Student Summer Scholars | Undergraduate Research and Creative Practice

Summer 2014

Sex and Age Differences in Bone Density in the Palatal Region, Analyzed using CT Scans to Aid in Oral Mini-Implant Success

Alicia P. Flores
Grand Valley State University

James Christopher Reed
Grand Valley State University

Sex and Age Differences in Bone Density in the Palatal Region, Analyzed using CT Scans to Aid in Oral Mini-Implant Success.

Alicia P. Flores and James Christopher Reed, Ph.D.

Abstract

Mini-implants are titanium alloy rods implanted in the bone of the hard palate to help secure dental prostheses like dentures, fixed crowns, and bridge installations. Recent research suggests pre-surgical determination of bone density quality provides increased mini-implant surgical success rates. In replication of these methods (Moon et al.), we evaluated 19 living individual CT scans from Saint Mary's Hospital, using Osirix 8.5 imaging software. Bone density was recorded at 90 separate coordinates using Hounsfield units, measured at three millimeter intervals (mediolaterally and anteroposteriorly starting at the incisive foramen.) The data was then analyzed for age differences and average bone density throughout different regions of the hard palate. Sex differences were closely investigated in this study because prior research has indicated that women may have a higher palatal bone density than men.

Introduction

Mini-implants are rod-like titanium alloys, implanted in the bone of the oral cavity, and are used as a permanent solution to tooth loss. They function to help secure dental prosthesis such as dentures, fixed crowns, and even bridge installations. When multiple teeth are missing they are used to support a dental bridge or crown, and represent a cavity-resistant stable foundation. When used with dentures they work as an anchorage site when little or no teeth are available. The quality of bone is critical to the successful placement and effectiveness of a dental implant (Wehbein and and Göllner 2007, Fuh et al. 2010). Surgical success rates have shown that "the type and architecture of bone is known to

Figure 1: Palatal implant with rods and expansion (Weherbein and Göllner 2007)

highly influence its load bearing capacity and it has been demonstrated that poorer quality bone is associated with higher mini-implant surgical failure rates" (Norton and Gamble 2001:79). In other words, areas of the oral palate with bone of higher density will provide better surgical outcomes than areas with less dense bone.

As medical imaging has become more commonplace in research and clinical settings, the use of computerized tomography (CT) has been established as an invaluable tool in establishing bone quality and density in investigations into craniofacial development (Harth et al., 2009; Reed et al., 2009, 2011) and in medical and dental applications (Fuh et al., 2010; Norton and Gamble, 2001; Parsa et al. 2013). Computerized tomography (CT) is a modern medical imaging technique that uses an x-ray source and an array of detectors to obtain a series of images of the palatal region that can be constructed into a 3-dimentional image for analysis (Spoor et al. 2000). CT can reveal bone density inside of the oral region that would otherwise be impossible to accurately measure. When a CT scanner obtains a series of x-ray images or "slices" of the human body, the x-ray images contrast the different densities of tissues found (Spoor et al. 2000). By viewing CT images in an analytical software package, different densities of tissue can be highlighted using different color schemes. In this way, different densities of the bone of the hard palate can be delineated. Also using analytical software, bone density, as a measure of quality for the location of location for implants, can be measured in Hounsfield units (soft tissue ranges from 100 to 300, while bone ranges from 800 to 1200), with a primary focus on the samples of palatal bone density and regions of mini-implant installation.

In one clinical study, Moon et al. (2010) evaluated mini implant success based on palatal bone density using CT scans and a sample size of thirty adult volunteered subjects from Korea (15male:15female). The outcome of this study highlighted the best palatal regions correlated with mini-implant success. During his statistical analysis a strange occurrence was discovered; women bone densities were higher than men in the palatal region.

Differences in bone density for the outer portion of the skull between males and females has clearly been demonstrated with females generally having a less dense structure (Schulte-Geers et al., 2011), although the opposite was found for the palate by Moon et al. (2010). This previous research raises two intriguing issues. One issue is the unexpected result that females seem to have more dense bone in the hard palate of the mouth than males (Moon et al. 2010:142), because generally females tend to have lower bone density values throughout the body, especially as age becomes more advanced. Because of this result, analysis of the scans were completed separately for the sexes in order to determine if there are truly significant difference between the sexes, and to determine if age is a factor in palatal bone quality. The second issue is that of the effect of age on bone quality and location of implants. As humans age, the bone density and quality generally decline. Age may or may not affect the bone density of the palate, and if it does, different areas of bone may have different densities at different ages. These changes could affect the ideal location of placement of dental implants.

In close parallel with Moon et al., bone density was assessed with an increased population sample. Age differences, as well as areas of highest bone density, were closely analyzed with a primary focus was on evaluating the relationship between men and women palatal bone densities to allow for a better selection of palatal implant anchorage sites.

Methods

The sample is a sample of convenience, consisting of pre-existing, clinical scans of 36 living individual CT scans provided by Saint Mary's Healthcare in Grand Rapids, MI. Each sample is a 3x3 canonical scan, taken with a Philips Brilliance 64 scanner, with a possible Housfield Unit (HU) range (density measure) from -1000 to 3096. The hard palates are from 19 living individual CT scans (12 male:7 female) of known ages ranging from 25-98 years. Each scan was then rendered anonymous, retaining only the demographic information obtained by the hospital, in order to comply with the standards of the institutional research boards (IRB) of both Saint Mary’s Healthcare System and Grand Valley State University (GVSU 100904-1; Saint Mary’s Healthcare SMO9-0224-01).

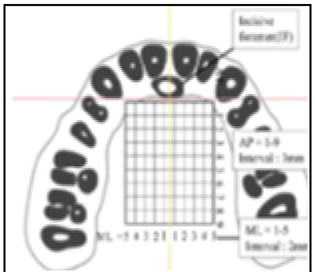


Figure 2: Moon et al. (2010)

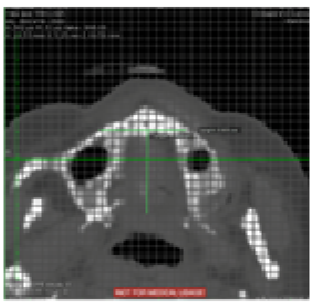


Figure 3: Osirix CT Image- Transverse slice with grid.

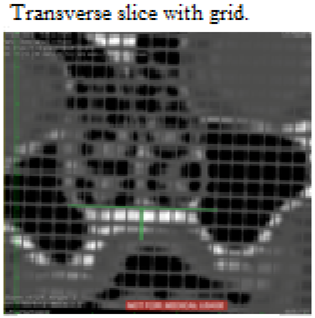


Figure 4: Osirix CT Image- Coronal slice with grid.

Analytical software, Osirix 5.8, was used to measure the density of bone (HU’s) at specific locations within the bony palate of the skull. A thresholding technique was used within the software to suppress the soft tissue in the CT images in order to show only the bone. Once loaded by the program, the CT slice images were adjusted from grayscale to a full rainbow of colors that reflect the different densities of tissue. The bone density was measured in Hounsfield Units (HU's) as an absolute measure of density (Moon et al, 2010), and was recorded at 90 separate coordinates through a series of CT image slices. In replication of the methods presented in Moon et al. (2010), three millimeter intervals were measured mediolaterally (cheek to cheek) and also anteroposterioly (hard to soft palate) starting at the incisive foramen (Figure 2). To make measurements more accurate, a three by three millimeter grid was created and placed over each CT scan. Unlike previous studies, which recorded densities of the palatal surface, bone density was measured in the center of the bone using transverse and coronal CT slices (Figure 3 and 4). After the grid was created, both transverse and coronal CT slices were viewed side by side using the split screen function. The transverse view was used to identify the anterior to posterior (AP 1-9) grid, as well as the region of each coronal slice. All measurements were then recorded within the bone, in the coronal view.

Results

Results, using statistical analysis software ANOVA, suggest that there is no statistically significant difference between the left and right halves of the palate, therefore only the right side was used for comparative analysis males and females (paired Student's T, α = .05) . In line with Moon et al. (2010), the Anterior-Posterior (AP) average bone density showed highest recordings between 4-6 AP at 600-800 HU, and highest Medial-Lateral (ML) results at 1L and 1R at 600-800 HU.

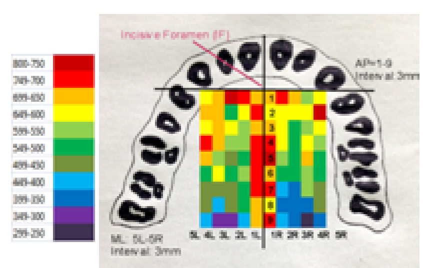
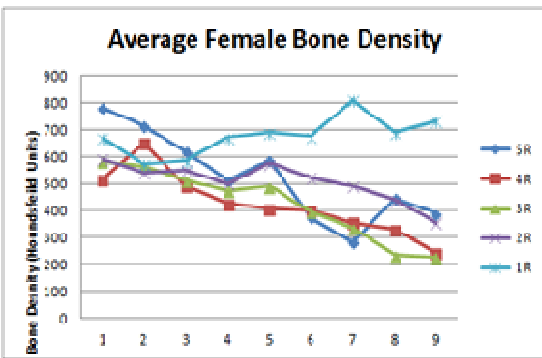
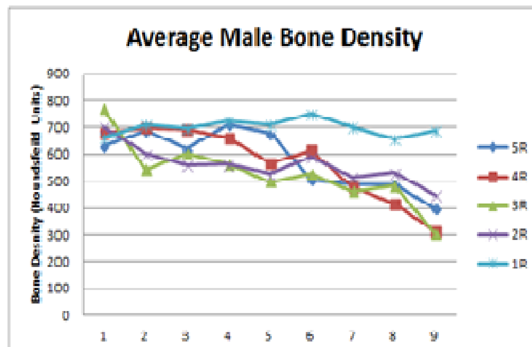


Figure 5: Color grid of average bone density (HU's) for all 19 CT scans.

Figure 5, using the average of all 19 individual palatal bone density recordings, was created to illuminate the average bone densities differences and highlight the noticeable highest density along the midline, as well as the most anterior interval (AP 1). Overall, the bone densities appear lower than those recorded by Moon et al. (2010). This result will be explored in our ongoing research. Average male and female palatal bone density is displayed in Graph 1 & 2, each showing highest bone density in agreement with the above results. Furthermore, sex differences (in contrast with Moon et al.) showed statistical analysis with no significant difference between male and female bone density (two-way ANOVA, α = .05).



Graph 1



Graph 2

Discussion

CT analysis was used as a tool for determining high bone density regions of the hard palate, which has been proven to contribute to mini-implant surgical success rates. In parallel with Moon et al., regions of highest palatal bone density occur along the midline and towards the anterior region of the palate. Results have exposed that age has an indirect effect on bone density, which is to be expected. In contrast with Moon's research, statistical analysis has revealed no significant difference between male and female palatal bone density. In conclusion, by investigating age and sex differences, we were able to effectively determine bone density in the palatal region and help aid in mini-implant surgical success.

Acknowledgments

Funded by the Office of Undergraduate Research at Grand Valley State University

Literature Cited

Clavert, P., Bouchaïb, J., Sommaire, C., Flurin, P. H., & Hardy, P. (2013). Does bone density of the greater tuberosity change in patients over 70? Orthopaedics & Traumatology: Surgery & Research, 2013 Nov 20 . [Epub ahead of print].

Filograna, L., Hatch, G., Ruder, T., Ross, S. G., Bolliger, S. A., & Thali, M. J. (2013). The role of post-mortem imaging in a case of sudden death due to ascending aorta aneurysm rupture. Forensic Science International, 2013 Jan 27 . [Epub ahead of print].

Fuh, L.-J., Huang, H.-L., Chen, C.-S., Fu, K.-L., Shen, Y.-W., Tu, M.-G., Shen, W.-C. and HSU, J.-T. (2010), Variations in bone density at dental implant sites in different regions of the jawbone. *Journal of Oral Rehabilitation*, 37: 346–351.

Grayeli, S. G., Yrieix, C. S., Imauchi, Y., Cyna-Gorge, F., and Ferrary, E. (2004), Temporal bone denisty measurements using ct in otosclerosis. *Act Oto-Laryngologica*, 124(10)

Harth S, Obert M, Ramsthaler F, Reub C, Traupe H, and Verhoff MA. (2009) Estimating age by assessing the ossification of cranial sutures with the aid of Flat-Panel-CT. *Legal Medicine* 11:S186-S189.

Moon, S. H., Park, S. H., Lim, W. H., & Chun, Y. S. (2010). Palatal bone density in adult subjects: implications for mini-implant placement. Angle Orthodontist, 80:137-144.

Norton, M. R. and Gamble, C. (2001), Bone classification: an objective scale of bone density using the computerized tomography scan. Clinical Oral Implants Research, 12: 79–84.

Reed, J. C., Algee-Hewitt, B. F. B, and Glazier, M. (2011), Analysis of cranial suture fusion using computerized tomography of living individuals. Poster presented at the 80th Annual Meeting of the American Association of Physical Anthropologists, April, 2011, Minneapolis, Minnesota.

Reed , J.C., Adams JW, Burson LK, DeGrande KM, Cray JJ, and Mooney MP (2009) The use of computerized tomography in the analysis of sagittal suture fusion. *American Journal of Physical Anthropology Supplement,* 45:337

Parsa, P, Ibrahim, N, Hassan, B, and Paul van der Stelt, P (2013) Bone quality evaluation at dental implant site using multislice CT, micro-CT, and cone beam CT. *Clicical Oral Implant Research*, 2013 Nov 9 [Epub ahead of print].

Daniel WismeijerSchulte-Geers C, Obert M, Schilling RL, Harth S, Traupe H, Gizewski ER, Verhoff MA (2011) Age and gender-dependent bone density changes of the human skull disclosed by high-resolution flat-panel computed tomography. *International Journal of Legal Medicine,* 125:417-25.

Spoor F, Jeffery N, and Zonneveld F (2000), Using diagnostic radiology in the evolutionary studies. Journal of Anatomy, 197:61-76.

Turkyilmaz, I., Tözüm, T. F. and Tumer, C. (2007), Bone density assessments of oral implant sites using computerized tomography. Journal of Oral Rehabilitation, 34: 267–272.