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REFERENCE VALUES ON HISTORICAL ANTHROPOLOGICAL SKULL SAMPLES FOR PLANNING OF MANDIBULAR REPLACEMENTS (METHODOLOGICAL CONSIDERATIONS)

S. PONYI AND GY. SZABÓ

Department of Oral and Maxillofacial Surgery, Semmelweis University of Medicine, H—1085 Budapest, Mária u. 52, Hungary

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Abstract

36 reference points and two contours on historical anthropological mandibles, and methods for the determination of their dimensions, are reported. Measurements have been made on 528 mandibles and will be evaluated for a computer data bank. The measurement data will be classified and averaged by computer and will be used for the planning of a series of mandibular replacements. Mandibles with average sizes will be selected from an anthropologically processed collection, and impressions of these taken for the preparation of wax models, the final refinements of which will give the actual series of mandibular prostheses. The data bank may also be used for the planning of dental implants better fitting the anatomical conditions. Accordingly, the practical aims and methodological considerations for their achievement are reported in the present article, while the results will be discussed in a subsequent paper.
Key words: Human skulls, mandibular dimensions, measurement devices, computer data, mandibular prostheses.

Introduction

Surgical correction of the facial deformities occurring in the maxillo-facial region often necessitates the utilization of mandibular replacements. Different biotolerant materials, e.g. metals, Al_2O_3 ceramics, etc., play a more and more important part in the rehabilitation of mandibular deficiencies and deformities due to tumor or trauma. For the planning and preoperative preparation of mandibular prostheses made from bioinert materials, it is of great advantage to determine the mandibular dimensions of a large sample of skulls of different age and sex from an anthropologically processed collection.

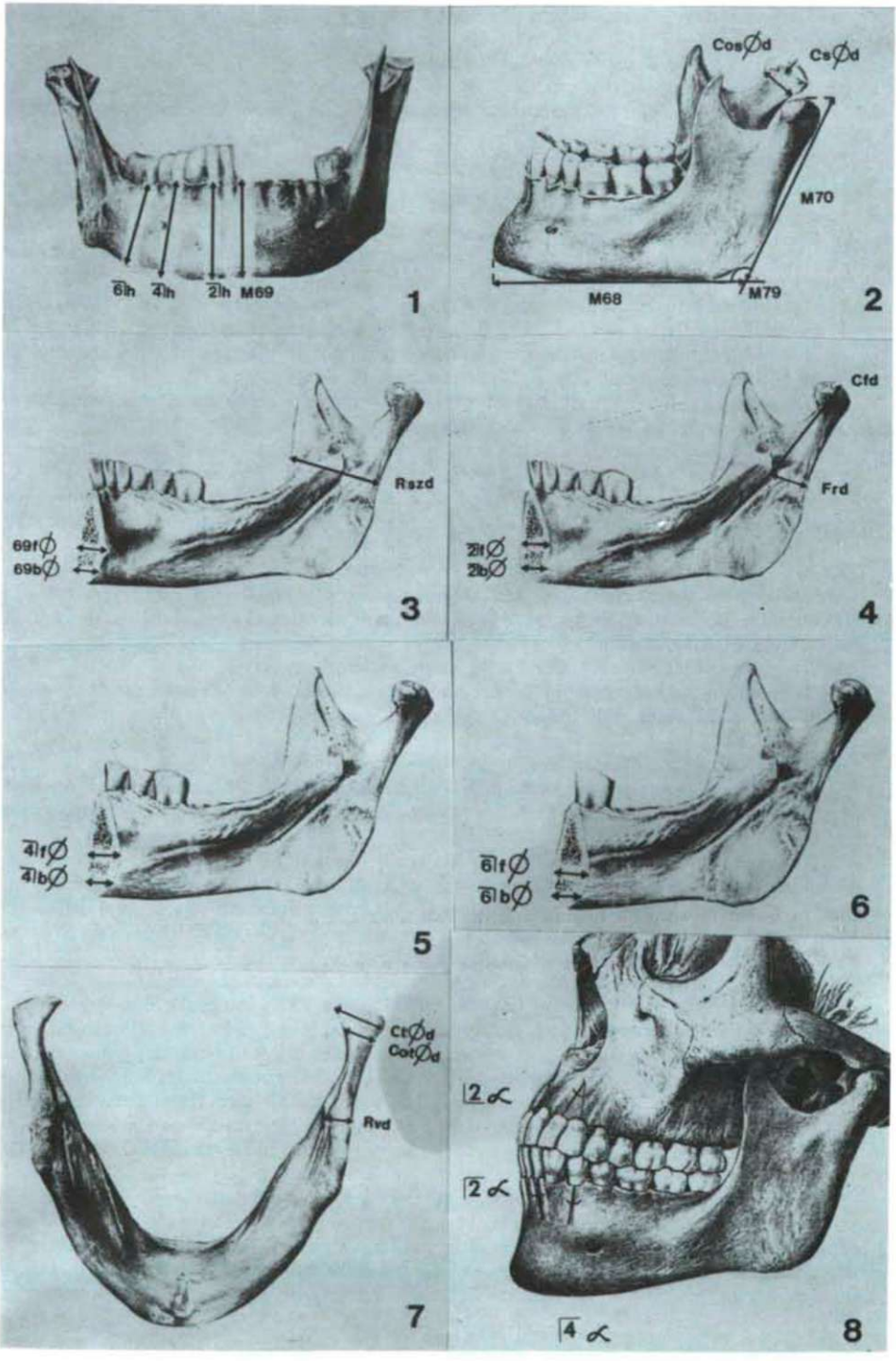
Following the measurement and computer data processing of the precisely determined dimensions, it is possible to prescribe, with the help of statistical methods, a series of mandibular condyle and corpus prostheses.

Materials and methods

528 well-preserved, European, 8th—16th-century A. D. skulls with intact mandible were evaluated from the anthropologically processed collection of the Department of Anthropology, A. J. University, Szeged. Careful sample selection was made to facilitate the creation of an informative computer data base suitable for medical biometric processing (FARKAS, 1968; JUVANCZ, 1970; BÉKY, 1971).

For classification of the dimensions of the mandibles, the following measurements were considered important for the planning of mandibular prostheses:

1. The infradentale (id) gnathion (gn) height (Martin no. 69) (M69, Fig. 1).
2. The height of the corpus mandibulae from the lower edge of the mandibular base to the alveolar margin, on the left and right sides, measured in the axis of 12, perpendicularly to the base ($\lceil\overline{2}$h and $\overline{2}\rceil$h; see $\overline{2}\rceil$h in Fig. 1).
3. The height of the corpus mandibulae from the lower edge of the mandibular base to the alveolar margin, on the left and right sides, measured in the axis of P1, perpendicularly to the base ($\lceil\overline{4}$h and $\overline{4}\rceil$h; see $\overline{4}\rceil$h in Fig. 1).
4. The distance of the lower edge of the mandibular base from the alveolar margin in the axis of the left and right M1, perpendicularly to the base ($\lceil\overline{6}$h and $\overline{6}\rceil$h; see $\overline{6}\rceil$h in Fig. 1).
5. The angle of inclination of the frontal surface of the alveolar process of the mandible to the straight line perpendicular to the Frankfurt horizontal plane measured with a goniometer following reconstruction of the occlusal relation, fixation of the mandible to the skull and setting of the Frankfurt horizontal plane; from the alveolar edge to the apical part of the root, on the left and right sides, in the axis of 12 ($\lceil\overline{2}\alpha$ and $\overline{2}\rceil\alpha$; see $\lceil\overline{2}\alpha$ in Fig. 8).
6. The angle of inclination of the frontal surface of the alveolar process of the mandible to the straight line perpendicular to the Frankfurt horizontal plane, measured from the alveolar edge to the apical part of the root, on the left and right sides, in the axis of P1 ($\lceil\overline{4}\alpha$ and $\overline{4}\rceil\alpha$; see $\lceil\overline{4}\alpha$ in Fig. 8).
7. The distance of the protruding edge of the chin from the straight lines laid on the posterior margins of the two gonions (Martin no. 68) (M68, Fig. 2).
8. The mandibular angle (Martin no. 79) (M79, Fig. 2).
9. The ramus height: rectilinear distance of the gonion (go) from the highest point of the capitulum mandibulae (Martin no. 70) (M70, Fig. 2).
10. The alveolar bend of the mandibular ridge, marked in the middle of the lower jaw ridge between the two most medial points of the foramen mentale on both sides, projected at right angles to the alveolar ridge (ml, Fig. 17).
11. The alveolar bend of the mandibular ridge, marked in the middle of the lower jaw ridge, between the center line and the two most medial points of the foramen mentale on both sides, projected at right angles to the alveolar ridge (mls and mld, Fig. 17).
12. The radii of the circles best fitting the alveolar bend of the mandibular ridge, on the left and right sides, measured between the midline and the two most medial points of the foramina mentale projected at right angles to the alveolar ridge (mrs and mrd, Fig. 18).
13. The greatest width of the corpus mandibulae at the height of the foramina mentale, measured in the axis of the symphysis mandibulae (69fØ, Fig. 3).
14. The greatest width of the corpus mandibulae at the height of the foramen mentale, measured in the axis of the left and right 12 ($\lceil\overline{2}$fØ and $\overline{2}\rceil$fØ; see $\overline{2}\rceil$fØ in Fig. 4).
15. The greatest width of the corpus mandibulae at the height of the foramen mentale, measured in the axis of the left and right P1 ($\lceil\overline{4}$fØ and $\overline{4}\rceil$fØ; see $\overline{4}\rceil$fØ in Fig. 5).
16. The greatest width of the corpus mandibulae at the height of the foramen mentale, measured in the axis of the left and right Ø1 ($\lceil\overline{6}$fØ and $\overline{6}\rceil$fØ; see $\overline{6}\rceil$fØ in Fig. 6).
17. The base width of the mandible, measured at a distance of about 3 mm from the base, in the axis of the midline between the two I1 (69bØ, Fig. 3).
18. The base width of the mandible, measured at a distance of about 3 mm from the base, in the axis of the left and right I2 ($\lceil\overline{2}$bØ and $\overline{2}\rceil$bØ; see $\overline{2}\rceil$bØ in Fig. 4).
19. The base width of the mandible, measured at a distance of about 3 mm from the base, in the axis of the left and right P1 ($\lceil\overline{4}$bØ and $\overline{4}\rceil$bØ; see $\overline{4}\rceil$bØ in Fig. 5).


6h 4h 2h M69
1
CosØd
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2
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5
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20. The base width of the mandible, measured at a distance of 3 mm from the base, in the axis of the left and right Ø1 ($\overline{6}$bØ and $\overline{6}$| bØ; see $\overline{6}$| bØ in Fig. 6).

21. The base contour of the mandible (Fig. 12B).

22. The lateral contour of the mandible (Fig. 12C).

23. The greatest transversal diameter of the left and right capitulum mandibulae (CtØs and CtØd; see CtØd in Fig. 7).

24. The greatest sagittal diameter of the left and right capitulum mandibulae (CsØs and CsØd; see CsØd in Fig. 2).

25. The transversal diameter of the collum mandibulae at the height of the sagittal diameter, measured perpendicularly to it on the left and right sides (CotØs and CotØd; see CotØd in Fig. 7).

26. The smallest sagittal diameter of the collum mandibulae on the left and right sides (CosØs and CosØd; see CosØd in Fig. 2).

27. The distance between the highest point of the capitulum mandibulae and the lowest point of the foramen mandibulae on the left and right sides (Cfs and Cfd; see Cfd in Fig. 4).

28. The width of the ramus mandibulae, on the left and right sides, measured at the height of the lowest point of the foramen mandibulae (Rszs and Rszd; see Rszd in Fig. 3).

29. The transversal width of the dorsal side of the ramus mandibulae, on the left and right sides, at the height of the foramen mandibulae (Rvs and Rvd; see Rvd in Fig. 7).

30. The rectilinear distance of the foramen mandibulae from the dorsal side of the ramus mandibulae, measured at right angles on the left and right sides (Frs and Frd; see Frd in Fig. 4).

31. The length of the external arc of the mandibular base contour on the left side between the center line and the most medial point of the foramen mentale, projected at right angles to the external arc (lfks, Fig. 19).

32. The radius of the circle that best fits the above arc length (rfks, Fig. 20).

33. The length of the external arc of the mandibular base contour on the left side between the most medial point of the foramen mentale, projected at right angles to the external arc, and the extremity of the external arc (lvks, Fig. 19).

34. The radius of the circle that best fits the above arc length (rvks, Fig. 20).

35. The length of the internal arc of the mandibular base contour on the left side between the center line and the most medial point of the foramen mentale, projected at right angles to the internal arc (lfbs, Fig. 19).

36. The radius of the circle that best fits the above arc length (rfbs, Fig. 20).

37. The length of the internal arc of the mandibular base contour on the left side between the most medial point of the foramen mentale, projected at right angles to the internal arc, and the extremity of the internal arc (lvbs, Fig. 19).

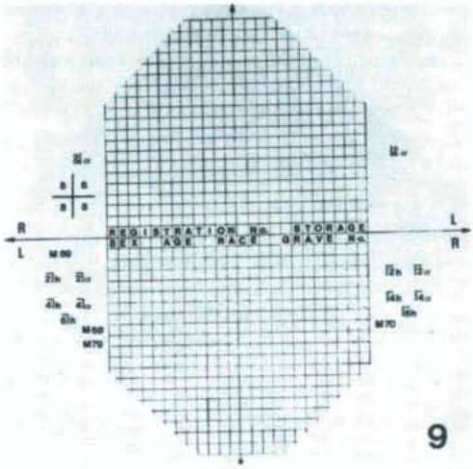
38. The radius of the circle that best fits the above arc length (rvbs, Fig. 20).

Anthropologically defined anatomical points and experience emerging from previous studies of the lower jaw were employed for the better comparison and classification of the measurements of the human mandibles (TÖRÖK, 1890, 1898, 1899; SOMOGYI, 1953; MARTIN and SALLER, 1957; BERNAU and KÖNING, 1968; MOORE et al., 1968; FAGOS et al., 1973).

The dimensions were determined with anthropometric instruments, e.g. slide gauge, calipers, goniometer, mandibulometer (MARTIN and SALLER, 1957; FARKAS, 1972), etc. in the following way:

a) Celluloid transparencies were prepared for the evaluation of the alveolar bend of the mandibular ridge and for the simultaneous recording of the acquired measurement data. Short designations of the dimensions were marked on the transparencies (Fig. 9 and 11), while the identifying data, registration number, age, sex, storage site, etc. were recorded on foil sheets attached to them (Fig. 10 and 12). Figure 13 shows the determination of the alveolar bend of the lower jaw ridge. The mandible to be measured was fixed in a mandibulometer, the transparency with a foil sheet was placed on the mandibular ridge, and the arch was simply marked with a permanent pen.

b) The length of a part of the alveolar bend was determined with a simple device. Thin steel wire was passed through a disposable hypodermic needle, the major part of which had previously been cut off, and the end of the wire was marked with a cross. The cross mark was fitted to the origin of the arch, the flexible wire was laid on the bend, and the cone of the needle was slid to the extremity (Fig. 14). The wire was then straightened out and the length of the arch was read off a scale paper.



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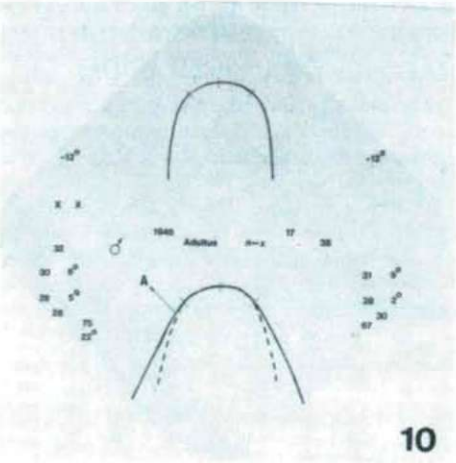

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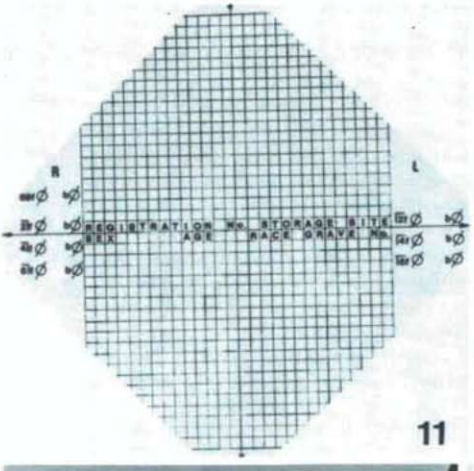

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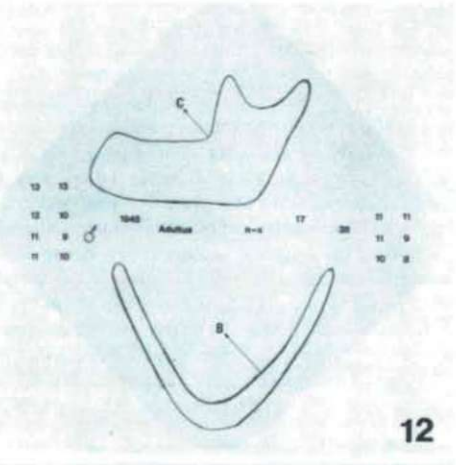

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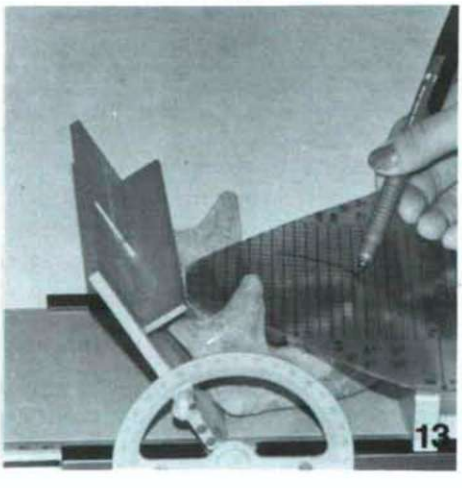

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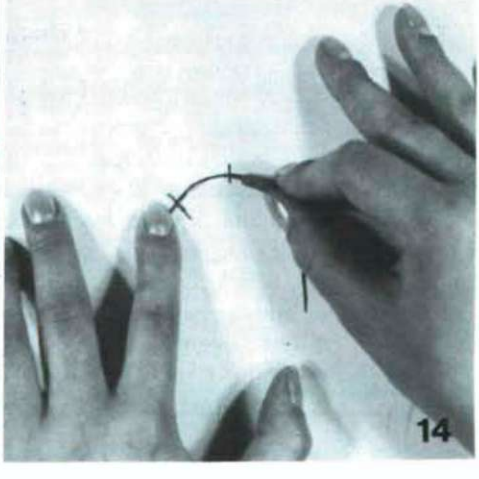

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c) The radius of the circle best fitting a part of an arch was given with two other home-made transparencies. The bisectors of the square measuring devices were marked with a mm scale. The upper edge of one of the transparencies was placed as tangent to the origin of the arch (Fig. 15), while the other was similarly laid tangentially to the extremity (Fig. 16). At the intersection of the bisectors, their lengths were read off the mm scales and averaged, and this average was taken as the radius of the circle that best fits the alveolar ridge. Special transparencies are often used in many fields of clinical practice, e.g. Orthogrids in orthodontics for obtaining rapid measurements from a cephalometric radiograph (MCEWEN and MARTIN, 1967).

Two mandibular contours were established:

d) The mandible to be examined was placed on a piece of graph paper and was pressed down at the premolar-molar region with the left hand. The base of the mandible was followed precisely, and the contour was simply drawn with a sharp pencil with the right hand. The center line and the foramina mentale were marked and the contour was also copied onto the foil record for examination (Fig. 12B).

e) A camera and a cephalostat (PONYI and NYILASI, 1971) were used for the determination of the other mandibular contour. With regard to the occlusal relations, the mandible was taped to the skull and a 10 cm piece of copper wire was fixed to the mandibular corpus. The skull was placed in the cephalostat and, from a distance of 152 cm, the measuring distance of lateral cephalograms, a lateral photograph was taken with a 135 mm teleobjective (Fig. 21). After processing of the film, the negative was put in an enlarger and the picture was enlarged with the help of the 10 cm copper wire to 1:1 size. The contour was drawn on graph paper and was copied onto the foil record for examination, too (Fig. 12C). The lateral mandibular contours achieved in this way will later be used for comparison with those of X-ray cephalograms to derive further measurement data (NITSCHE and VÁLYI, 1955; SAVARA et al., 1966).

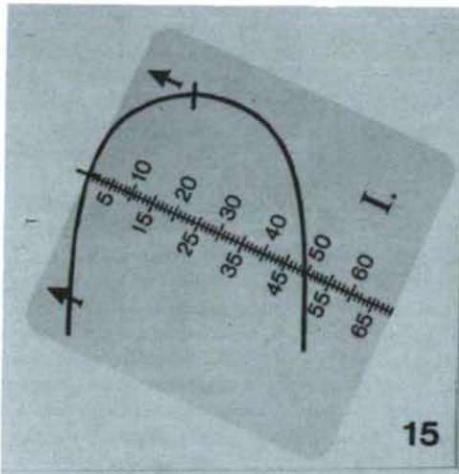
f) For the measurement of the angle of inclination of the frontal surface of the alveolar process of the mandible, a craniophore, a positioner needle and a goniometer were used. Only those skull samples were examined in which the dentition was satisfactorily intact for fixation of the mandible to the skull with regard to the accurate occlusal relation. The skull was stabilized in the craniophore, it was set in the Frankfurt horizontal plane with the positioner, and the measurements were made with the goniometer (Fig. 22). The alveolar edges of the upper and lower jaw ridges and the frontal surfaces of the alveolar processes at the height of the apical part of the dental roots, in the axes of the upper and lower I2 and the lower P1 on both sides, were established as the measuring points of the angle of inclination. The angles were measured to the straight line perpendicular to the Frankfurt horizontal plane. Angles anterior to this straight line were taken as positive, and those posterior to it as negative.

Classification of the measured dimensions and percentage frequency analysis were performed by computer. The measurement data were then displayed in charts, and the class medians and their percentage distribution representing the sample were also calculated.

Discussion

On the basis of the determined mandibular dimensions, the preparation of wax models of mandibular replacements is planned, with average sizes equal to the class medians. With the help of the created computer database, that number of mandibles required in the replacement series, with dimensions corresponding to the averages for the class medians, are to be chosen from the anthropologically processed collection of the Department of Anthropology, A. J. University, Szeged. Impressions will then be taken from the selected mandibles for the preparation of wax models. Final refinement of these, according to the calculated average dimensions, will give the actual replacement series.

The most up-to-date procedure known for the planning of mandibular replacements is three-dimensional CT imaging and subsequent computer modeling



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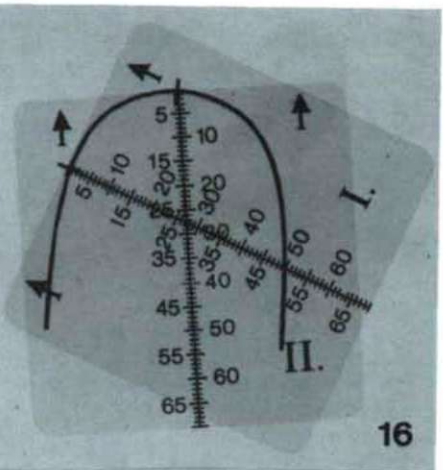

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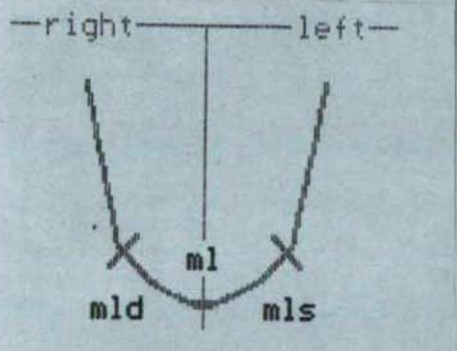

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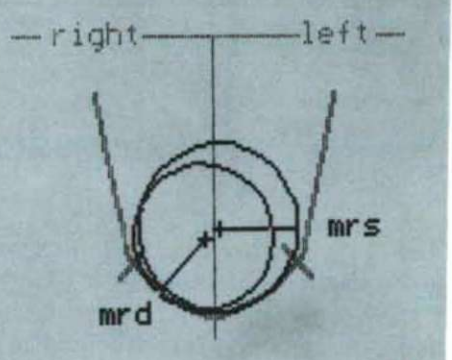

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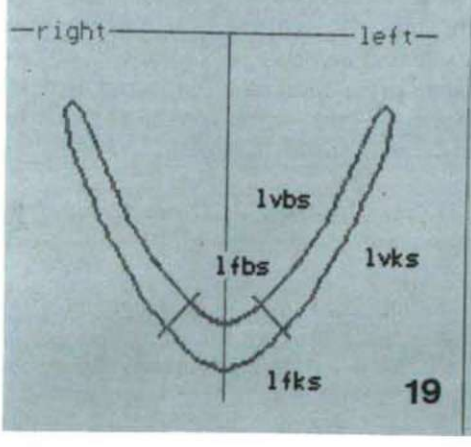

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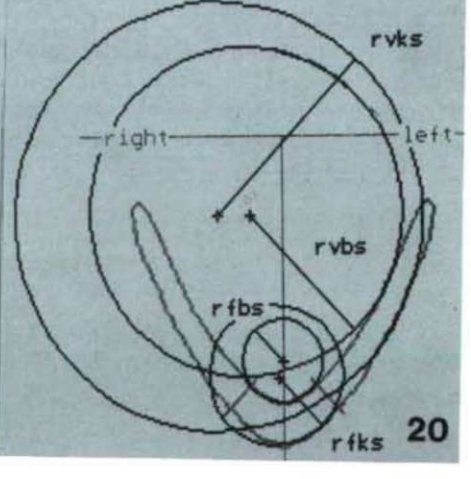

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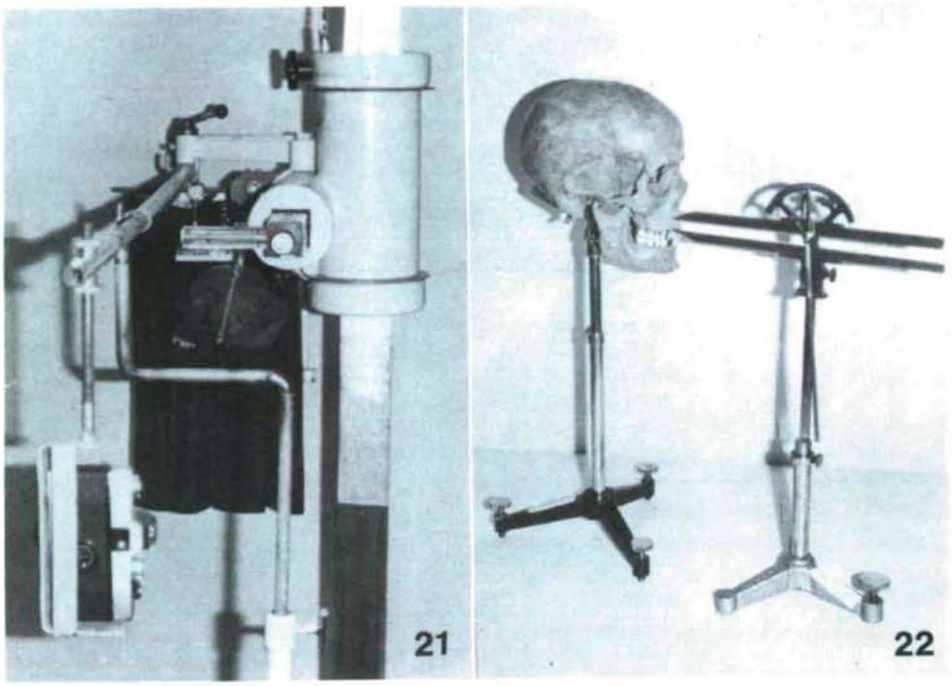

(LOBREGT and SCHAARS, 1987; TANAKA et al., 1988), which is today very costly and frequently inaccessible.

Our method, however, offers an alternative possibility for predetermination of the dimensions of factory-produced mandibular prostheses. A knowledge of the percentage distributions of the measurement data facilitates stipulation of the numbers of the various types of mandibular replacement to be produced.

The future broadening of our computer databank is planned, utilization of which is equally valuable for scientific studies of, for example, the differences between the dimensions of the left and right sides, the two sexes, the dimensions of skulls from different historical periods and different archeological sites, etc., and for practical aims. Apart from the planning of mandibular replacements, the measurement data provide information that is of great value for the planning of dental implants better fitting the anatomical conditions of the jaws.

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