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RESEARCH ARTICLE

BONWILL'S TRIANGLE - THE UNCHARTED ANATOMIC GEOMETRY

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ABSTRACT

Background: Mandibular fractures include a significant bulk of cases encountered in craniofacial trauma. When the fracture occurs, it affects the patient's occlusion significantly, causing infection and leads to considerable amount of pain. Interventions to prevent these sequelae require either closed or open forms of reduction and fixation. The proper alignment of the fractured fragment is essential to maintain the normal anatomy, function and aesthetics. (1) Through this study I wish to shed light on a long-forgotten theory that could simplify the reconstruction of mandibular defects. Dr. William Gibson Arlington Bonwill believed that there was a geometrical basis for occlusion and a 4-inch equilateral triangle exists between the two condyles and anterior teeth of the mandible. (2) He played a pivotal role in developing the first anatomical articulator utilized in construction of complete dentures in dentistry. (3)

Objective:

- To determine the existence of the equilateral triangle subtended between the mandibular condyles and the incisal point.
- To reappraise the Bonwill's triangle that has been ignored from Medical Anatomy literature.

Materials and methods: A cross-sectional observational study was conducted at Department of Anatomy, Vydehi Institute of Medical Sciences & Research Centre, Whitefield, Bangalore, utilizing 100 adult human mandibles irrespective of age and gender. Digital Vernier Caliper with a resolute accuracy of 0.01mm +/- 0.02mm (<100mm), was utilized to measure the parameters. Three parameters measured were - Right Condyle center to the point between medial mandibular Incisors (X), Left Condyle center to the point between medial mandibular Incisors (Y), and between the centers of both Condyles (Z). A paired student t test was employed to determine whether any significant relation existed between the variables X, Y and Z. Data analysis was carried out using SPSS Version 16 and validation of Bonwill's historical geometric theory was deemed possible only if p value exceeded 0.05. **Result:** All mandibles studied fulfill Bonwill's geometric theory, thereby establishing the existence of the equilateral triangle between the bony landmarks. **Conclusion:** Patients who succumb to mandibular injuries can be benefited through modest surgical interventions, utilizing the geometric theory of Dr Bonwill, with the aid of head and neck radiology. (4) Apart from its clinical relevance, shedding light on its existence will add value to the current literature pertaining to mandibular anatomy.

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INTRODUCTION

Mandibular fractures include a significant bulk of cases encountered in craniofacial trauma. When the fracture occurs, it affects the patient's occlusion significantly, causing

infection and leads to considerable amount of pain. Intervention to prevent these sequelae require either closed or open forms of reduction and fixation. The proper alignment of the fractured fragment is essential to maintain the normal anatomy, function and aesthetics. (1) Defects in mandible may be functional or cosmetic can be by congenital, pathologic, or iatrogenic such as tumor excision, infections or post radiation necrosis. (5) Indications for partial or total mandibulectomy include malignancies, especially squamous

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cell carcinomas, benign tumors like ameloblastomas, sequelae of radiotherapy such as osteoradionecrosis. Dimension of the pathology determines defect size in ablative surgery. Following mandibulectomy, reconstruction of mandible is done using vascularized bone or alloplastic materials like reconstruction plates (6). Through this study, I wish to shed light on a long-forgotten theory that could simplify the reconstruction of mandibular defects. Dr. William Gibson Arlington Bonwill believed that there was a geometrical basis for occlusion and a 4-inch equilateral triangle exists between the two condyles and anterior teeth of the mandible (2) He played a pivotal role in developing the first anatomical articulator utilized in construction of complete dentures in dentistry (3)

AIMS AND OBJECTIVES

- To determine the existence of the equilateral triangle subtended between the mandibular condyles and the incisal point.
- To reappraise the Bonwill's triangle that has been ignored from Medical Anatomy literature.

MATERIALS & METHODS

A cross-sectional observational study was conducted at Department of Anatomy, Vydehi Institute of Medical Sciences & Research Centre during June 2013, utilizing 100 adult human mandibles irrespective of age and gender, after obtaining ethical clearance from the institutional research board. Digital Vernier caliper with a resolute accuracy of 0.01mm \pm 0.02 (<100mm), was utilized to measure the parameters. Three parameters measured were - Right Condyle center to the point between medial mandibular incisors (X), left Condyle center to the point between medial mandibular incisors (Y), and between the centers of both Condyles (Z). In order to validate Bonwill's triangle the three important parameters mentioned above, were measured and values documented on a master chart. The data was thereafter statistically analyzed using SPSS 16 data analytic software. A paired student t test was done to determine whether any significant relation existed between the variables X, Y and Z. Validation of Bonwill's historical geometric theory was deemed possible only when p value exceeded 0.05.

OBSERVATION

The above three parameters were measured for the 100 adult human mandibles included in the study irrespective of age and gender. A paired student t test was performed to establish any significant relation existing between the variables. P values obtained for X-Y, Y-Z and Z-X comparisons were 0.561, 0.937 and 0.897 respectively. The p values of each pair exceeded 0.05. Hence it was conclusively proved that all the three variables were equal, and the values obtained led to the confirmation of the 4-inch equilateral triangle that had been proposed by Dr. Bonwill.

RESULTS

All mandibles studied fulfilled Bonwill's geometric theory, thereby establishing the existence of the equilateral triangle between the bony landmarks.



Fig. 1. Mandibles used for study



Fig. 2. Three parameters measured – X, Y and Z

Table 1. Paired Samples Statistics; n = number; Std. = Standard

n=100		Mean	Std. Deviation	Std. Error Mean	P Value
Pair 1	X	10.1248	0.32902	0.03290	0.561
	Y	10.1161	0.33368	0.03337	
Pair 2	Y	10.1161	0.33368	0.03337	0.937
	Z	10.1194	0.25255	0.02525	
Pair 3	Z	10.1194	0.25255	0.02525	0.897
	X	10.1248	0.32902	0.03290	

DISCUSSION

In our study, the three parameters measured in the 100 mandibles were coinciding with the proposed value of 4 inches or 10cm. This proves the existence of the Bonwill's triangle irrespective of age and gender in adult Indian population. Absence of previous Indian studies on similar lines have provided no venues for demographic comparison within our nation. Ackerman *et al.*, 2007, in his article had stated that Dr. William Gibson Arlington Bonwill believed, there was a geometrical basis for occlusion and a 4 inch equilateral triangle existed between the two condyles and anterior teeth of the mandible. This statement had intrigued us and formed the basis for the null hypothesis enunciated in our study. (2) Deepak Nallaswamy, a proficient Indian prosthodontist elaborates on Bonwill's theory of occlusion. The teeth move in relation to each other, guided by the condylar & incisal guidances. Bonwill's concept is also known as the theory of equilateral triangle according to which, the distance between the mandibular condyles is equal to the distance between the condyle and the midpoint of the mandibular incisors (incisal point).

An equilateral triangle is formed between the two condyles and the incisal point. Theoretically, the dimension of the equilateral triangle is 4 inches or 10cm (7). Magetti *et al.*, 2015, conducted a Computed Tomography study in 120 arbitrarily selected individuals. One of the conclusions drawn from their work suggests Bonwill's triangle is more likely to be isosceles than equilateral. This is contrary to the null hypothesis for our study where we had considered the triangle subtended between the 3 bony landmarks, to be an equilateral triangle of 10cm (8). Nikolopoulou *et al.*, 2019, from Greece, had carried out an osteology study utilizing 10 Male and 9 female mandibles at the Department of Anatomy, Medical School National and Kapodistrian University of Athens. The parameters examined included, distance between middle condylar point and middle incisal point, and distance between left and right middle condylar points. Their results were in accordance with Bonwill's theory. It was observed that Bonwill's triangle in Greek human mandibles were equilateral (10cm approx.) and there was no difference in dimension of triangle between male and female. The parameters utilized were analogous to that used in our research work and their results concur the null hypothesis and results obtained from our study (9)

These parameters can be radiologically measured and proper alignment of the fractured fragment, vascularized bone grafts or alloplastic materials (reconstruction plates) can be achieved in order to maintain the normal anatomy, function and aesthetics. However, Bonwill's triangle does not necessarily apply to all cases and should be considered as an oversimplification which has led dentistry to develop the present theories of occlusion used today. These mandates further extension of study to closely observe anatomical dimensions of adult mandible in certain hormonal imbalances and genetic disorders possibly taking aid of radiological diagnostic tools.

Conclusion

The inferences drawn from our study conclusively prove the existence of Bonwill's triangle in adult Indian population irrespective of age and gender. Knowledge of the mandible geometry Bonwill's triangle will help us to circumvent major issues faced during surgical planning and help surgeons to effectively reconstruct mandible even while operating under limited resources. Moreover, this study helps to shed light on the forgotten theory of Bonwill, which demands a place in modern anatomy literature.

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Conflict of Interest

All mandibles utilized for study were obtained from Anatomy department, Vydehi Institute of Medical Sciences & Research Center (VIMS & RC), Bangalore, India. The mandibles were previously procured by the department for the purpose of Medical education. Vernier Caliper used for measuring the scrutinized parameters was also readily made available with the wide range of anthropometric instruments accessible at our department.

I Dr. Athul Antony Simon, then anatomy post-graduate student at my alma mater (2011-2014), VIMS & RC can confirm that there is no conflict of interest existing on any aspect of this self-funded study for any of the authors.

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Glossary of Abbreviation

Abbreviation	Word
Dr	Doctor
mm	Millimeter
SPSS	Statistical Package for Social Sciences
p value	Calculated probability
t test	Hypothesis test statistic
Std. Deviation	Standard deviation
Std. Error Mean	Standard error mean
n	Number
cm	Centimeter
Fig.	Figure

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