Original Article

International Journal of Dental and Health Sciences
Volume 04,Issue 05

THE VOMER BONE ANALYSIS IN RELATION TO CLASS III MALOCCLUSION USING THREE DIMENSSIONAL IMAGES ANALYSIS

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ABSTRACT:

Objective: To evaluate the vomer bone dimenssional outline changes in relation to the midface hypoplasia of a Class III malocclusion by comparing with normal controls using a three dimenssional CBCT images analysis of Mimics 19.0 software.

Material and Method: In total of 96 patients images were both Class III malocclusion as study cases and normal occlusion as controls with age between 15 to 30 years old. All patients were classified into three group based on ANB angular value of Steiner's analysis. The study group were : normal, mild and sever malocclusion type groups. Linear and angular planes were determined by using 13 skeletal points and analysed by using Mimics 19.0 software. All study groups parameters statistically analysed for significant differences and correlation.

Results: A high significant differences between the vomer bone anterior variables (P<0.01) followed by vomer posterior variables (P<0.05) in relation to cranial and midfacial measurements with positive correlation. The pattern of vomer bone was shown highly anterior impaction and backward inclination in sever type malocclusion group and male higher than female. No statistically significance at different ages.

Conclusion: Within this study limitation, the eventual role of the vomer bone affect dentofacial complex contour that accuratly appear using 3D image analysis of CBCT software.

Keywords: Mimics , Steiner's analysis, Vomer bone, Class III maloclusion.

INTRODUCTION:

A skeletal Class III malocclusion is one of the most difficult dentofacial problem to treat with a consequence of maxillary deficiency, resulting in a concave profile. [1,2] Maxillary deficiency or midfacial hypoplasia characterized by deficiency of skeletal height, width, and anterioposterior relationships of nasomaxillary complex, which requires multidirectional correction. [3,4]

Remarkably, the nasal septum as an important functional matrix consists of septal cartilage, the perpendicular plate of the ethmoid bone and the vomer. [5-8] Indeed, last centry studies determined the role of vomer bone in sustaining good occlusion and a balanced stomatognathic system. [9-11]

As a result, remodeling and reconfiguration of the midfacial bones surfaces have an adaptation response represented by the vomer bone which act as a space maintaionr to compenste the dentofacial pattern discrepancy through malocclusion

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development in different manner according to sex, age and other factors. [12,13] A Treatment Approach to the malocclusion under that consideration of craniofacial dynamics has a better prognosis with accuarte result in demand. [14]

The morphometry of malocclusion could be evaluated by use of two dimenssional (2D) radiographs analysis which has limitation such as structural superimpositions in two-dimensional imaging, particularly in the regions of the of the midfacial complex and loss of accurate view. [15]

Currently, CBCT as a three-dimensional (3D) diagnostic element may provide advantages over (2D) conventional radiographs of the midfacial compartment. CBCT has been shown to provide a high resolution imaging that allows the qualification and quantification of facial bone tissues in approximately real dimensions without significant magnification or distortion. [16]

However, some of CBCT studies have failed to demonstrate clearly the superior diagnostic capability of newly computer-based software like MIMICS like accurate postion and spatial pattern of examined vomer bone. [17]

For that facts, this study hypothesized that the vomer bone in relation to class III malocclusion need to be reviewed in accuarte three imenssional analysis. Thus this study aimed to evaluate the vomer bone dimenssional changes in relation to midfacial deficiency of class III malocclusion using 3D CBCT analysis tool of Mimics 19.0 version software.

MATERIALS AND METHODS:

This is a retrospective study undertaken at the Department of Oral and Dentomaxillofacial radiology, faculty of Dentistry, Marmara University, Istanbul, Turkey. The study comprised CBCT images of one hundred patients' with age between 15-30 years old for both angle class III malocclusion and normal dentofacial pattern. A comparison was made with the determination of vomer bone dimensional changes.

Pre-operative CBCT scan data of the craniofacial skeleton were reconstructed in three level (cranial, midfacial, vomer) and on each scan thirteen osseous landmarks were determined in linear and angular measurements using mimics 19.0 version analysis tool software package (Materialise, Leuven, Netherlands). A subset of these landmarks can be seen in (Table.1).

An outline border of the vomer bone was examined in all subjects images with the same set of osseous landmarks being determined on transsagittal view of CBCT. Shape analysis for three group of different dentofacial pattern (normal, mild and sever) midface hypoplasia type groups was performed using Steiner's (ANB) angle analysis.

There were several steps performed for the vomer outline determination from surrounding hard tissue for construction for different type groups. Firstly, the skeletal bone scale threshold used. (Figure.1) Then the 13 landmarks selected for the cranial, midfacial and vomer bone planes determination. (Figure.2)

After planes determination, the midfacial area cropped using growth growing tool then segmented and the vomer bone planes outlined. (Figure.3) The conversion of the resulting vomer bone outline to the 3D analysis for each patient in three study groups was performed. (Figure.4) all planes measurements of the shape difference of the vomer bone described accurately with malocclusions in linear and angular relations.

Finally, the vomer morphometric significant differences and correlation statistically analyzed, to investigate if this measurements could be a contributory factor affecting malocclusion development.

RESULT:

Data analysis of study groups obtained in total of one hundred patients. Four patient excluded from this study because of image distortion. In result 96 patients were (45.8%, n = 44) female and 54.2% (n = 52) male. The ages of the cases ranged from 15 to 30, with an average of 23.23 ± 3.92 years. When three different types examined according to ANB Steiner's angle; 37.5% (n = 36) were normal (A type) group, 18.8% (n = 18) were mild (B type) and 43.8% were sever (B type) group (n = 42). No significant difference between the mean age and study type groups ($p > 0.05$). There was a significant difference between male and female with three type groups ($p < 0.01$). The incidence of sever malocclusion pattern type in males than females is significantly higher.

When the cranial, midfacial and vomer measurements of study groups in linear reference (Table.2) and angular inclination (Table.3) determination were examined. The linear measurements of the vomer bone diminished transsagittaly (Alp-C), (Ala-C), (C-BV) when maxilla (ANS-PNS) and cranial base (N-S) planes diminished ($p<0.01$). There was less significant difference to the vertical posterior vomer parameters (Alp-BV), (Ala-BV) in relation to vertical facial variables (N-ANS), (S-PNS) ($p<0.05$) but still have a positive correlation with severity of malocclusion. (Table.4) surprisingly anterior inclination of vomer bone (Ala-C-BV) be more diverge with positive correlation of increasing ANB angle toward long face profile with class III malocclusion. (Table.5)

Remarkabley, the vomer bone appeared backward inclined by (CBV-ANS) value in relation to occlusal plane of maxilla (ANS-PNS) diminishing and increasing the ANB angle with sever type group. No statistical differences between posterior inclination and the vomer bone dimensional change in all groups. However; there was a considerable increasing between mild and sever type group angular inclination. Shape analysis of the vomer bone in class III malocclusion using 3D CT scans was appeared the vomer bone backward-upward displacement direction.

Statistical analysis of the data was performed using SPSS program (version 22.0, SPSS, Chicago, IL, USA). The Kruskal Wallis test was used in the comparison of the three groups with no normal distribution. Spearman's Correlation Analysis was used to evaluate inter-variable relationships. Significance was assessed at $p<0.05$ and $p<0.01$.

To determine intra-observer reliability and assess cephalometric method error, duplicate 3D tracing and measurements of 25 randomly selected images were performed by the same investigator after 1 month. Random and standard errors were calculated by correlation, which showed values between 0.80 and 0.99, and paired samples t-test between first and second angular and linear measurements. No systematic errors were detected.

DISSCUSSION:

This study results showed that the vomer bone has very interesting interrelations with malocclusion development. Last decades, the vomer bone remains hidden because of difficulties in identifying it using conventional (2D) radiographs. [15,18]

The application of the (3D) CBCT, and the possibility of reconstruction digital model provided the opportunity to analyze the identified bone with great accuracy and reproducibility [19,20] using a professional software. [5]

The analysis of parameters developed by defining landmarks and planes. These were used in the 2D conventional standard cephalometric then the data compared with other study results. Some of parameters redefined in 3D environment in order to be able to correlate accuratly same anatomical structures. [18]

The definition of the reconstructed vomer bone points slightly differs from that of a appaerd in previous vomer bone study. [17] The reason was to obtain a clear landmarking and excellent reproducibility in positioning them. In this way, the (3D) reconstructed vomer bone was not extended forward to the ANS point and base of the vomer was not at alar region. This must be considered in the interpretation of the results.

The Dentofacial class III discrepancy has been reported as a unique anatomical variation of midface complex pathoetiology. [2,11] Although there are various theories about its distinct, it is still a matter of debate. [3,4]

Some authors have mentioned the potential role of vomer bone in the development of malocclusion. There is a functional complex involving the midfacial complex and vomer.[21] This complex has some degree of dynamic interrelation through sutures. Transmission of forces from the occlusion, or from any other structure can influence the entire complex. [22] The role of vomer bone in the transmission of the masticatory forces was also described that indicated transmission of the masticatory forces through the vomer to the sphenoid bone. [23,24]

Indeed, several studies had been highlighted the morphometric relation of the vomer bone with the ontogeny of the midfacial skeleton. [5,25]

Although the author did not find a reason to believe the importance of the septal cartilage in the growth of the maxillary complex, the results were consistent with the correlation found in this study but with different parameters and more accuarte discription analysis using 3D analysis. Other studies have been described the importance of the vomer bone in the growth deficiency of the maxilla in the clefts patients.[25]

In the postnatal development of the nasal septum, described some of cartilaginous structure could increase the ability of the septum to transfer forces from the incisor region to the sphenoid bone. In this study, a description of the the dimension increase of the vomer bone was established by apposition in the anterior surface during the first 12 years, and in the posterio-superior margin (ala of the vomer) was until 17 years in men and 15 years in woman.[26]

Last decades, some studies have been indicated that trauma to the vomer bone may impair anterior–posterior growth of the premaxilla and maxilla. Also they reported that alteration in the vomero-maxillary suture in the etiology of the midfacial retrusion of the clefts and reported also that the maxillary complex was displaced forward-downwards in relation to the vomer bone.[27,28]

From the results of this study, the vomer bone variables were seem a high significant differences ($p<0.01$) with linear and angular measurements in all examination level and in all study groups. Firstly; upper cranial base plane (N-S) and lower maxilla occlusal plane (ANS-PNS) length diminished transsagittaly with the dimensional decreasing of the vomer bone planes (Alp-C), (Ala-C), (BV-C) decreased respectively with positive correlation. Some researcher reported the relation of class III malocclusion with cranial base dimensional changes and maxillary retrusion but did not mentioned the vomer bone. [2,29-31]

As well as, the posterior vertical vomer planes (Ala-Alp), (Ala-BV) positively proportional with vertical anterior (N-ANS), posterior midface (S-PNS) planes measurements with a high statically significant ($p<0.05$) with positive correlation. That researches reported these parallel findings but in short determination to the nasomaxillary effect on the development of vertical facial profile with the malocclusion. [32]

However, there was no statistical significant or correlation between the vomer bone variables and vertical midsagittal N-ANS planes anteriorly or posteriorly S-PNS ($p >0.05$).

The small premaxilla region is most important in midface growth and different parameters used for that evidence proof. One of these parameters was anterior vomer-premaxilla C-ANS which has high significant and correlation with the midfacial deficiency by the vomer bone apex (C) point retarted anteriorly. [33,34]

All vomer bone posterior angular values (AlpAlaBV, BaAlaBV, CBVAlp, CAlaBV were statistically significant ($p<0.05$) with a negative correlation in relation to cranial base angle (NSBa), intermaxillary angle (ANB) and facial convexity profile (NAB) measurements. That result revealed the evidence of compensation by posterior the vomer bone angulation. So increasing posterior vomer inclination led the vomer bone pushed forward to preserve anterior contour of midface through posterior vomer parameters. Also a high significant positive correlation was found between the anterior vomer bone impaction angle AlaCBV and cranial angle NSBa, intermaxillary angle ANB and facial convexity NAB measurements ($p<0.05$). [11,35] That result give a rational evidence of the vomer bone anteriorly displacement by posterior alar-sphenoidal region to balanced the increasing in ANB angulation.

Thus a new finding interesting result of this study that a strong relation of C-ANSPNS and Ala-CBV inclinations with ANB angle during malocclusion development. [10,13]

Thus, a high significant differences of vomer bone emphasize a strong correlation anteriorly transagittal planes and posteriorly vertical planes with maxillary retrusion especially in type C severe group when it was compared with other study groups. This study findings give an emphasis of the hypothesis of the force transferring from occipital to maxilla through vomero-sphenoidal joint and the reverse forces through the vomer bone from masticatory dentofacial forces. [36,37]

Nowadays, using of the CBCT and its applications in craniofacial diagnosis provide a new alternatives to evaluate the morphology of the malformed skeleton in a three-dimensional way with great accuracy. [16] More longitudinal evaluation studies in growing patients childhood period and later life with a large sample should be conducted in order to complement the understanding of its role in the craniofacial architecture.

CONCLUSION:

There is a high significant differences and correlation of vomer bone dimensional changes with midface complex of angle class III malocclusion. An orthodontist must also consider other parameters like soft tissue parameters like nasolabial musculature anteriorly and Pterygoid musculature complex posteriorly while undertaking decision for orthodontic malocclusion patients.

In order to evaluate a more reliable relationship of the vomer bone with dentofacial discrepancy pattern, further studies are still needed to be conducted.

REFERENCES:

1. McNamara Jr JA. An orthopedic approach to the treatment of Class III malocclusion in young patients. J Clin Orthod. 1987;21:598–608.
2. Ngan, P., Hu, A. M., & Fields, H. W. Treatment of Class III problems begins with differential diagnosis of anterior crossbites. Pediatric dentistry. 1997; 19, 386-395.
3. Deguchi T, Kuroda T, Minoshima Y, Graber TM. Craniofacial features of patients with Class III abnormalities: growth-related changes and effects of short-term and long-term chincup therapy. American Journal of

Orthodontics and Dentofacial Orthopedics. 2002;121(1), 84-92.

4. Masucci C, Franchi L, Defraia E, Mucedero M, Cozza P, Baccetti T. Stability of rapid maxillary expansion and facemask therapy: a long-term controlled study. American Journal of Orthodontics and Dentofacial Orthopedics. 2011;140(4), 493-500.
5. Foster, A., & Holton, N. Variation in the developmental and morphological interaction between the nasal septum and facial skeleton. The Anatomical Record. 2016; 299(6), 730-740.
6. Sandikcioglu M, Molsted K, Kjaer I. The prenatal development of the human nasal and vomeral bones. J Craniofac Genet Dev Biol. 1994;14:124–134
7. Eloff FC. On the relations of the human vomer to the anterior paraseptal cartilages. J Anat. 1952;86:16–19
8. Fawcett E. The development of the human maxilla, vomer and paraseptal cartilage. J Anat Phys. 1911;45:378–405
9. Wada T, Kremenak CR, Miyazaki T. Midfacial growth effects of surgical trauma to the area of the vomer in beagles. J Osaka Dent School. 1980; 20:241–246.
10. Hansen L, Nolting D, Holm G, Hansen B, Kjaer I. Abnormal vomer development in human fetuses with isolated cleft palate. Cleft Palate Craniofac J. 2004;41(5):470–3.
11. Tanaka E, Sato S. Longitudinal alteration of the occlusal plane and development of different dentoskeletal frames during growth. Am L Orthod Dentofacial Orthop. 2008;134(5):602.e1– 602.e11.
12. Enlow DH, Bang S. Growth and remodeling of the human maxilla. Am J Orthod.1965;51:446–64.
13. Hall, B. K., & Precious, D. S. Cleft lip, nose, and palate: the nasal septum as the pacemaker for midfacial growth. Oral surgery, oral medicine, oral pathology and oral radiology. 2013; 115(4), 442-447.
14. Sato S. A Treatment Approach to malocclusion under the consideration of craniofacial dynamics. Grace Printing Press Inc.; 2001.
15. Van Vlijmen OJ, Berge SJ, Swennen GR. Comparison of cephalometric radiographs obtained from cone-beam computed tomography scans and conventional radiographs. J Oral Maxillofac Surg. 2009;67(1):92–7.
16. Adams GL, Gansky SA, Miller AJ, Harrell WE, Hatcher DC. Comparison between traditional 2-dimensional cephalometry and a 3-dimensional approach on human dry skulls. American journal of orthodontics and dentofacial orthopedics. 2004;126(4), 397-409.
17. Basili, C., Otsuka, T., Kubota, M., Slavicek, R., & Sato, S. Three-dimensional CT analysis of vomer bone in the architecture of craniofacial structures in caucasic human skulls. International journal of stomatology & occlusion medicine. 2009; 2(4), 191-204.
18. Muramatsu A, et al. Reproducibility of maxillofacial anatomic landmarks on

3-dimensional computed tomographic images determined with the 95% confidence ellipse method. Angle Orthod. 2008;78:396–402.

19. Lagravère M, Carey J, Toogood R, Major PW. Three dimensional accuracy of measurements made with software on cone beam computed tomography images. Am J Orthod Dentofacial Orthop. 2008;134:112–6.
20. Periago D, et al. Linear accuracy and reliability of cone beam CT derived 3-dimensional images constructed using an orthodontic volumetric rendering program. Angle Orthod. 2008;78:387–95.
21. Slavicek R. The masticatory organ. Austria: Gamma Medizinisch-Wissenchaffliche Fortbildungs-AG; 2002.
22. Dixon A, Hoyte D, Rönning O. Fundamentals of craniofacial growth. New York: CRC Press; 1997.
23. Jerolimov V, Keros J, Bagic I, Lazic B, Komar D. Vomer as a relevant factor in the mastication forces transmission system. Coll Antropol. 1999;23(1):133–42.
24. Hilloowala R. The transmission of masticatory forces and nasal septum: structural comparison of the human skull and gothic cathedral. Cranio 2007;25(3):166–71.
25. Latham R, Deaton T, Calabrese C. A question of the role of the vomer in the growth of the premaxillary segment. Cleft Palate. 1975;12:351–5.
26. Melsen B. Histological analysis of the postnatal development of the nasal septum. Angle 1977;47(2):83–96.
27. Friede H. Growth sites and growth mechanism at risk in cleft lip and palate. Acta Odont Scand. 1998;56(6):346–51.
28. Squier C, Wada T, Ghoneim S, Kremenak C. A histological and ultrastructural study of wound healing after vomer resection in the beagle dog. Arch Oral Biol. 1985;30(11–12):833–41.
29. Dhopatkar A, Bathia S, Rock P. An investigation into the relationship between the cranial base angle and malocclusion. Angle Orthod 2002;72:456–63.
30. Klocke A, Nanda RS, Kahl-Nieke B. Role of cranial base flexure in developing sagittal jaw discrepancies. Am J Orthod Dentofacial Orthop. 2002;122:386–91.
31. Polat OO, Kaya B. Changes in cranial base morphology in different malocclusions. Orthod Craniofacial Res. 2007;10:216–21.
32. Barteczko K, Jacob M. A re-evaluation of the premaxillary bone in humans. Anat Embryol. 2004;207(6):417–37.
33. Bacon W, Eiller V, Hildwein M, Dubois G. The cranial base in subjects with dental and skeletal Class II. Eur J Orthod. 1992;14:224–8.
34. Ho HD, Akimoto S, Sato S. Occlusal plane and mandibular posture in the hyperdivergent type of malocclusion in mixed dentition subjects. Bull Kanagawa Dent Coll. 2002;30:87–92.
35. Sato S. Alteration of occlusal plane due to posterior discrepancy related to development of malocclusion-introduction to denture frame

analysis. Bull Kanagawa Dent Coll. 1987;15:115–23.

36. Kimes K, Mooney M, Siegel M, Todhunter J. Growth rate of the vomer in normal and cleft lip and palate human fetal specimens. Cleft palate Craniofac J. 1992;29(1):38–42.

37. Takada K, Petdachai S, Sakuda M. Changes in dentofacial morphology in skeletal Class III children treated by a modified maxillary protraction headgear and a chin cup: a longitudinal cephalometric appraisal. Eur J Orthod. 1993;15: 211-21.

FIGURES:

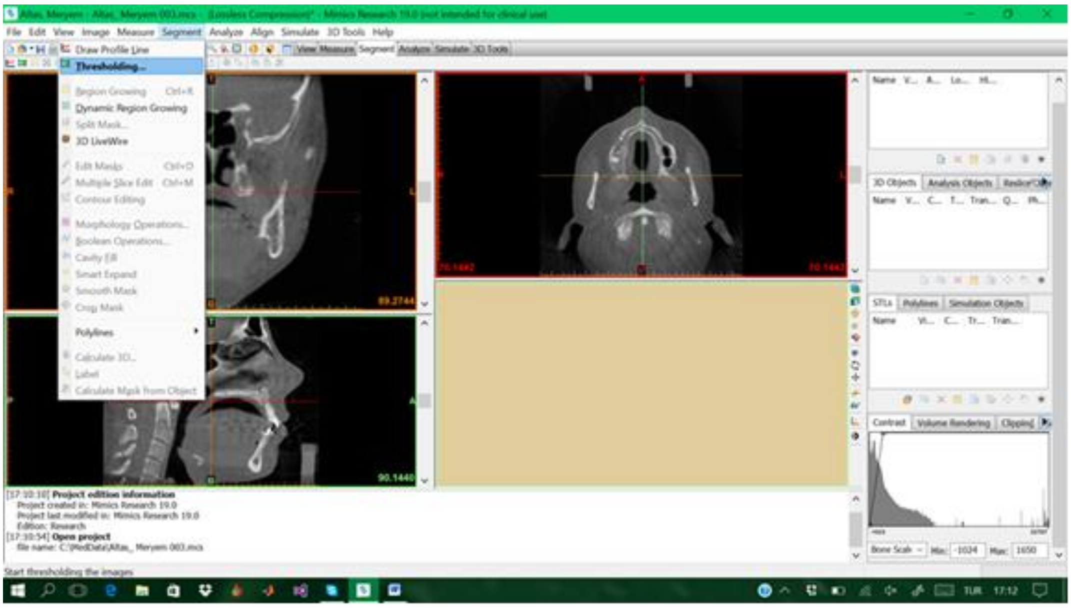

Figure.1 Bone Scale Threshold

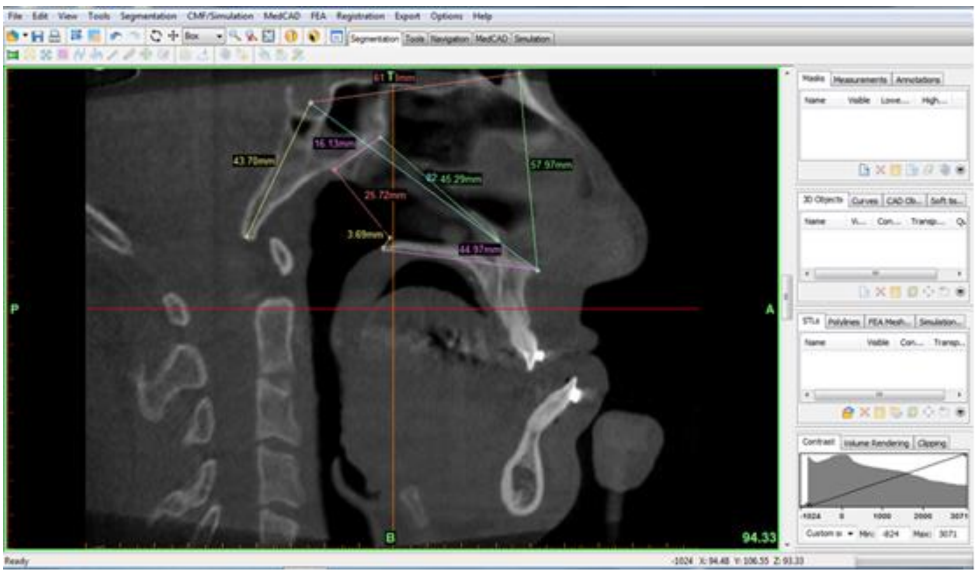

Figure.2 Dimensional measurements of different planes

Figure. 3 Vomer Bone Outline Determination

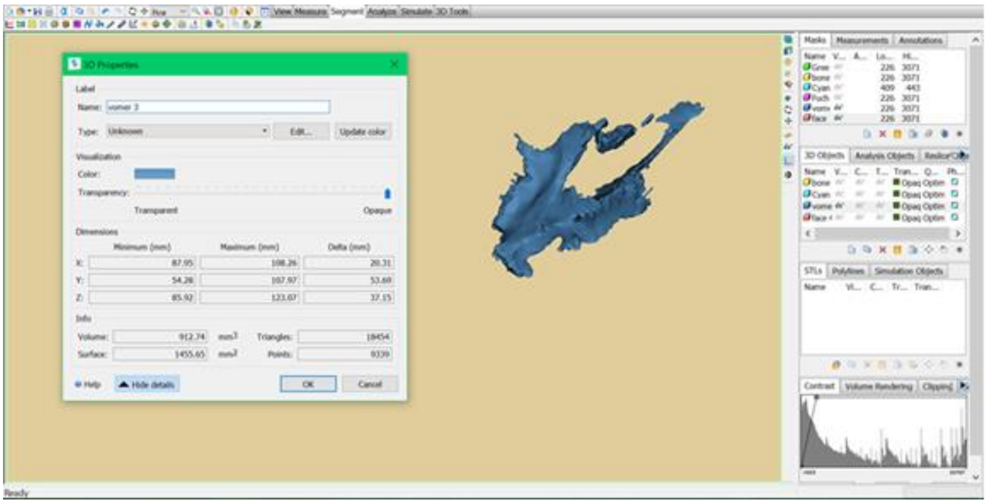

Figure. 4 Vomer Bone 3D model analysis