wax rims for full dentures. It was assumed that the ideal tooth position in a complete denture would be where the natural teeth had been. Only a small number of authors investigated the tooth position in complete dentures. Although both approaches are interesting to compare, the data from complete dentures seem more relevant in our opinion.

Average values for the *sagittal* distance from the central incisors to the incisive papilla were reported to be between 5 and 13 mm (1, 5, 7–10). The average *transversal* distance from the canines to the palatal midline ranged from 9 to 11 mm (5, 7, 10). For the mandible, only Faber (26) published data on the position of premolars and molars in relation to the alveolar ridge. No other data on the horizontal tooth position with respect to anatomical structures are available, to the best of our knowledge.

In dentate subjects the mean distance of the incisal edges from the vestibule was described as 18–20 mm in the maxillary denture and 16–17 mm in the mandibular denture (3). To our knowledge, there is only one study on the 'height' of complete dentures which investigates the stretch of the incisal edges from the deepest point of the flange (13). Yet the denture's flange seems a difficult reading point, because it is rarely parallel to the incisal edges or the occlusal plane and in addition, might vary depending on the impression technique used (27). Thus data are difficult to compare between studies. It seems that the 'height' of denture's premolar and molar teeth has not been studied.

Interpretation of data

The data indicates an enormous inter-individual variability, and so meticulously prepared functional impression trays with tooth-position analogue plastic rims might still need considerable adjustments when in clinical use. The variability of the present data is similar to reports in the literature. Other authors have also concluded that average values should be used for the fabrication of functional impression trays only when no existing functionally adequate denture of good appearance is available for an individual survey (16, 18). The significantly longer distances measured in men came as no surprise because of the usually smaller body size in women which reflects in a smaller jaw.

The use of average values for the fabrication of wax rims or registration templates is still rare in dental laboratories. A possible explanation might be that the equipment for measurements with reference to the incisive papilla is not widely available. Guidelines on the height of the lateral wax rim are only indirectly available via the average anterior height and the occlusal plane determined in relation to the hamular notch or retromolar pad. Further reasons for the limited use of arbitrarily pre-shaped wax rims might be lack of demand. However, the present results provide sufficient information to facilitate the fabrication of functional impression trays with tooth-position analogue plastic rims, which are arbitrarily pre-shaped not only in the anterior but also in the lateral area.

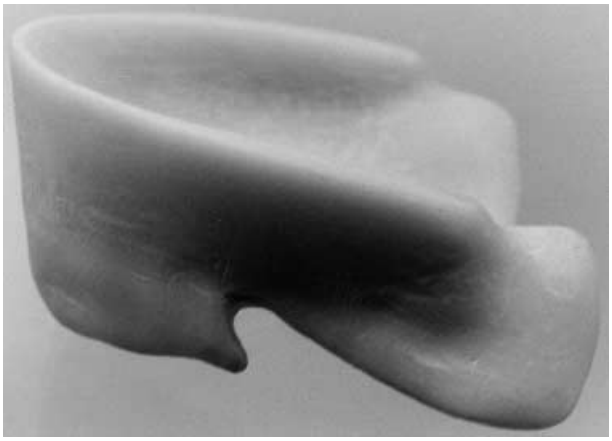

Fig. 6. Arbitrary functional impression trays for the upper jaw with tooth-position analogue acrylic rims.

Fig. 7. Arbitrary functional impression trays for the lower jaw with tooth-position analogue acrylic rims.

Conclusions

Tooth-position analogue plastic rims on impression trays (Figs 6, 7) have essential advantages for the functional impression of the edentulous jaw. First, they can be considered as a kind of piezograph and thus help to tailor dentures into the edentulous space, of which the positive effect on adaptation and function is well documented. Secondly, they serve as a handle that does not conflict with the peri-oral muscles. In addition they support the material used to mould the outer seal. Furthermore, aesthetic aspects such as lip support are considered at an early stage. Last but not least, the single procedure for functional impression and jaw registration proved clinically and technically advantageous: the lining with impression material does provide rigid retention which is very convenient for the jaw registration. Another advantage is that the acrylic rims do not deform at mouth temperature like wax rims do.

The present study indicates that the anatomical and morphological variability from patient to patient might still necessitate a considerable amount of adjustment when using arbitrarily moulded impression trays/registration templates, so the survey of an existing denture is preferred to the use of arbitrary data. They can be surveyed by means of the Gutowski-gauge and planned alterations could be introduced at this stage. Individual data provide sufficient information for the technician to construct functional impression trays with tooth-position analogue plastic rims that require very little chair-side adjustments.

If the occlusal plane and the border moulding of the existing maxillary denture are perfect, the dentures could even be duplicated as a base for individualized functional impression tray with tooth-position analogue plastic rims. The transition between both techniques is smooth.

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