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Anatomical Features of Maxillary Bone Related to Removable Prosthetics: Review

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The maxillary bone is placed centrally, within the facial cranium. As well as the aesthetic appearance, it is related to normal vital functions – eating, breathing and speaking. There are physiological changes in the jaws of the growing organism, which are influenced by the presence or absence of the teeth, parafunctions, and transference of the masticatory pressure. Anatomical features of the upper jaw are directly related to the prosthetic method of choice.

Key words: anatomy, maxilla, prosthetics

The upper jaw (maxilla) is connected rigidly to the hard palate (os palatinum) and they often are considered together because of their morphological and functional properties. The main characteristics of this complex include apertures, protuberances, bone junctions and the shape of the dental arch. The apertures include: foramen incisivum and foramina palatina minora. The presence and the degree of growth of torus palatinus can be classified by four forms: strongly convex, flat, convex in an anterior part and convex in a distal part [26]. Bone junctions are: sutura incisiva, sutura intraincisiva and sutura palatina transversa. The configuration of sutura palatina transversa is formed by three classical types: straight directed, forward directed and backwards directed [18]. The shape of the upper dental arch can be described like an ellipse, U-shaped, semicircular and also parabolic [27].

Bone structures in the mouth are covered with soft tissues. The mucosa on a prosthetic field can be defined in three main types: immovable, which covers the alveolar crests and hard palate; movable, which is placed on the cheeks and lips; and transitional – which is placed between them. This transitional mucosa is called sulcus gingivobuccalis. The physiological range of the prosthetic field is determined by the following anatomical structures: spina nasalis anterior, crista zygomaticoalveolaris, m. buccinators, m. orbicularis oris, m. incisivus labii superioris. In the distal area this range is placed behind Tuber maxillae to the facies infratemporalis maxillae [29]. Tuber maxillae can be either strongly or weakly developed, retentive or non-retentive [28].

The composition of the fully healed edentulous ridge of the posterior maxilla was recently examined and was found to contain approximately 50% mineralized bone and 16% bone marrow.The marginal portion of the jaws almost consistently contained a cortical cap that was significantly thinner in the maxilla.The bone marrow occupied was close to 40% of the anterior maxilla, while the posterior maxilla comprised between 13-18%. The maxillary anterior region was discovered to be poor in lamellar bone but rich in bone marrow [16].

There are similar studies for quantitative evaluationmodule of elasticity, density and hardness in different anatomical regions.The aim of these investigations was to determine whether elastic properties and apparent density of bone differ in different anatomical regions of the maxilla and mandible. Additional analysis assessed how elastic properties and apparent density were related. Elastic modulus and hardness were measured using the nano-indentation technique. Elastic modulus and hardness were higher in the posterior maxilla than in the anterior regions; the reverse was true for apparent density. Posterior maxillary density was significantly the lowest [17].

Bone densitometry of the jaws was performed with a densitometer, and bone mineral density was calculated at three regions of the maxilla. Significant differences were found between the mean bone mineral density of each site when compared with the three other locations. The mean bone mineral density of the anterior maxilla was measured (mean = 0.55 g/cm^{-2}). The bone mineral density of the posterior maxilla was significantly the lowest (mean = 0.31 g/cm^{-2}; and the hard palate, mean = 0.45 g/cm^{-2}) [6].

Bone density can be measured byHounsfield units (HU). The Hounsfield unit scale is a linear transformation of the original linear attenuation coefficient measurement into one in which the radiodensity of distilled water, at standard pressure and temperature, is defined as zero Hounsfield units (HU), while the radiodensity of air at standard pressure and temperature is defined as 1000 HU [11].Cortical and cancellous bone density was measured at the interradicular areas at the alveolar and basal bone levels of the maxilla and mandible, and the data was subjected to statistical analysis for comparisons. The highest cortical bone density was observed between the second premolar and first molar at the alveolar bone level and between the first and second molars at the basal bone level in the maxilla. Maxillary tuberosity showed the least bone density [3].

Parka's investigation showed very similar results. The highest bone density in the maxilla was observed in the canine and premolar areas, and maxillary tuberosity showed the lowest bone density [21].

Sogo's study examined the bone densities of edentulous posterior maxillae by computed tomography (CT). The density was calculated in the range from 150 to 2,000 Hounsfield units (HU) and it was categorized according to Misch's classification.Misch (1988) described four bone densities found in the edentulous regions of the maxilla and the mandible based on macroscopic cortical and trabecular bone characteristics: D1 bone is primarily dense cortical bone; D2 bone has dense to thick porous cortical bone on the crest and coarse trabecular bone underneath; D3 bone has thinner porous cortical crest and fine trabecular bone within and D4 has almost no crestal cortical bone and fine trabecular bone composes almost all of the total volume of bone [12]. More than 80% of the edentulous posterior maxillae consisted of porous cortical crest or no cortical bone according to CT, although the bone densities varied amongst individuals [24].

Bone density, in Fanuscu's study, values based on the Hounsfield scale ranged from 186 to 389 HU, in the maxilla, anterior site being higher. 3-D morphometric analysis in microCT produced a range of values within anterior specimens being favorable: bone volume density (0.12-0.291), trabecular thickness (0.12-0.16 mm), trabecular separation (0.46-0.82 mm), trabecular number (1.08-2.071/mm) and structural model index (0.29-1.27) [7].

Cortical thickness, density, elastic properties, and the direction of greatest stiffness were obtained in Peterson's study. Results showed that cortical bone in the alveolar region tended to be thicker, less dense, and less stiff. Cortical bone from the body of the maxilla was thinner, denser, and stiffer. Palatal cortical bone was intermediate in some features but overall was more similar to cortical bone from the alveolar region. The principal axes of stiffness varied regionally. The regions with the greatest consistency was the alveolar area and the frontomaxillary pillar, where the grain of the cortical bone was aligned vertically from the incisors to the medial external aspect of the orbit. Elastic properties in the human maxilla, especially the orientation of the principal axes of stiffness, were more variable than in the mandible [22].

Maxilla's resorption is centripetal and it decreases in its volume. Edentulous jaws are classified according their shape, type and degree of atrophy [29]. According to the shape of alveolar crests there are three basic and many transitional forms. The basic are ovoid-shape, pointed-shape and square-shape. The type of atrophy can be symmetrical and non-symmetrical, regular and irregular. The type of atrophy is heavily influenced by sequence of tooth loss, and by premature extraction [30]. The inclination of alveolar crests is important for retention of the dentures. According to inclination alveolar crest can be retentive, vertical and non-retentive [29].

Boyanov classified the degree of atrophy in three basic and one additional form. First grade complies to normal non-functional atrophy, alveolar crests are round and good developed. Second grade is due to senile or pathological atrophy, alveolar crests are smaller and are covered with immovable mucosa. Third grade is due to senile or pathological atrophy in advanced form, alveolar crests decrease their volume, the immovable mucosa is a narrow strip on the top of the crests. Additional grade represents heavy atrophy with almost disappeared alveolar crests [25]. Kurlyanskiy's classification grades the atrophy in three types (**Fig. 1**) [29].

Resorptive processes can be considered from the length of incisive canal, which is a different value in dentulous and edentulous maxillary bone. The Y-morphology canal was most frequently observed at 60% in the dentulous maxilla and 55% in the edentu-

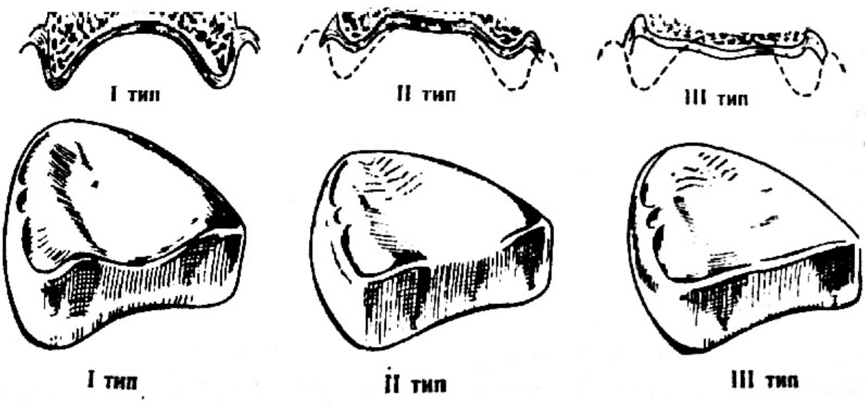

Fig. 1. Degrees of the atrophy according to Kurlyanskiy [4]

lous maxilla. Fukuda's study established mean length 10.75±1.70 mm in teeth presence, and 10.84±2.42 mm in teeth absence [8].

The purpose of Güncü's study was to identify the influence of gender and tooth loss on incisive canal characteristics and buccal bone dimensions in the anterior maxilla. Men had a significantly higher buccal bone dimension (length and width of the bone anterior to the canal) than women. Absence of teeth in the anterior maxilla decreased incisive canal length and buccal bone dimensions; however, the canal diameter remained unchanged [10].

In the literature there is little information for the connection between the residual height of the bone and its density. Monje identified a statistically significant, positive correlation between bone volumetric fraction and ridge height ($r = 0.417$, $p = 0.03$). A statistically significant negative correlation between trabecular pattern factor and ridge height was also found ($r = -0.415$, $p = 0.03$) [19].

There are different investigations for evaluating the thickness of a facial alveolar bone in the frontal area. A thin bone contributes to risk of bone fenestration, dehiscence, and soft-tissue recession [9]. The thickness of a vestibular bone wall in edentulous maxilla is between 0.5 and 1 mm [14].

It has been suggested that a minimal width of 1-2 mm of buccal bone is necessary to maintain a stable vertical dimension of the alveolar crest. The mean width of the buccal and palatal bony walls was 1 and 1.2 mm, respectively ($p < 0.05$) [13]. In another survey it's ranged 1.0 to 1.3 mm because of the apparent fenestration occurrence (0 mm bone) within approximately 12% of teeth [20].

Edentulous maxillary first molar sites were analyzed on Cone Beam Computed Tomography. The alveolar ridge height (RH), widths at 1 and 3 mm from crest (RW1; RW3), and relative position of the bone crest (RR) were measured.Prevalence of patients with severe periodontal disease status was most frequent from 49.2% to 50.4%. The lower ridge heights were observed; 13.1% to 14%had RH < 2 mm, sites with both RH <8 mm and RW1 < 6 mm occurred at 59% to 68%. Gender and the adjacent teeth significantly affected RW [1].

To obtain successful treatment with complete dentures it is essential to appropriately plan the type of prosthesis (fixed or movable) and prosthetic design [15]. From the best available data, construction of technically correct dentures, a well-formed ridge and accuracy of jaw relations are also all positive indicators for success.There have been many attempts to relate the ridge form to prosthetic success. It is logical to assume that the better the alveolar ridge form is, the greater the chance of producing a stable, retentive denture with good support, which will be tolerated well by the patients. Patient negativity and a poorly formed alveolar ridges are both significant indicators for negative success rates. Other prognostic indicators have not been shown to be of significant value. There are afew patients who will never adapt to any conventional complete denture [5]. More failures are observed in the posterior maxilla, which is related with bone characteristics, local status and hygiene (smokers) [4].

Carlsson thinks that there is not strong evidence for an association between anatomical and technical prerequisites of a successful treatment with complete dentures, together, with the fact that psychological factors and personality are of great importance for the outcome of treatment [2].

Our investigation presents that the areas around Spina nasalis anterior and Tuber maxillaeare more conservative in the course of evolution and symmetrically changing. In the variable regions susceptible to evolutionary change are zones of canines, first and second premolars [23].

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