



Alveolar arch shapes and its relation to complete denture retention

Theresia TARIGAN¹, IsmetDanial NASUTION²

¹ Department of Prosthodontics Residency Program, Faculty of Dentistry, University of Sumatera Utara, Medan, Sumatera Utara, Indonesia

² Department of Prosthodontics, Faculty of Dentistry, University of Sumatera Utara, Medan, Sumatera Utara, Indonesia

* Corresponding Author. E-mail: theresiatarigan26@gmail.com

Received; January 3, 2020, Revised, April 15, 2020, Accepted, April 25, 2020

ABSTRACT The alveolar ridge consists of denture bearing mucosa, sub-mucosa and periosteum, and residual alveolar bone. After tooth extraction, the remaining alveolar bone undergoes a remodeling process that leads to morphological reduction and alteration, which results in the change in alveolar ridge forms. However, it does not change alveolar arch shapes. This literature review aimed to analyze the relationship of alveolar arch shapes with complete denture retention. According to House (1958), alveolar arch shapes classified into three classes: Class I-square, Class II-tapering, Class III-ovoid. Those three alveolar arch shapes have a difference in the denture bearing area, with the largest denture bearing site on Class I-Square alveolar arch shape. Some factors that influence complete denture retention are adhesion, cohesion, interfacial force, oral and facial musculature, atmospheric pressure, undercut, rotational insertion path, parallel walls, and gravity. The alveolar arch shapes can affect retention regarding the size of the denture bearing area. The alveolar arch forms with a wider denture bearing area provide more considerable surface contact between the denture and mucous membranes. The forces resulting from those factors of retention might produce more excellent complete denture retention. The square arch shape is the alveolar arch shape with the largest denture bearing area. Hence, the square arch shape is believed to have the best complete denture retention.

KEYWORDS: arch shape; retention; complete denture; denture bearing area

INTRODUCTION

The alveolar ridge is part of alveolar bone with its soft tissues covering the remaining tissues after losing all teeth.¹ This alveolar ridge consists of denture bearing mucosa, sub-mucosa and periosteum, and residual alveolar bone. In the post-tooth extraction, the remaining alveolar bone undergoes a remodeling process that leads to morphological reduction and alteration.^{2,3,4} Alveolar ridge experiences the fastest decline in the first six months, while resorption activity in the alveolar ridge will last in all one's life is a slow process.^{3,5,6,7} This alveolar ridge is the main denture bearing area. The resorption process in the alveolar ridge causes changes in its shape and size; however, alveolar arch shapes, classified as square, tapering, and ovoid shapes, always follow the pattern teeth are still complete.^{1,8}

The jaw arch is a combination of the curvature of the permanent teeth at the alveolar ridge.¹ The

maxillary arch is formed by the alveolar ridge, palate, tuberosity zygomaticus, and buccal vestibule. In contrast, the mandibular arch is formed by the alveolar ridge, mylohyoid ridge, retromolar pad, buccal, and lingual vestibule. Based on the preliminary research, it is found that the three alveolar arch shapes (square, ovoid, and tapering) have different denture bearing area, and the square arch shape has the largest denture bearing area. The larger the complete denture holding area is, the larger the denture bases surface maximally so that retention factors such as adhesion, cohesion, interfacial force, atmospheric pressure, and the capillary attraction will produce more excellent retention.^{8,9,10,11}

This literature review aims to evaluate the relationship of alveolar arch shapes with complete denture retention.

How to cite this article: Tarigan T and Nasution ID.. Alveolar arch shapes and its relation to complete denture retention. JDS. 2020; 5(1): 36-42.

LITERATURE REVIEW

I. Jaw Arch

Jaw arch is the curve shape of the structure of the combination of permanent teeth and alveolar ridge or only alveolar ridge after the loss of some or all permanent teeth. After tooth extraction, the alveolar ridge is shaped by cortical and trabecular bones, connective tissue, and epithelium cover. The

maxillary arch is shaped by the alveolar ridge, palate, tuberosity zygomaticus, and buccal vestibulum. The mandibular arch is shaped by the alveolar ridge, mylohyoid ridge, retromolar pad, and buccal and lingual vestibulum (**Figure 1a and 1b**).¹²

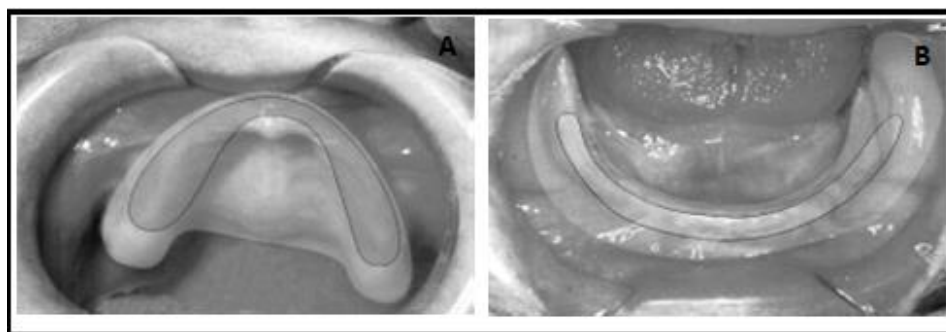


Figure 1. The clinical aspect of the edentulous arch in the maxilla (a) and mandible (b). The outer part, the bright reflection in the outer part, is the denture bearing area used for prosthodontics, and the inside dark part is the alveolar ridge outline.

There are 3 (three) types of jaw arch: (1) Basalt arch is the foundation where teeth implanted. Its shape and size are permanent even though teeth have fallen out or processus alveolar undergoes resorption. (2) The alveolar arch is an arch-shaped by the processus alveolar located in the middle part, between dental arch and basalt. It is the place where teeth are implanted in basalt bones. The alveolar

arch corresponds to the dental arch's basal size. (3) While a dental crown forms the dental arch. It connects to the anterior component's strength and the power of the lips, cheeks, and tongue.¹³ According to Barber, the dental arch is an imaginary arch line which connects the row of teeth in the maxilla and mandible.

1.1 The Size of Jaw Arch

Pietrokovski, at.al. (2007) measure the length and width of the edentulous jaw arch. The measurement point on the maxilla uses the confluence of tuberosity tips at the peak of the left and right alveolar ridge to measure the jaw's width and the alveolar ridge's height papilla incisive with the inter-tuberosity line at the middle palate to measure the length of the jaw.

The mandible measurement point uses the confluence of the alveolar ridge's peak with the left and right anterior retromolar pad to measure the jaw's width and the point of middle insisivus peak with the middle line of the left and right retromolar pad point.^{3,12} Based on the index value, it is found that the measurement of the edentulous jaw arch is classified into small (<79), medium (80-89), and large (>90) for maxilla and mandible.

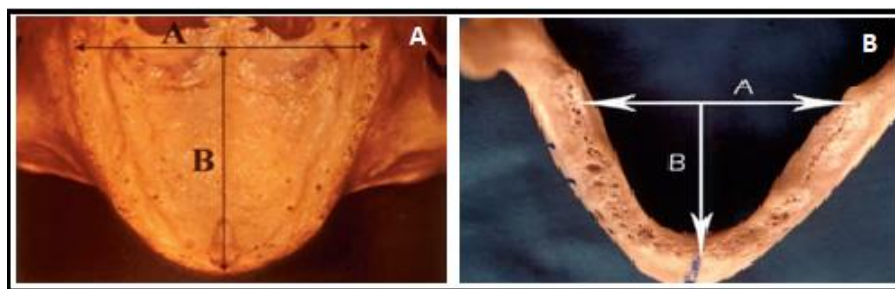


Figure 3. The edentulous maxillary arc (A). The edentulous maxillary arch's width is measured from the left and right alveolar ridge's peak at the tuberosity tip (Line A). The arch's length is measured from the incisal alveolar ridge's peak to the inter-tuberosity line at the middle of the palate (Line B). (A). The mandibular arch's

1.2 The Shape of Jaw Arch

Jaw arch has varied shapes. The variation of jaw arch shape is based on the difference in the arch's length and width. If both jaw arch sizes are nearly the same length or almost the same length, it has a wide shape. If they are far different, they will produce long and narrow forms. The anterior jaw arch can generally be classified as square, tapering, and ovoid shapes, following dental arch shapes when they still exist.⁸ A previous research concerning maxillary and mandibular arch usually evaluates its size and shape. A few centuries ago, Hawley pointed out that the dental arch was like a triangle with the pad between the two mandibular

condyles. In the anterior part, they are like an arch curve, which consists of 6 anterior teeth. McConnell and Scher compare dental arch shapes with curves related to the row, resembling an endless long-chain row. Still, the interior variable has the range among the suspension points. Another research has considered an arch shape such as one of the curves: ellipse curve, parabola curve, hyperbolic curve, or mixed curves. The other forms of the dental arch, explained by Thompson (cited by Nakatsuka and Kumabe), are square, round-square, round, and round-V shapes.¹⁴

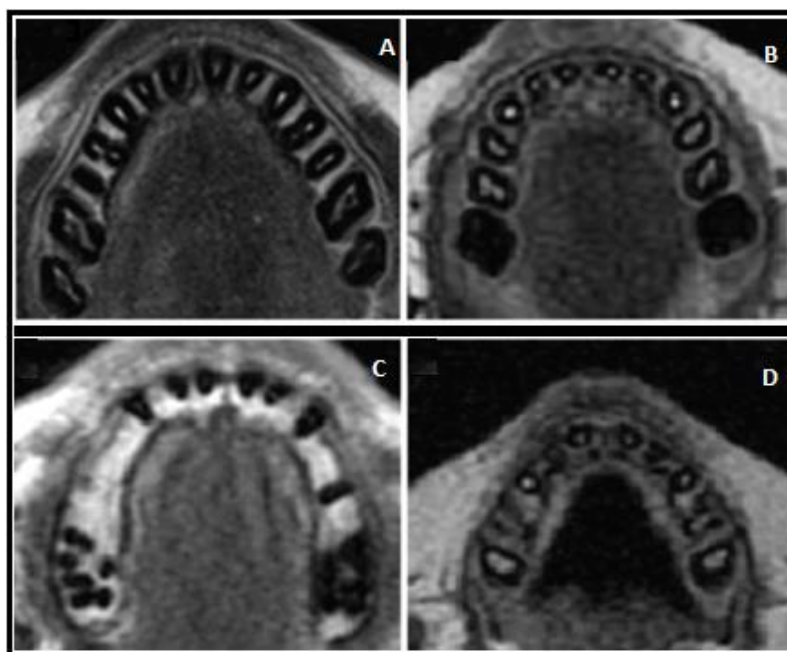


Figure 3. Shapes of the upper alveolar arch: a. elliptic shape; b. round shape; c. U-shape; e. V-shape¹⁴

The shape of the jaw arch, according to Kawabe (1992), has three types: (1) *Tapering*, it has a narrow anterior and becomes wider toward the posterior; (2) *Ovoid*, it has a round part, either in the anterior or in the rear; (3) *Square*, it has right and left sides, which almost run parallel. Based on House's classification, there are three arch shapes: (1) Class 1:

Square; the square arch shape is the best shape for prevention from rotational movement; (2) Class II: Tapering; tapering form offers resistance to move but with a smaller degree than that of square shape; and (3) Class III: Ovoid; ovoid shape, since it becomes round, gives a little or no resistance to rotational movement.¹⁵

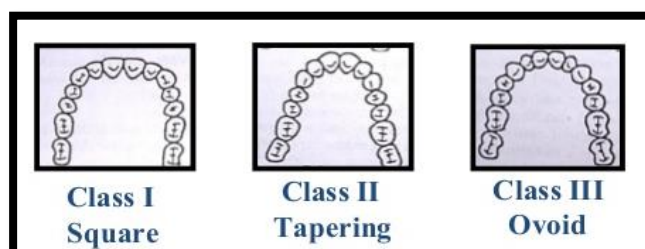


Figure4. Arch shape, based on House's classification.

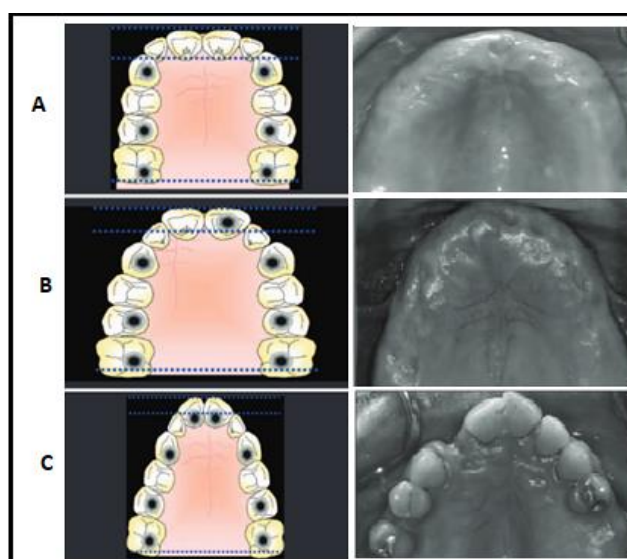


Figure. 5. Square arch shape clinically (A); ovoid arch shape clinically (B); tapering arch shape clinically (C).
(source: British Dental Journal 2006; 201: 261-279)

2. The Factors of Retention in Complete Dentures

A combination of the number of pressures and factors collectively holds dentures in the mouth. Not all of these factors work at the same time. Some of these factors only do when needed to get or to resist a particular style that can release dentures. These are enabling factors for the characteristics of retention, stabilization, and support.¹⁶ Retention is the quality attached to a dental prosthesis, which is functioned to hold the strength of the power that releases it along its installment direction. Denture retention is resistance to the power which removes it from supporting tissue, especially in the standing order.¹ The retention factors are as follows:

Adhesion, adhesion is an attraction force among heterogeneous molecules. Adhesion between saliva to mucosa membrane and denture **base** is achieved through ionic strength between glycoprotein saliva and surface epithelium or acrylic resin. Adhesive power increases by tight and similar contact in the denture, contrary to its supporting tissues.⁸

Cohesion, cohesion is an attraction force among homogenous molecules. It is a retentive force because it occurs in the liquid layers between denture bases and mucosa, and it works to maintain the wholeness of intermediary liquid.⁸ When the force that releases it appears on the denture,

cohesive force in saliva plays its role in preserving the meniscus' fullness in the peripheral area. A complete meniscus in the peripheral region is produced by a peripheral seal, covering the whole denture fitting surface to prevent air entrance to dentures and tissues. It can be done by 1) making post dam in the posterior limit of a maxillary denture, 2) establishing buccal and labial surface of the denture to maintain elastic contact with lip and cheek tissues, 3) Impression is done by using mucocompressive impression technique.^{8,10,11}

Interfacial surface tension is resistance to separation in two parallel surfaces caused by liquid layers between them. It depends on the capacity of the liquid to moisten the rigid substance around it. When the materials surrounding it have low surface tension such as mucosa, the liquid will maximize its contact with the materials, wetting it and spreading to become a thin layer. When the denture base adaptation to the mucosa is adequate, the space among them will fill up with thin layers, and saliva will play its role like a capillary tube in which the liquid will increase its contact with the two denture surfaces and mucosa. By this method, capillarity will help hold dentures.^{8,9,10}

Atmospheric pressure, atmospheric pressure can restrain the power which can release denture when there is maximum coverage in its constraint. This restraining power is called 'suction' because it is resistant to denture removing power from basal seats. However, there is no suction or negative pressure except applying other forces. Retention concerning atmospheric pressure is directly proportionate with the area covered by a denture base. Dentures should have a perfect seal around the edges for the atmospheric pressure to be effective. This can be achieved by physiological border

molding, a selective pressure technique essential to get the benefit of this retentive mechanism.^{8,10,11}

Oral and Facial Muscles, the muscular factor can be used to increase denture retention (stability). Additional retention force by facial muscles is obtained from 1) the position of artificial teeth in the neutral zone, 2) delicate denture surfaces with proper shape specified by dentists, and accurate molding technique should be used to achieve it. Besides that, denture polish design in the labial, buccal, and lingual parts, and dental arch shape should be carefully considered to match the pressures exerted by the tongue, perioral muscles, and occlusal pressure.⁸ Gravitation, When a patient is in a standing position, gravitation functions as a retention force in complete mandibular dentures and a releasing force in full maxillary dentures.^{8,9}

Undercut, Rotational Insertion Path, and Parallel Walls, the Mucosal and sub-mucosal resilience on basal bones bring about simple undercut, which can increase retention. Although excessive bone undercut or reducing it by thin epithelium covering can cause denture retention, it needs sizeable internal denture adjustment. The reduction of undercut in the maxillary premolar area, lateral tuberosity, distolingual area and mid mandibular lingual area is helpful for the prosthesis retention. Some undercuts are related to the direction of linear installment or the focus of vertical installment. When the undercut area has been occupied, and the other remaining bases are moved approaching the basal seat by rotating prosthesis surrounding occupied undercut, this rotational line will resist vertical release. The protrusion of alveolar ridge with buccal and lingual walls can also provide significant retention by adding surface area between dentures and mucosa. Thus, interfacial force and atmospheric pressure are maximized.^{8,11}

DISCUSSION

The alveolar arch shape divided into the variables of measurement and condition. According to some researchers, there are some classifications of alveolar arch shape, which clinically consist of a square shape, tapering form, an **ovoid** shape.^{8,13} These arch shapes use the conventional method to be subjective and depend on individual visual observation. Thus they lack mathematical proof, which can cause different perceptions between two researchers. In prosthodontics, information about arch shape gives important information about selecting anterior teeth and arranging them.¹³

Nuran et al.¹⁰ compare denture-bearing areas in the maxilla and mandible based on the three alveolar arch shapes – square, tapering, and ovoid

shapes. They have differences in the denture bearing area in the maxilla with the average bearing area in the edentulous maxilla. It is 1.7 times more than that in the edentulous mandible. Based on the alveolar arch shape, it is found that the value of the denture bearing area in the maxilla is 21.62cm² (ovoid), 22.12cm² (square), and 20.91cm² (tapering). This measurement is based on arch shapes and the differences in alveolar ridge resorption in the jaw. Other reports point out that the average denture bearing area in the edentulous maxilla is 22.96cm² and 12.25cm² in mandible. This result shows that the maxilla's denture bearing area is twice as much as in the mandible.⁸

The surface of the denture bearing area, which becomes larger, will produce bigger retention. Some retention factors that work between the denture and mucosal tissues of denture bearing are adhesion, cohesion, interfacial surface tension, atmospheric pressure, and capillary attraction. Adhesion and cohesion are important physical factors in denture retention. The amount of retention produced by bonding is directly proportionate with the area covered by a denture bases. The limit of molecular strength gives the effect of 10^{-6} cm (0.000001 cm). Therefore, an arch shape that has a large bearing area will produce more retention. It is achieved by through molding procedure, which spreads to the structure of oral tissue function and barrier to get maximum adhesion and retention.^{17,18}

Cohesion is a retentive model because it occurs in the salivary layer between denture bases and mucosa. This model is directly proportionate with the area covered by a denture bases when the other factors are the same as the model. The salivary fluid layer should be as thin as possible (the thickness of the layer is 10^{-2} cm or 0.01 cm) to get effective retention; therefore, denture bases contact with mucosa should be as tight as possible.^{17,18}

Interfacial surface tension is found in a thin salivary layer between the denture and mucosal-bearing areas, which resembles cohesion and capillary tug-of-war. Capillary attraction works when the denture bases is adjusted to the tissue surface, which creates a space of about 0.1 mm. With contact between the ground and sealed mucosal bearing, the distance between them will fill with a thin salivary layer, which plays a capillary tube and helps hold dentures. This model is also useful and proportionate with the denture bearing area. The change and the shift of soft tissues that occur due to molding or denture pressure should be as little as possible and should be as fixed as possible.¹⁸ Surface tension and capillary attraction function to hold the strength which releases in the horizontal direction.

Pirtrokovski, et al.¹² evaluate the measurement of length and width of bearing tissues in edentulous maxillary and mandibular arch and height measurement of the alveolar height and width ridge in the edentulous maxilla and mandible. Based on the bulk of the jaw arch, which consists of small size (<79), medium size (80-89), and large size (>90). In patients who wear an arch denture, the edentulous maxilla has a length of 52 ± 7.7 and a width of 46 ± 9.2 . In patients who do not have any arch denture, the edentulous maxilla has a size of 55 ± 3.3 and a width of 56 ± 5.1 . The edentulous arch in mandible measurements has a length of 55 ± 2.7 and a width of 53.4 ± 4.6 . Based on the result of measurement, the length and the arch's width in patients who do not

wear denture are bigger than those of those who wear a denture. Age also has the influence which limits the alveolar arch size. Young, elderly patients (60 to 69 years old) have a little larger than that of the old elderly (80 to 89 years old). Zarb et al.¹² point out that the mandible's denture bearing area is 14 cm^2 and for the maxilla is 24 cm^2 .

The area is an essential parameter for analyzing and valuing tissue bearing in the edentulous jaw related to better denture retention and stabilization and for the pre-prosthetic treatment plan and reconstructive surgery. Postic¹⁹ researched denture bearing tissues' surface area in edentulous patients with skeletal class I relation. The surface area of maxillary edentulous in males is $4654 \pm 407 \text{ mm}^2$ and in females is $4212 \pm 368 \text{ mm}^2$. The surface area of mandibular edentulous in males is $2843 \pm 339 \text{ mm}^2$ and in females is $2334 \pm 295 \text{ mm}^2$. Based on the result of the measurement, it is found that the surface area denture bearing is greater in males than that in females, and the maxilla is wider than that in the mandible in the two sexes. Other report stated examine alveolar arch shapes using MRI in adult patients. They found that alveolar arch conditions were varied based on the examination method by the estimation method in the tooth model or by using devices. Based on the research conducted by Nuran et al,¹⁰ square arch shapes have the greatest denture bearing area in the maxilla (22.12 cm^2) than tapering form (20.91 cm^2) and ovoid shape (21.62 cm^2). The value of the denture bearing area in the mandible is also greater in square arch shape (12.46 cm^2) than ovoid arch shape (12.13 cm^2) and tapering arch shape (11.98 cm^2). Alveolar arch of square shape is good in the maxilla and mandible since it has a greater surface area.¹⁰

The greater the surface area is for denture bearing, the greater the retention produced by the models of retention factors such as adhesion, cohesion, and interfacial surface tension. It can be achieved by enlarging denture bases and making tight contact between the denture and denture-bearing mucosa.⁸ The adhesion model will occur when saliva moistens and attaches to the denture bases surface and mucosal membrane from the bearing area. In this case, watery saliva is more effective. This model will be effective when there is a very tight contact between the denture bases and bearing tissues. The models produced by other retention factors, such as atmospheric pressure, will be effective when the denture has a perfect seal around its fringe. The wider the area covered by denture bases is related, the greater the resistance to chewing power. It is better for the maxilla because there is a palate, but it is not good for the mandible due to its horseshoe shape.^{8,10,11} Square arch shape is

an alveolar arch shape with the largest denture bearing area.¹⁰ The more extensive the denture bearing area is in providing surface contact between denture bases and the more significant mucosal

membrane, the greater the models produced by retention factors such as adhesion, cohesion, interfacial surface tension, atmospheric pressure, and capillary attraction.

CONCLUSION

The resorption process in the alveolar ridge can cause changes in its size and shape, but it does not occur in alveolar arch forms. The three alveolar arch shapes (square, ovoid, and tapering) have different basal seat areas in which the square arch

shape is the alveolar arch shape with the largest basal seat area. The larger the basal seat area is, the more excellent the retention. Therefore, the square arch shape is believed to have the best denture retention.

REFERENCES

- [1]. Academy of Prosthodontics. Glossary of prosthodontic terms. J Prosthet Dent. 2005; 94:10
- [2]. Geering A.H, Kundert M, Kelsey C.C. Color atlas of Dental medicine. Complete denture and overdenture prosthetics. Thieme. medical publishers, inc, New York.1993
- [3]. Pietrokovski J, Starinsky R, Arensburg B, Kaffe I. Morfologic characteristics of bony edentulous jaws. J Prosthodont 2007;6(2):141-7.
- [4]. Souza D. Residual ridge Resorption-revisited. Oral Health Care- Prosthodontics, Peridontology, Biology, Research and Systemic Conditions. Intech. 2012
- [5]. Singh O.P, Kaur R, Nanda S.M, Sethi E. Residual ridge resorption: A major Oral Disease entity in relation to bone density. Indian journal of Sciences. 2016; 7(1):3-6
- [6]. Kovacic I, Celebic A, Zlataric D. Decreasing of residual alveolar ridge height in complete Denture wearer. A five year follow up study. Col. Antropol.34(2010)3: 1051-1056.
- [7]. Reich KM, Huber CD, Lippnig WR, Ulm C, Watzek G, Tangl S. Atrophy of the residual alveolar ridge following tooth loss in an historical population. Oral Diseases 2011;17:33-44.
- [8]. Zarb, Bolender. Prosthodontic Treatment for Edentulous Patients. Complete Denture and Implant Supported Protheses. 12th ed. St. Louis: MO: Mosby; 2004:437-442
- [9]. Darwell BW, Clark RK. The physical mechanisms of complete denture retention. Br Dent J. 2005;189(5):248-252
- [10]. Nuran Y, Ceylan G, Aladag L. A Comparison Of The Basal Seat Areas Of The Maxillary And Mandibular Dentures According To Arch Shapes. Ataturk Univ. Dis. Hek. Fa. Derg 2005;15(1): 29-33
- [11]. Soratur SH. Essentials of Prosthodontics. Jaypee Brothers, 2006
- [12]. Pietrokovski J, Harfin J, Levy F. The influence of age and denture wear on the size of edentulous structure. Gerodontology 2003; 20: 100-5.
- [13]. Saleem T, Shafique A. Mandibular arch form analyses: A Comparison between results of two different methods. Pakistan Oral & Dental Journal, 2012;32(3):556-560
- [14]. Stom B.J. Shape of the upper alveolar arch in Albanian Subjects. Balkan Journal of stomatology 2010;14:23-25
- [15]. Maller SV, KS Khartik, Maller US. A Review on Diagnosis and Treatment Planning for Completely Edentulous Patients. JIADS 2010; 1(2) :15-21.
- [16]. Memon MR, Ghani fazal, Shahzad M. Functional assessment of removable complete denture. Pakistan oral and dental journal 2013; 33(3):563-564
- [17]. Blahova Z, Neuman M. Physical factors in retention of complete dentures. J Prosth. Dent. 1971;25(3):230-2
- [18]. Zarb A.G, Bolender C.L, Hickey J.C, Carlsson G.E. Buku ajar prostodonti untuk pasien tidak bergigi menurut Boucher. Edisi 10. EGC, 2001
- [19]. Postic SD. Surface area analysis in edentulous jaws of patients with skeletal class I. Serbian Dental Journal 2011; 58(4):209-213