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Anatomic site evaluation of the zygomatic bone for dental implant placement

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Key words: bone mineral density; trabecular bone pattern factor, trabecular bone volume; zygomatic bone; zygomaticus implant

Abstract: Thirty human zygomatic bone specimens (15 females mean age 81.60 ± 11.38 years, 15 males, mean age 78.47 ± 6.58 years) were examined by quantitative computed tomography and histomorphometry. The aim of the study was to assess the bone mineral density, the trabecular bone volume and the trabecular bone pattern factor. Moreover, the anterior-posterior and the medio-lateral dimensions and the estimated implant length within the zygomatic bone were determined. For quantitative computed tomography the specimens were scanned together with a bone mimicking anthropomorphic reference phantom. The bone mineral density was calculated for the specimens in the plane of the intended direction of the implant placement. Subsequently, with the sawing and grinding technique, the specimens were prepared in the same plane for histomorphometry. The trabecular bone mineral density was 369.95 ± 188.80 mg/cm^3 for the female and 398.94 ± 99.11 mg/cm^3 for the male specimens ($P = 0.23$). The male trabecular bone volume showed a value of 27.32 ± 9.49%, while the female group reached a value of 19.99 ± 7.60% ($P = 0.23$). The trabecular bone pattern factor was $1.2 \times 10^{-2} \pm 1.28$ mm^{-1} for the male and 1.02 ± 0.96 mm^{-1} for the female specimens ($P = 0.045$). The study reveals that the zygomatic bone consists of trabecular bone with parameters that are unfavourable for implant placement. However, the success of implants placed in the zygomatic bone is secured by the employment of at least four cortical portions.

Date:
Accepted 12 November 2001

To cite this article:
Nkenke E, Hahn M, Lell M, Wiltfang J, Schultze-Mosgau S, Stech B, Radespiel-Tröger M, Neukam FW. Anatomic site evaluation of the zygomatic bone for dental implant placement
Clin. Oral Impl. Res, **14**, 2003; 72–79

ISSN 0905-7161

The use of endosseous implants has become a standard procedure in the treatment of complete and partially edentulous patients. Rehabilitation of the masticatory function with dental implants can be achieved with predictable success in various clinical situations. However, the problem of insufficient height and width of the alveolar ridge at the implant site remains. Inadequate bone volume is caused by resorption following extraction, trauma, infection, pneumatization of the maxillary sinus and ablative tumour surgery (Von Arx & Kurt 1998).

Several surgical procedures have been developed to increase the bone volume. Autogenous bone grafts, guided bone regeneration, allogenic material and combinations of these procedures are used in order to overcome insufficient bone volume. These techniques have in common that they require an additional operation site or that an increased number of infections are likely to occur (Schlegel et al. 2000). Especially bone grafting is a common procedure to increase the bone volume. The grafts can be harvested from different intra- and extraoral regions. The donor sites are often related to complications such as sensitivity disorders, haematomas and postoperative pain (Nkenke et al. 2001). Moreover, to obtain high success rates, a two-stage procedure with delayed implant placement is recommended (Lundgren et al. 1999). The result is an increased number of operations, which reduce the patients' comfort.

Therefore, the use of alternative implant sites for the masticatory rehabilitation of the maxilla has been advocated to reduce the necessity of bone grafting procedures. The placement of dental implants in the zygomatic bone is well known from preprosthetic surgery following ablative tumour surgery (Vuillemin et al. 1990; Izzo et al. 1994; Roumanas et al. 1994; Evans et al. 1996; Weischer et al. 1997). The clinical use in patients with severely resorbed posterior maxillae has been described (Reichert et al. 1999). The zygomaticus implant passes through the sinus close to the crista zygomaticoalveolaris. It is placed slightly palatal in the region of the second premolar and its apex perforates the cortical portion of the zygomatic bone close to the angle between the zygomatic arch and the processus frontalis (Stella & Warner 2000).

To date, there is a lack of information on the dimension and the microstructure of the zygomatic bone. Therefore, the aim of the present study was to evaluate quantity and quality of bone of the zygomatic complex in human specimens by means of quantitative computed tomography and histomorphometry.

Material and methods

In all, 30 left zygomatic bones (15 male, 15 female) were examined (Fig. 1). The age of the deceased subjects ranged from 57 to 91 years (mean age 80.47 ± 9.30 years). They had bequeathed their bodies to the Anatomic Institute I of the University of Erlangen-Nuremberg for medical-scientific research and training purposes. The reason for death was unknown. All patients were edentulous.

For quantitative computed tomography the specimens were scanned in a Spiral CT (Somatom Plus 4, Siemens, Erlangen, Germany) in the plane of the intended direction of implant placement. The samples were placed in water together with a reference phantom. This phantom (European Forearm Phantom, EFP) is composed of three sections, each containing geometric-

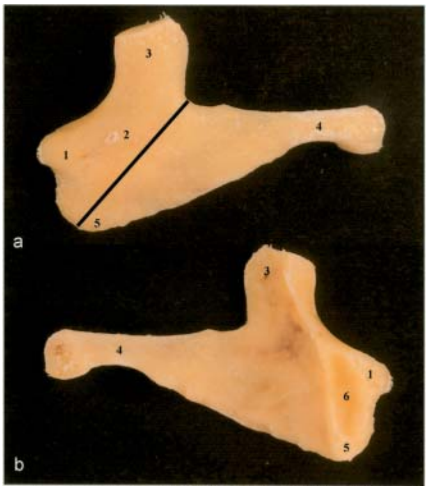

Fig. 1. Zygomatic complex. a) Facial surface (black line: plane of the intended direction of the implant placement). b) Medial surface. 1) Infraorbital rim. 2) Foramen of the nervus zygomaticofacialis. 3) Processus zygomaticofrontalis. 4) Zygomatic arch. 5) Crista zygomaticoalveolaris. 6) Maxillary sinus.

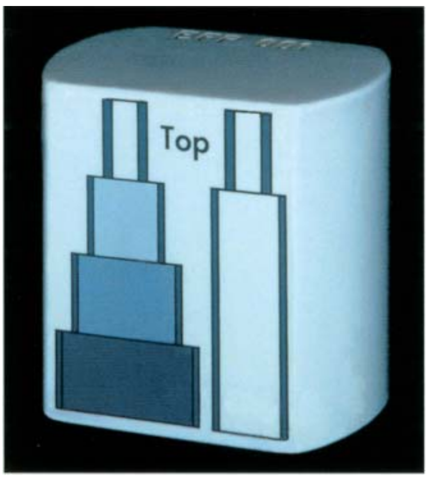

Fig. 2. European forearm phantom (EFP).

ally defined anthropomorphic structures (Fig. 2). Water-equivalent plastics are used together with calcium hydroxyapatite, which simulates bone tissue. Cortical and spongiosa densities and thicknesses are varied from section to section, offering a range of spongiosa densities from 50 to 200 mg hydroxyapatite/cm^3. The true values for all measured quantities are well defined (Kalender & Suess 1987; Kalender et al. 1989, 1995).

The zygomatic bones were scanned contiguously with a 1-mm slice thickness. 1.5 mm pitch, 170 mA, 120 kV, and a field of view (FOV) of 75 mm were chosen. The rotation time was 1.5 s. The field of view

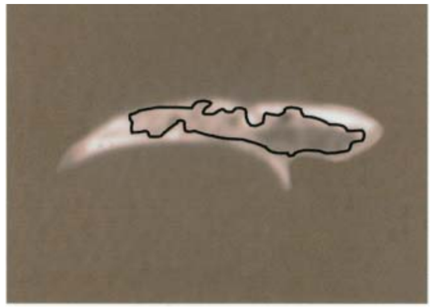

Fig. 3. Computed tomography section in the intended plane of the implant placement with the region of interest bordered by a black line.

Fig. 4. Histologic specimen sliced in the intended plane of the implant placement (Trichrome-Masson-Goldner-staining, original magnification ×1.25). 1) Anterior-posterior length. 2) Medio-lateral thickness. 3) Estimated implant length within the zygomatic bone.

covered an area of 75 mm^2. A high resolution kernel (AH 70) was used. A reconstruction increment of 1 mm was applied. In the computed tomography images the region of interest was marked in the axial slices bordering the trabecular bone portion (Fig. 3). Two slices were added together and the Hounsfield units (HU) computed. From the Hounsfield units measured for the reference phantom, a regression line was calculated, which was used to assess the corresponding values for the trabecular bone mineral density in mg/cm^3 of the zygomatic bones (Moegelin et al. 1993).

After fixation in Schaffer's solution (two parts 96% ethanol, one part 37% formaldehyde) 5-mm-thick sections were sawn in the region of the second premolar perpendicular to the crista zygomaticoalveolaris in the plane of the intended direction of implant placement. The undecalcified sections were embedded in Technovit 7200 VCL (Heraeus Kulzer, Wehrheim, Germany). Ground sections 30 μm thick were produced with a diamond band-saw and a microsectioning system (Exakt-Apparatebau, Norderstedt, Germany) (Donath

1988). A Trichrome-Masson-Goldner-staining was performed (Fig. 4). With a videocamera, images were assessed at a magnification of $\times 12.5$. The images were transferred into an automatic image analysing system (IBAS 2000, Kontron-Zeiss, Munich, Germany). They were transformed into binary images. Measuring field boundaries of the trabecular bone were defined and artefacts such as air bubbles within the plastic resin or scratches were eliminated from the image. The measuring field area, the bone area and the bone perimeter were assessed for the subsequent calculations. A programmed dilation of the trabeculae was carried out with a median filter to calculate the trabecular bone pattern factor (TBPf). This dilation resulted in a thickening of all trabecular margins by 1 pixel (Hahn et al. 1992; Ulm et al. 1999). Subsequently, a second measurement of the bone area and the bone perimeter was performed. The following histomorphometric parameters, which are based on the plate-like trabeculae model, were calculated:

The trabecular bone volume (= trabecular bone volume per tissue volume = BV/TV = evaluation of the stained cancellous bone, as compared to the total area of the image detail; %);

The cortical bone volume (= cortical bone volume per tissue volume = evaluation of the stained cortical bone, as compared to the total area of the image detail; %);

The trabecular bone pattern factor (TBPf), which describes the extent of the intertrabecular connectivity. The trabecular bone pattern factor is based on the idea that the connectedness of cancellous bone structures in a two-dimensional section can be described by the relation of convex to concave surfaces. Concave surfaces represent a well connected spongy lattice, while convex surfaces indicate a poorly connected trabecular lattice. The calculation formula (bone perimeter − dilated bone perimeter/bone area − dilated bone area; mm^{-1}) reveals that the intertrabecular connectivity is the higher, the lower the value of the trabecular bone pattern factor (Parfitt 1962; Parfitt et al. 1987; Hahn et al. 1992; Kneissel et al. 1994; Ulm et al. 1995, 1999).

Additionally, on the histological specimens the maximum anterior-posterior length (distance between the middle of the cortical layer of the maxillary sinus and the most peripheral point of the specimen), the maximum medio-lateral width of the zygomatic bones (distance between the medial and the lateral cortex tangent to the cortical layer of the maxillary sinus), the maximum thickness of the buccal cortical portion and the estimated maximum implant length within the zygomatic bones in the plane of the intended implant direction (distance between the middle of the cortical layer of the maxillary sinus parallel to the crista zygomaticoalveolaris) were assessed (Fig. 4). All histological specimens were checked for the occurrence of the nervus zygomaticofacialis.

Statistics

Multiple measurements per sample at identical points of time were aggregated prior to analysis using the mean as aggregation measure. Mean values are given with standard deviation. For comparison of continuous variables in unpaired small samples, the Mann–Whitney-test was used. The Spearman correlation coefficient was calculated for evaluation of a possible association between continuous covariates without assumption of normal distribution. A multiple linear regression was performed for evaluation of a possible predictability of mineral bone density by measuring the CT bone density. P-values equal to or smaller than 0.05 were considered significant. All calculations were made using SPSS Version 10 for Windows (SPSS Inc., Chicago, IL, USA).

Results

The female specimens ranged in age from 57 to 91 years (81.60 ± 11.38 years), the male specimens from 70 to 89 years (78.47 ± 6.58 years). The differences in age were not statistically significant ($P = 0.11$). The results from the quantitative computed tomography measurements and the histomorphometric analysis are reported in Tables 1 and 2. The trabecular bone mineral density (BMD) was slightly higher for the male than for the female group (398.94 ± 89.11 mg/cm^3 and 369.95 ± 188.80 mg/cm^3, respectively, $P = 0.23$).

The histomorphometrically assessed trabecular bone volume (BV/TV) was lower for the female than for the male specimens (19.99 ± 7.60% and 27.32 ± 9.49%, respectively). However, the values did not differ significantly ($P = 0.06$). The trabecular bone pattern factor (TBPf) showed a significant difference between male and female specimens ($1.2 \times 10^{-2} \pm 1.28\,mm^{-1}$ and $1.02 \pm 0.96\,mm^{-1}$, respectively, $P = 0.045$). The cortical bone volume did not differ for both of the groups (female 83.18 ± 8.87%, male 83.68 ± 6.35%, $P = 0.90$).

Table 1. **Results of quantitative computed tomography and histomorphometry**

Sex	*n*	Mean age (years)	Bone mineral density of the trabecular portion (BMD, mg/cm^3)	Trabecular bone volume (BV/TV,%)	Trabecular bone pattern factor (TBPf, mm^{-1})	Cortical bone volume BV_{CORT} (%)
Female	15	81.60 ± 11.38	369.95 ± 188.80	19.99 ± 7.60	1.02 ± 0.96	83.18 ± 8.87
Male	15	78.47 ± 6.58	398.94 ± 99.11	27.32 ± 9.49	$1.2 \times 10^{-2} \pm 1.28$	83.68 ± 6.35
P-value	/	0.11	0.23	0.06	0.045	0.90

Table 2. **Morphometric analysis**

Sex	*n*	Anterior-posterior length (mm)	Medio-lateral thickness (mm)	Thickness of the lateral corticalis (mm)	Estimated implant length within the zygomatic bone (mm)
Female	15	25.40 ± 2.64	7.60 ± 1.45	1.71 ± 0.52	14.00 ± 3.10
Male	15	24.93 ± 4.67	8.00 ± 2.26	1.75 ± 0.66	16.53 ± 4.55
P-value	/	0.92	0.98	0.98	0.08

Table 3. **Analysis of correlation according to Spearman**

		Age	BMD	TBPf	BV/TV	BV_{CORT}
Age						
Female	Spearman's correlation coefficient	1.000	0.284	0.018	0.147	0.199
	significance (two-way)	/	0.305	0.949	0.600	0.476
Male	Spearman's correlation coefficient	1.000	− 0.336	− 0.271	0.864	0.004
	significance (two-way)	/	0.221	0.328	0.328	0.990
BMD						
Female	Spearman's correlation coefficient	0.284	1.000	− 0.668	0.775	/
	significance (two-way)	0.305	/	0.007	0.001	/
Male	Spearman's correlation coefficient	− 0.336	1.000	− 0.034	0.395	/
	significance (two-way)	0.221	/	0.904	0.145	/
TBPf						
Female	Spearman's correlation coefficient	0.018	− 0.668	1.000	− 0.821	/
	significance (two-way)	0.949	0.007	/	< 0.0005	/
Male	Spearman's correlation coefficient	− 0.271	− 0.034	1.000	− 0.749	/
	significance (two-way)	0.328	0.904	/	0.001	/
BV/TV						
Female	Spearman's correlation coefficient	0.147	0.775	− 0.821	1.000	/
	significance (two-way)	0.600	0.001	< 0.0005	/	/
Male	Spearman's correlation coefficient	0.048	0.395	− 0.749	1.000	/
	significance (two-way)	0.864	0.145	0.001	/	/
BV_{CORT}						
Female	Spearman's correlation coefficient	0.199	/	/	/	1.000
	significance (two-way)	0.476	/	/	/	/
Male	Spearman's correlation coefficient	0.004	/	/	/	1.000
	significance (two-way)	0.990	/	/	/	/

BMD = trabecular bone mineral density, TBPf = trabecular bone pattern factor, BV/TV = trabecular bone volume, BV_{CORT} = cortical bone volume.

Table 4. **Analysis of correlation according to Pearson**

		Age	BMD	TBPf	BV/TV	BV_{CORT}
Age						
Female	Pearson's correlation coefficient	1.000	0.218	− 0.023	0.141	0.143
	significance (two-way)	/	0.436	0.935	0.617	0.612
Male	Pearson's correlation coefficient	1.000	− 0.413	− 0.345	0.100	− 0.085
	significance (two-way)	/	0.126	0.208	0.722	0.763
BMD						
Female	Pearson's correlation coefficient	0.218	1.000	− 0.625	0.779	/
	significance (two-way)	0.436	/	0.013	0.001	/
Male	Pearson's correlation coefficient	− 0.413	1.000	− 0.204	0.359	/
	significance (two-way)	0.126	/	0.465	0.189	/
TBPf						
Female	Pearson's correlation coefficient	− 0.023	− 0.625	1.000	− 0.855	/
	significance (two-way)	0.935	0.013	/	< 0.0005	/
Male	Pearson's correlation coefficient	− 0.345	− 0.204	1.000	− 0.821	/
	significance (two-way)	0.208	0.465	/	< 0.0005	/
BV/TV						
Female	Pearson's correlation coefficient	0.141	0.779	− 0.855	1.000	/
	significance (two-way)	0.617	0.001	0.000	/	/
Male	Pearson's correlation coefficient	0.100	0.359	− 0.821	1.000	/
	significance (two-way)	0.722	0.189	< 0.0005	/	/
BV_{CORT}						
Female	Pearson's correlation coefficient	0.143	/	/	/	1.000
	significance (two-way)	0.612	/	/	/	/
Male	Pearson's correlation coefficient	− 0.085	/	/	/	1.000
	significance (two-way)	0.763	/	/	/	/

BMD = trabecular bone mineral density, TBPf = trabecular bone pattern factor, BV/TV = trabecular bone volume, BV_{CORT} = cortical bone volume.

Spearman's rank correlation coefficient was used to assess relationships between the different measured parameters. A significant correlation was found between the trabecular bone volume (BV/TV) and the trabecular bone pattern factor (TBPf) (female $P < 0.0005$, male $P = 0.001$). However, the trabecular bone mineral density (BMD) and the trabecular bone pattern factor (TBPf) correlated only for the female specimens (female $P = 0.007$, male $P = 0.904$) (Table 3).

Pearson's correlation coefficient was used to determine whether different parameters can be predicted by one another. In the female group the trabecular bone mineral density (BMD) can be used to predict the trabecular bone volume (BV/TV)

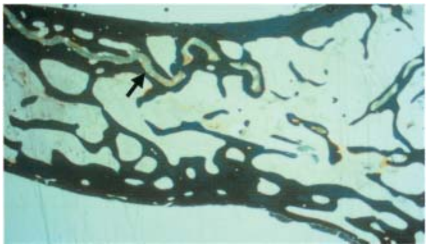

Fig. 5. Nervus zygomaticofacialis (arrow) within the zygomatic bone (Trichrome-Masson-Goldner-staining, original magnification ×5).

and the trabecular bone pattern factor (TBPf) ($P = 0.001$ and $P = 0.013$, respectively). Moreover, the trabecular bone pattern factor (TBPf) can be used to predict the trabecular bone volume (BV/TV) and vice versa ($P < 0.0005$). In the male group only the trabecular bone pattern factor (TBPf) can be used to predict the trabecular bone volume (BV/TV) and vice versa ($P < 0.0005$) (Table 4).

The average anterior-posterior length was the same for female and male specimens (female 25.40 ± 2.64 mm, male 24.93 ± 4.67 mm, $P = 0.92$). The medio-lateral thickness was less pronounced for the female group (female 7.60 ± 1.45 mm, male 8.00 ± 2.26 mm, $P = 0.98$). The average thickness of the lateral corticalis showed no differences between male and female group (1.75 ± 0.66 mm and 1.71 ± 0.52 mm, respectively, $P = 0.98$). The estimated implant length within the zygomatic bone was higher for the male specimens (male 16.53 ± 4.55 mm, female 14.00 ± 3.10 mm). However, a statistically significant difference could not be found ($P = 0.08$). In 11 of the male and eight of the female specimens the nervus zygomaticofacialis was encountered (Fig. 5).

Discussion

The use of the zygomatic bone as an implant site in conjunction with ablative surgical procedures has been described several times before (Parel et al. 1986; Vuillemin et al. 1990; Izzo et al. 1994; Roumanas et al. 1994; Evans et al. 1996; Weischer et al. 1997). Recently, this implant site has been adopted for patients with extremely resorbed maxillae. The clinical use of zygomatic bone implants has been established successfully (Reichert et al. 1999). The aim of this procedure is to avoid shortcomings arising from grafting procedures.

The classic anatomic sites for implant placement in the mandible and maxilla have been studied extensively by histomorphometry (Razavi et al. 1995). However, information concerning bone quality and quantity of the zygomatic bone is difficult to achieve (Triepel 1922). To date, an anatomic site evaluation of the zygoma with state-of-the-art techniques is not available. Therefore, the aim of the present study was to assess morphology and microarchitecture by quantitative computed tomography and histomorphometry.

Bone density is one of the decisive factors that influence the survival rate of dental implants. The measurement of this parameter is an important tool in the diagnostic evaluation of patients to assess the skeletal status. The techniques of measuring bone mineral density have been improved significantly over the recent years. Quantitative computed tomography is considered the method of choice, because it provides a high precision (McClean et al. 1990; Klemetti & Vainio 1993; Moegelin et al. 1993; Kalender et al. 1995). While daily quality control and constancy checks have been addressed appropriately by each single manufacturer, problems still exist in the comparability of results obtained from different CT units. There are no generally accepted calibration standards and there are no agreed procedures for measurements of patients and evaluation of images. Therefore, when quantitative computed tomography is applied, the decisive factor is the use of a calibration phantom (Cann & Genant 1980). This serves to control the apparatus stability and to provide a calibration standard for conversion of CT numbers, measured in Hounsfield units (HU), into density values, usually expressed in mg/cm^3. Calcium hydroxyapatite is used as bone-equivalent material. The aim is to obtain quantitative results independent of scan parameters or scanner condition and to compare results obtained on different scanners (Kalender & Suess 1987). Reference values for spongiosa densities have been reported in a large number of trials on quantitative computed tomography studies (Block et al. 1989; Kalender et al. 1989). However, BMD-values for the zygomatic bone cannot be find in the literature. The study reveals values that are lower than measurements for the mandible as determined by Moegelin et al. (1993). Quantitative computed tomography of the maxilla is difficult to achieve according to the current literature. Only HU can be obtained (Yilderim et al. 1998). However, due to the described problem of calibration their use seems not to be reasonable, when different measurements have to be compared. Therefore, at the moment a comparison of the trabecular bone mineral density assessed in the present study to the maxilla is not possible.

Histomorphometrically, structures are described in general by their porosity, density, and the configuration of several structure elements. Many parameters for the estimation of bone structure have been established. However, the most important parameter is still the bone volume (BV/TV) (Parfitt et al. 1987). Measurement and calculation of this value are easy and essential for the understanding of osteopenias and other pathological conditions. Nevertheless, by using it, a complete characterization of the trabecular lattice is impossible. Early changes in the trabecular bone structure, such as small perforations, cannot be detected. Only progressive disturbances in the trabecular bone structure can be demonstrated. The degree of connectivity of spongy bone is determined mainly by the number of perforations. A perforation is the complete, osteoclastic penetration of plate- or rod-like trabeculae. Therefore, the trabecular bone pattern factor has been introduced to quantify the connectedness of the trabecular bone. The lower the value, the higher the stability of the bone (Hahn et al. 1992). This assumption is supported by the results of the present study, which show a correlation between trabecular bone mineral density (BMD) and the trabecular bone pattern factor (TBPf). Ulm et al. (1999) found values of $0.123 \pm 1.68\,\text{mm}^{-1}$ for female and $-0.708 \pm 1.72\,\text{mm}^{-1}$ for male specimens in the region of the first premolar of the maxilla. Compared to these investigations the values for the trabecular bone pattern factor of the zygomatic bone were higher (female specimens $1.02 \pm 0.96\,\text{mm}^{-1}$, male specimens $1.2 \times 10^{-2} \pm 1.28\,\text{mm}^{-1}$, Table 1), i.e. less favourable for implant placement.

The dependence of bone density on sex has been shown before (Parfitt et al. 1983; Klemetti & Vainio 1993; Kneissel et al. 1994; Ulm et al. 1994, 1995). However, in the present study this relationship could not be found for the measured parameters.

Although more favourable values were measured for the male zygomatic bones, the differences were not statistically significant. It seems that reduction of bone density and rarefication of trabeculae, which are normally more pronounced in women, affect both sexes to the same extent where zygomatic bone of edentulous individuals is concerned.

The determination of the dimensions of the zygomatic bone showed a medio-lateral thickness of 7.60 ± 1.45 mm for the female and 8.00 ± 2.26 mm for the male specimens (Table 2). Therefore, the placement of a zygomaticus implant of 4.5 mm in diameter should leave more than 1 mm of bone around the implant. However, the study of Jensen et al. (1992) reveals the dependence of the medio-lateral thickness on the race of the patients. They examined the zygomatic bones of Indian people and found average values of 4.4 mm, which seem to be critical for implant placement.

When the amount of bone provided by the zygomatic complex is confined, the computer-assisted insertion of the zygomaticus implants has been proposed. Based on spiral computed tomography data, a navigation system can be installed for the preoperative planning and intraoperative control of insertion of the implants. The preoperative planning is supported by 3D-visualization of the anatomic sites and virtual positioning of the implants. By guiding the drill in the intended direction, the clinical procedure of the implant placement can be carried out with an improved precision (Schramm et al. 2000).

In the histological specimens of the present study the nervus zygomaticofacialis is encountered frequently. Therefore, it seems that during the clinical procedure of implant placement a damage of this nerve is likely to occur. Sensitivity disorders of the malar skin following implant placement in the zygomatic bone have been reported. (Reichert et al. 1999).

Success rates of 65% to 75% have been described for implants placed solely in the zygomatic bone after ablative tumour surgery of the maxilla (Weingart et al. 1992). However, when zygomaticus implants are installed in patients with extremely resorbed maxillae, success rates of over 80% hav been reported (Reichert et al. 1999). The reason seems to be that in such cases the palatinal alveolar crest and the sinus floor become part of the implant site.

Fig. 6. Implant placement through the fossa infratemporalis (arrow).

The result is the use of four cortical portions compared to one or a maximum of two cortical portions with conventional implant placement in the maxilla. The engagement of as much cortical bone as possible has been advocated as a decisive factor for the success of dental implants, because it provides more stability than a larger amount of less dense trabecular bone (Hessling et al. 1990; Ivanoff et al. 1996). Therefore, to gain additional stability of the zygomaticus implants a modification of their placement has been proposed by Jensen et al. (1992). By the insertion of the implants through the fossa infratemporalis in the zygomatic arch, two additional cortical layers can be employed (Fig. 6). Although muscles in the fossa infratemporalis may be perforated, complications or sequelae arising from this procedure have not been encountered (Jensen et al. 1992).

In conclusion, it seems that despite the unfavourable microarchitecture of the zygomatic bone, implants can be placed in patients with extremely resorbed maxillae with good clinical success when it is possible to achieve a multicortex stabilization. The latter seems to be more important for a long-lasting success of the zygomaticus implants than the structure of the trabecular bone.

AcknowledgementsThe authors thank Tony Simpson, Jochen Lennerz and Prof. Dr Winfried Neuhuber of the Anatomy Institute I of the University of Erlangen-Nuremberg (Head: Prof. Dr W. Neuhuber) for providing the zygomatic specimens, and Brigitte Kart and Christian Dittmann for the preparation of the figures.

Résumé

Trente zygomatiques de cadavres(15 femmes [82± 11 ans], 15 hommes [78±7ans]) ont été examinés par tomographie quantitative par ordinateur et histomorphométriquement. Le but de cette étude a été d'évaluer la densité minérale, le volume d'os trabéculaire et le facteur de modèle d'os trabéculaire. De plus, les dimensions antéro-postérieures et médio-latérales et la longeur implantaire estimée dans l'os zygomatique ont été déterminées. Pour la tomographie quantitative par ordinateur les spécimens étaient balayés avec un os de référence. La densité minérale osseuse était ensuite calculée dans le plan de la direction voulue du placement de l'implant. Ensuite par la technique de sciage et d'usure les spécimens ont été préparés dans le même plan pour l'histomorphométrie. La densité minérale osseuse trabéculaire était de 370 ± 189 mg/cm^3 chez les femmes et de 399 ± 99 mg/cm^3 chez les hommes (p=0,23). Le volume osseux trabéculaire chez l'homme montrait une valeur de 27±9% et chez la femme de 20±8% (p=0,23). Le facteur de modèle d'os trabéculaire était de $1{,}2\text{x}10^{-2}\pm1{,}3\text{mm}^{-1}$ chez l'homme et de $1{,}02\pm0{,}96\ \text{mm}^{-1}$ chez les femmes (p=0,045). Cette étude révèle que l'os zygomatique consiste en de l'os trabéculaire avec des paramètres qui sont défavorables pour le placement des implants. Cependant, le succès des implants placés dans l'os zygomatique est sécurisé par l'utilisation d'au moins quatre portions corticales.

Zusammenfassung

Präparate von 30 Jochbeinen (15 weibliche(81.60+/-11.38 Jahre), 15 männliche (78.47+/-6.58 Jahre)) wurden mittels quantitativer Computertomographie und Histomorphometrie untersucht. Das Ziel der Studie war die Ermittlung der Knochenmineraldichte, des trabekulären Knochenvolumens und des Faktors des trabekulären Knochenmusters. Zudem wurden die anterio-posterioren und medio-lateralen Dimensionen und die geschätzte Implantatlänge innerhalb des Jochbeinknochens bestimmt.

Für die quantitative Computertomographie wurde die Proben zusammen mit einen anthropomorphischen Phantom, mit welchem Knochen imitiert werden kann, eingelesen. Die Knochenmineraldichte der Proben wurde in der Ebene der geplanten Implantatrichtung berechnet. Daraufhin wurden die Proben mit der Säge- und Schleiftechnik in derselben Ebene für die Histomorphometrie aufgearbeitet.

Die trabekuläre Knochenmineraldichte betrug 369.96+/-188.80 mg/cm^3 bei den weiblichen und 398.94+/-99.11 mg/cm^3 bei den männlichen Präparaten (p=0.23). Das männliche trabekuläre Knochenvolumen zeigte einen Wert von 27.32+/-9.49%, während die weibliche Gruppe einen Wert von 19.99+/-7.60% (p=0.23) erreichte. Der Faktor des trabekulären Knochenmusters betrug $1.2\text{x}10^{-2}$+/-1.28 mm^{-1} bei den männlichen und 1.02+/-0.96 mm^{-1} bei den weiblichen Präparaten (p=0.045).

Die Studie zeigt, dass das Jochbein trabekulären Knochen mit ungünstigen Voraussetzungen für eine Implantation enthält. Jedoch wird der Erfolg von Implantaten, welche in den Knochen des Jochbeins gesetzt werden, durch die Verwendung von mindestens 4 kortikalen Anteilen gesichert.

Resumen

Se examinaron por tomografía computarizada e histomorfometría 30 especimenes óseos zigomáticos humanos (15 femeninos [81.60±11.38], 15 masculinos [78.47±6.58 años]). La intención del estudio fue valorar la densidad mineral del hueso, el volumen trabecular del hueso y el factor de patrón trabecular óseo. Además, se determinaron las dimensiones antero-posterior y medio-lateral y la longitud estimada del implante dentro del hueso zigomático.

Se escanearon los especimenes junto con un fantomas de referencia de imitación antropomórfica por tomografía computarizada cuantitativa. Se calculó la densidad mineral del hueso para los especimenes en el plano de la dirección en la que se tiene la intención de colocar el implante. Subsecuentemente, con la técnica de corte y desgaste se prepararon los especimenes en el mismo plano para histomorfometría.

La densidad del mineral del hueso trabecular fue de 369.95±188.80 mg/cm^3 para las mujeres y 398.94±99.11 mg/cm^3 para los especímenes de los hombres (p=0.23). El volumen trabecular óseo de los hombres mostró un valor de 27.32±9.49 %, mientras que en el grupo de las mujeres alcanzó un valor de 19.99±7.60 % (p=0.23). El factor del patrón de hueso trabecular fue de $1.2x10^{-2}$±$1.28mm^{-1}$ para los hombres y 1.02±0.96 mm^{-1} para los especimenes de las mujeres (p=0.045).

El estudio revela que el hueso zigomático consiste en hueso trabecular con parámetros que son desfavorables para la colocación de implantes. De todos modos, el éxito de los implantes colocados en el hueso zigomático esta asegurado por el empleo de al menos 4 porciones corticales.

要旨

ヒトの頬骨標本３０個（女性１５［８１．６０±１１．３８才］、男性１５［７８．４７±６．５８才］）を、定量的コンピュータ断層像と組織学的形態計測によって検討した。本研究は、骨密度、骨梁骨量及び骨梁骨のパターン因子を評価することを目的に行った。さらに頬骨の前後的及び内外側の寸法と、予測されるインプラントの長さを測定した

定量的コンピュータ断層像では、標本は人体の形態を模倣した基準ファントムと共に撮影した。意図されたインプラントの埋入方向の平面において標本の骨密度を計算した。次に研磨標本を作成し、同じ平面において標本の組織学的形態計測を行った。

骨梁骨の密度は、女性が３６９．９５±１８８．８０ｍｇ／ｃm^3、男性が３９８．９４±９９．１１ｍｇ／ｃm^3であった（ｐ＝０．２３）。男性の骨梁骨量は２７．３２±９．４９％、女性は１９．９９±７．６０％であった（ｐ＝０．２３）。骨梁骨のパターン因子は、男性が $1.2x10^{-2}$±１．２８mm^{-1}、女性が１．０２±０．９６mm^{-1}であった（ｐ＝０．０４５）。

本研究は、頬骨はインプラント埋入に望ましくないパラメーターを有する骨梁骨から成ることを示したが、頬骨に入れるインプラントは、少なくとも４箇所の皮質部に固定することによって確実に成功する。

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