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RESEARCH ARTICLE

TO STUDY THE EFFECT OF EDENTULISM ON MANDIBULAR MORPHOLOGY: A PANORAMIC RADIOGRAPHIC STUDY

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ABSTRACT

Objective: The purpose of this study was to evaluate the phase stability, surface characteristics, hardness and flexural strength of Yttrium stabilised zirconia ceramics after various low temperature aging using X-ray diffraction analysis, Scanning Electron Microscopy, a micro hardness tester and a universal testing machine respectively. ***Materials and methods:*** Blocks of Y-TZP from two manufacturers (n=15) Group-A AIDITE (Qinhuangdao Technology Co., Ltd, Hebei, China) and Group-B UPCERA(Shenzhen Upcera Dental Technology Co. Ltd, Guangdong, China) were machined, sintered and glazed according to manufacturer's specifications. These were of 40mm (length)×5mm (width)×3mm (height). Specimens were artificially aged in distilled water by heat treatment at 100°C, 150°C and 200°C for 10 hours each to induce phase transformation. These specimens after aging were individually evaluated for the phase transformation using X- ray diffraction (JDX 8P, JEOL machine) and surface characteristics using scanning electron microscopy (6380 LA, JEOL machine). They were also evaluated for hardness using micro hardness tester (Reichert Austria micro hardness tester) and flexural strength using universal testing machine (Unitest-10). ***Results:*** The results from x-ray diffraction analysis of both the specimens with and without low temperature aging revealed only the tetragonal phase. On scanning electron microscopy, the surface of the specimens in as received condition appeared to be smooth with a few blebs here and there. As aging was carried out, the surface irregularities became more pronounced. Hardness testing showed that the hardness was highest without aging as compared to when aging was carried out. There was a considerable decrease in hardness in group B when compared to group A. The results from flexural strength evaluation showed that in group A, there was a decrease in the mean flexural strength when aging was carried out. The flexural strength in group B kept fluctuating and was the highest when aged at 100°C. A sudden decrease in the flexural strength was noted when aged at 150°C. ***Conclusion:*** The in vitro tests conducted reveal that the two materials Aidite and Upcera did not show significant results on x-ray diffraction analysis and scanning electron microscopy. These tests also reveal that when low temperature aging was carried out at a temperature of 100°C for 10 hours, the hardness of Y-TZP ceramics decreased whereas the flexural strength increased. However, beyond this temperature of 100°C especially at 150°C and above, the flexural strength of both the materials started to decrease.

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INTRODUCTION

Changes in the morphology of the edentulous mandible are influenced by the dental status and age of the patient (Joo *et al.,* 2013; Tallgren, 1972). The most consequence in morphological alterations of the mandible related to the loss of teeth is residual ridge resorption and has received increasing attention over the past several decades (Oksayan *et al.,* 2014; Joo *et al.,* 2013; Yaniko˘glu and Yilmaz, 2008). Several studies have focused on morphological and anatomical changes in between edentulous and dentulous mandible (Oksayan *et al.,* 2014; Joo *et al.,* 2013 Ceylan *et al.,* 1988; Dutra *et al.,* 2006). Generally, Gonial Angle (GA), Antegonial Notch Depth (AND), Ramus Notch Depth (RND), condylar height (CH), and Ramus Height (RH) are by and large used parameters to evaluate the anatomical changes in edentulous subjects (Oksayan *et al.,* 2014; Joo *et al.,* 2013; Yaniko˘glu and Yilmaz, 2008; Raustia and Salonen, 1997; Ali *et al.,* 2005). Panaromic radiographs have extensive clinical and radiological applications in dentistry. According to a study conducted by Alhaija, panoramic radiographs can be considered as a useful tool for the measurement of GA (Oksayan *et al.,* 2014; Yaniko˘glu and Yilmaz, 2008; Alhaija, 2005). According to the mandibular morphology, GA dimensions can change with age, tooth loss and use of complete denture prosthesis (Oksayan *et al.,* 2014; Slagsvold

and Pedersen, 1977). It has been demonstrated that GA size can be correlated with the development of masticatory muscles (Oksayan *et al.,* 2014; Kasai *et al.,* 1994). Antegonial notch is the upward curving of the inferior border of the mandible anterior to the angular process (gonion) (Oksayan *et al.,* 2014; Ali *et al.,* 2005). Some studies have investigated the possibility that antegonial notch morphology predicts mandibular growth (Oksayan *et al.,* 2014; Aki *et al.,* 1994). Mangla *et al.* stated that RH was significantly bigger in the hypodivergent group and males have greater RHs than females (Mangla *et al.,* 2011). The purpose of this study was to compare the mandibular morphological measurements of totally edentulous, young dentate and old dentate subject.

MATERIALS AND METHODS

Study sample: 150 panoramic radiographs had been selected from Department of Radiology and Prosthodontic archives of SDM Dental College. They were selected and grouped into the following 3 categories such that

Group 1- completely dentulous group of 50 subjects above 50 years of age;
Group 2- completely dentulous group of 50 subjects below 50 years of age;
Group 3- completely edentulous group of 50 subjects above 50 years of age.

GA, AND, RND, RH and CH were measured on panoramic radiographs. In young and old dentate groups, all the teeth were present except third molars, patients wearing partial dentures, with craniofacial syndromes and facial trauma were excluded from the study. In edentulous group, all subjects were old denture patients.

Radiographic evaluation: The radiographs were taken with the same digital machine and by the same technician. The criteria for selection being high quality and sharp patient radiographs. Additionally, the condylar area, the posterior border of the ramus and the lower border of the mandible had to be clear on the left part of the panoramic radiograph to define skeletal landmarks. Each panoramic radiograph was traced on tracing paper with a 0.5 mm mechanical pencil by the same investigator as follows (Figure 1). Pearson correlation coefficient was between 0.80 and 0.91 for all the variables, when ten randomly selected radiographs were traced by the same investigator.

Statistical analysis: Statistical analy was performed using SPSS statistics for Windows 10. Descriptive statistics including the mean, SD, median, minimum and maximum values, were calculated for each of the 3 groups. Kolmogorov-Smirnov and Shapiro-Wilk tests were conducted to assess the normality of variances (p 0.05). The Kruskal-Wallis nonparametric statistical test was used to determine significant intergroup differences, while the Mann-Whitney U test was used to compare the subgroups.

RESULTS

Among the three groups, significant differences ($p < 0.05$) were found in GA, CH, RH. According to the Mann-Whitney U test, which was used to compare the subgroups, significant differences were found in GA and RND between Groups 1 and 2; GA, CH and RH between Groups 1 and 3; CH and RH between Groups 2 and 3. According to Kruskal-Wallis statistical test, significant differences were found between GA, CH and RH when comparing young dentate, older dentate, and completely edentulous subjects ($p < 0.05$).

Comparison of variables with Kruskal-Wallis test related to groups

Variables	Group I mean ± SD (dentulous above 50 years)	Group II mean ± SD (dentulous below 50 years)	Group III mean ± SD (edentulous above 50 years)	5 value
Gonial Angle (□)	122.94±8.36	116.52±19.21	124.35±15.08	0.032
Condylar Height (mm)	7.68±1.96	7.83±1.46	9.18±1.59	0.000
Ramus Height (mm)	56.92±8.22	56±5.21	61.77±7.38	0.000
Antegonial Notch Depth (mm)	2.44±1.91	2.017±1.514	2.025±2.37	0.208
Ramal Notch Depth(mm)	3.98±1.136	3.54±1.536	3.69±1.48	0.144

Mann-Whitney Test- Group1 vs Group2

	Gonial angle	Condylar height	Ramus height	Antegonial notch depth	Ramal notch depth
Mann-Whitney U	1155.00	1367.00	1225.50	1384.00	1206.50
Wilcoxon W	2808.00	2852.00	2878.50	3037.00	2859.50
Z	-2.270	-1.031	-1.855	-0.926	-1.997
Asymp.Sig. (2-tailed)	0.023*	0.303	0.064	0.354	0.046*

Mann-Whitney Test- Group1 vs Group3

	Gonial angle	Condylar height	Ramus height	Antegonial notch depth	Ramal notch depth
Mann-Whitney U	1271.00	915.00	809.500	1527.00	1470.00
Wilcoxon W	2924.00	2568.00	2462.500	3297.00	3123.00
Z	-2.271	-4.295	-4.824	-0.869	-1.189
Asymp.Sig. (2-tailed)	0.023*	0.000*	0.000*	0.385	0.235

Mann-Whitney Test- Group2 vs Group3

	Gonial angle	Condylar height	Ramus height	Antegonial notch depth	Ramal notch depth
Mann-Whitney U	1579.50	801.500	945.500	1291.00	1485.00
Wilcoxon W	3349.50	2286.500	2430.500	3061.00	3255.00
Z	-0.078	-4.628	-3.730	-1.759	-0.648
Asymp.Sig. (2-tailed)	0.938	0.000*	0.000*	0.079	0.517

*Indicate that there is a significant difference between those pair of groups since $p<0.05$.

DISCUSSION

In this study, five mandibular morphological and anatomical parameters, including one angular and four linear ones, were measured using panoramic radiographs. Orthopantomograms avoid the unsettling influence of the superimposed image of lateral cephalograms and are regarded to be better than cephalograms. Therefore, it is considered gold standard for measuring the gonial angle (Xie and Ainamo, 2004; Singer *et al.,* 1987). They are suitable for measuring the vertical symmetry of the mandible, i.e. vertical dimensions of the ramus and condyle.

For Gonial angle: Numerous studies have stated that the gonial angle tends to increase in the edentulous state (Marcus *et al.,* 1996; Raustia and Salonen, 1997; Oksayan *et al.,* 2012; Schwartz-Dabney and Dechow, 2002). Some studies have reported about non-widening of the angle in the edentulous state, while others reported that GA becomes larger with aging and advancing edentulism (Ohm E and Silness, 1999; Ali *et al.,* 2005; Kasai *et al.,* 1994). Xie and Ainamo found that the GA did not change with age, gender or dental status. In a study conducted by Jheong-Ki Joo *et al,* edentulous subjects had significantly widened gonial angles and the gonial angle in the edentulous subjects was wider than that of the dentate subjects (Joo *et al.,* 2013; Xie and Ainamo, 2004). Ceylan et al. found that there was no significant difference in GA between the dentulous and edentulous states (Ceylan *et al.,* 1998). Similar results were found in a study conducted by Oksayan *et al.* where completely edentulous group (all older than 50 years) showed highest mean value for the gonial angle when compared to the old dentate group and young dentate group.

For Condylar height: Türp *et al.* studied the asymmetry of the condylar area and ramus heights on panoramic radiographs; after comparison with different measurements from the skulls, they found a low correlation between measurements (Xie *et al.,* 1997). Joo *et al.* found a negative correlation between GA and CH in both sexes (Marcus *et al.,* 1996). Similar findings were demonstrated in a study conducted by Oksayan et al.

For Ramus height: Subtelny reported that decreased ramal height correlated with reduced lower jaw development, and this condition may cause degenerative mandibular condyle and asymmetry (Türp, 1996). In a study conducted by Mangla *et al.,* RH value was significantly smaller in the hyperdivergent group than in the hypodivergent group, and gender resulted in significant differences, with the RH values being significantly smaller in females when compared to males (Alhaija, 2005). The results demonstrated in a study conducted by Oksayan et al. showed decreased mean values of RH among edentulous subjects, which is similar to the results obtained in our study.

For Antegonial notch depth: AND was affected by many factors, including muscle functions, osteoporotic and osteopenic conditions, and mandibular growth rotation (Oksayan *et al.,* 2014). A study conducted by Singer et al. notified that subjects with deep antegonial notches had a more retrusive lower jaw, smaller ramus height, and higher gonial angle than individuals with a shallow notch depth (Mattila *et al.,* 1977). Mangla et al. reported that greater antegonial notch depth values and no sexual dimorphism were found between hyperdivergent and hypodivergent subjects (Alhaija, 2005). Studies conducted by Kolodziej *et al.* and Lambrechts et al. have reported that antegonial notch depth can be used to predict the mandibular growth. In our study, no significant differences were found in the AND values between the three groups, which is similar to the results obtained by Oksayan et al.

For Ramal notch depth: Ali *et al.* reported that there was a relationship between condylar bone change and ramus notch depth; they found that increased ramus notch depth might be related to condylar posterior bone apposition (Oksayan *et al.,* 2010). A study conducted by Oksayan *et al* showed no significant difference in the RND results between the young dentate, old dentate and completely edentulous groups, which is similar to the results obtained in our group.

Conclusion

Edentulousness causes adverse esthetic and biomechanical sequelae including morphological changes of the mandible. It appears that the complete loss of teeth considerably modifies the shape of the mandible not only in its alveolar part but also in its basal part. The edentulous subjects had larger gonial angles than did dentate subjects in possession of all teeth. The size of the gonial angle was negatively correlated with the ramus height and cortical bone thickness regardless of gender.

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