



Biomechanical Factors Affect Tooth Arrangement for Different Arch Relationship

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ABSTRACT: When a patient is entirely edentulous, this results in adverse esthetic and biomechanical sequelae, so treatment with a complete denture is considered rehabilitation for most of the stomatognathic system.

A process known as habituation is a "gradual diminution of response to continued or repeated stimuli" that is considered part of complete denture acceptance.

Completing a complete denture requires several factors, such as accurate need assessment, building a reliable rapport between the patient and the dentist, effective communication, precise clinical techniques, high-quality laboratory support, and post-delivery patient education and maintenance.

The deficiency of reparative mechanisms, coupled with tooth loss and illness, is a major prosthodontic concern. The artificial occlusion functions in a situation where change is primarily regressive, and the prosthesis is supported by tissues that will alter gradually and irreversibly.

Various tooth arrangement schemes aim to provide functional stable prostheses. Dislodging forces, discrepancies in a residual ridge, maxillo-mandibular relationships, residual ridge relationships, functional and para-functional mandibular movements, esthetic requirements, and preferences of patients are factors governing appropriate tooth arrangements.

The artificial teeth must be arranged to harmonize with the centric relation even though the problems of tooth arrangement are complicated by the disharmony in the sizes of the two jaws. The problems involve both mechanical and esthetic considerations.

KEYWORDS: biomechanics, occlusal scheme, teeth arrangement

I. INTRODUCTION

The most artistic area of dentistry is prosthetics. Rehabilitation with a complete denture is regulated by several parameters including the neural framework, physiological influences (e.g., endocrine, metabolic, and immunological), genetic

and environmental elements (e.g., mechanical trauma, tissue loading), and other "life events" (e.g., psychological stress).[1]

Introducing dental prostheses is likely to alter the biomechanical state in the oral structures concerning both stimulus transfer and distribution [2, 3] changes in the dental occlusion's biological and neural framework may affect the masticatory system's functional reserve. They may function as risk or predisposing factors that can compromise the system's adaptive capacity associated with both pain and changes to the biomechanical elements (such as the temporomandibular joint's structural characteristics, and cuspal inclines)[4].

Tooth selection and arrangement steps affect the successful outcome of complete denture treatment. Clinically, the arrangement of artificial teeth has been recommended to be in the same relationship as the previous natural ones. The tooth position is determined based on forces imposed on it against the denture. These forces either help stabilize it or dislodge it [5]

BIOMECHANICAL FACTORS

1- MUSCULAR CONTROL: The muscular effect affects many aspects of denture design, and muscular control is frequently cited as an important contributor to retention[6]

Muscular control is relevant to 'patients' manipulative skill' as Dentures move during mastication due to the dislodging forces imposed by the surrounding musculature.

The extension of the denture base, design of the labial, buccal, and lingual polished surface of the denture, and the dental arch form are considered in balancing the forces generated by the intrinsic and extrinsic muscles of the tongue and perioral musculature (buccinator, the orbicularis oris).[7]

The tongue and cheek muscles responsible for regulating the food bolus between the tooth's occlusal surfaces must be in a functional balance for the teeth to be in position.[8]



Movements of the mandible and occlusal forces reflect the activity of the mandibular muscles. While the amplitude of muscular impulses in removable denture wearers is twice as high as in persons with normal dentition [9]

Oral perception enhances orofacial muscle activity to support adaptation [10]. Functional adaptation to dentures has several consequences. Patients must be alert that, after the insertion of the dentures, a new muscular behavior may develop to control the functional activities. [11]

2- MUCOUS MEMBRANE SUPPORT AND OCCLUSAL LOAD TRANSMISSION:

The resilience of the denture foundation is the mechanical characteristics that provide the cushioning properties that allow it to tolerate cyclic compression (distribute the mastication loading from the denture to the supporting bone). Low resilience is commonly believed to be the primary cause of treatment failure when using removable dentures[12].

Most post-insertion problems are associated with lower dentures whose stabilization conditions are noticeably poorer than those of upper dentures [13].

An edentulous patient's ability to transmit functional load to the supporting tissues is completely disrupted. Because deprived of the two principal functions of the periodontium which are support and conditional adjustment of the tooth and the secondary dependent function of sensory perception. [14]

Across the residual ridge, the mucosa morphology and thickness can vary significantly[15], and the heterogeneous bone with different qualities underneath further contributes to the varying mechanical responses.[16]

The functional and aesthetic results of prosthodontic treatment are affected directly by the relationship between buccal bone thickness and site-dependent dimensional changes in the alveolar ridge following tooth extraction[17]. Researchers have computed the mean denture-bearing area to be 22.96 cm² in the edentulous maxillae and approximately 12.25 cm² in an edentulous mandible which is less than the support area available in natural teeth.[18]

3- RESIDUAL RIDGE:

The residual ridge is composed of denture-bearing mucosa, submucosa, periosteum, and remaining alveolar bone. A multitude of alterations occur in the remaining bone following tooth extraction and the use of full dentures.[19]

The bone quality of the residual ridge is crucial to the stability and functionality of a denture due to its role in maintaining good support for different kinds of dentures[20]

It is believed that the alveolar bone begins to atrophy following teeth extraction or with edentulous aging, owing to a lack of stimulus to maintain the local bone quality [21].

The inappropriately designed dental prosthesis may cause clinical complications instead of restoring the masticatory function problem if the relevant biomechanics are not considered properly.[22]

Any demonstration of higher hydrostatic stress in mucosa during parafunctional habits and misuse of prostheses such as Intensive denture wearing, and use of improperly designed dentures were major factors contributing to residual ridge reduction. [23]

Residual ridge resorption is a continuous process and complete denture wearers do not experience any improvement in the masticatory efficiency or positive stimulation bone growth[24].

the shape and extension of a complete denture should be designated to minimize the force diffused to the supporting structure to overcome compromised support that is further complicated due to the movement of complete dentures about the underlying bone during function.[8]

Major problems were observed mainly with lower dentures such as instability, pain, and difficulty in mastication because ridge resorption is more common in mandibular ridges. The smaller the mandibular plane angle or the closer the bite, the stronger the forces exerted on the body of the mandible. Craniofacial morphology is also related to the amount of residual ridge loss.[25]

4- SALIVARY PROPERTIES:

Saliva composition, consistency, and flow rate are major contributors to the successful rehabilitation of edentulous patients with complete dentures. It physically washes away food and other debris. The lubrication is important in making the dentures' surface more compatible with the movements of the lips, cheek, and tongue during speech, mastication, and swallowing. Salivary β -glycoproteins facilitate and contribute to denture retention in terms of adhesion, cohesion, interfacial surface tension, and capillarity. [26,27]

Matsuda et al. (2009) stated that the salivary flow rate after denture replacement increases with improvement in the maximal occlusal force. According to the observation stimulated and unstimulated average salivary flow rates increased from 0.45 and 0.06 mL/min,



respectively, before replacement dentures to 0.75 and 0.10 mL/min, after insertion of new complete dentures [28].

Due to the crucial role of the salivary properties as a potential basis of the functional performance of dentures. Impaired salivation causes chewing and speaking discomfort, as well as pain in the denture-bearing tissues in complete denture wearers[29].

YanSH et al observed how a salivary coating affected wet ability and surface free energy. The 0-degree contact angle group has the most hydrophilic surface, possibly related to surface roughness. The authors concluded that while more wet table materials can enhance denture retention, more wet table materials—such as heat- and 3D-printed acrylic resins—are a desirable option for clinical application.[30]

Teeth arrangement should distribute the occlusal load in such a manner as to encourage stability and decrease sliding motion or friction of the denture base. The viscosity and lubrication properties prompt denture sliding rather than denture retention because of the association of denture horizontal movement with chewing efficiency[31, 32].

5- FUNCTION MOVEMENTS AND THE BIOMECHANICS OF MASTICATION:

Preparing food for swallowing demands biophysical and biochemical processes and the neuromuscular control of chewing involving the use of all oral tissues, so the masticatory performance of patients with conventional complete dentures is impaired.[33]

The primary distinction between individuals with natural teeth and patients with complete dentures is that edentulous patients have lost the mucosal mechanism of support as opposed to support by the periodontium. Therefore, they haven't physical stimuli to the sensor motor systems.[34]

Edentulous patients experience altered maxillomandibular relations due to wearing removable dentures resulting from unilateral chewing movements and the eventual migration of dentures. These changes cause masticatory function to be impaired in these patients [35].

The exchange of teeth/periodontium mechanism by complete removable denture alters functional equilibrium (starting from the Development of motor skills and neuromuscular learning to Compromised reflex adaptability), the best environment for the masticatory system to function well is the continuing functional equilibrium [1].

Fixed or removable prosthodontic therapy are treatment plan procedure that dentists choose them as a way to resort to a functional occlusal equilibrium for patients with faded dentition. [36]

The oral stereo gnosis (tactile sensibility) was found to be impaired with age and diminished capability of adaptation. Oral perception enhances the purposeful coordination of muscular movements of the orofacial system and therefore sensory information is required to control mastication within the mouth's narrow ranges. [37]

The findings of investigations show that there is no change in mandibular movement patterns between those with natural teeth and those who wear dentures. Consequently, compensatory neuromuscular modification developed by the patients significantly improves the Functional parameters after the post insertion period these neuromuscular modifications are not related to the mandibular coordination. [38]

The ability of denture wearers to comminute foods is modulated by a number of variables. A masticatory cycle of removable dentures approximates half the normal chewing cycle. Therefore, the duration of occlusal pressure is shorter than the chewing cycle, Movements of the mandible and occlusal forces reflect the activity of the mandibular muscles. While the amplitude of muscular impulses in removable denture wearers is twice as high as in persons with normal dentition, Muscle activity is greater after denture delivery and decreases during adaptation [39].

The so-called balancing contacts between an upper and lower denture are necessary to keep the lower denture in place during chewing. A balanced contact is required for effective chewing, within the mouth. It was discovered that balancing contact occurs before the development of occlusal pressures on the working side. [40]

Even if their use does not indicate a significant improvement in chewing efficiency, dentures that improve the proper distribution of the soft tissue foundation loading and mastication comfort are more acceptable.[41]

Finally, in the edentulous state, few natural adaptive mechanisms are left. [42]

6- PARAFUNCTIONAL MOVEMENTS:

Nonfunctional or parafunctional habits involving repeated or sustained occlusion of the teeth can harm the teeth or other components of the masticatory system.[43]

Wearers of dentures may have parafunctional behaviors that further stress the tissues supporting their dentures. Because the oral mucosa's ability to tolerate continuous loading



varies depending on the amount and duration of mechanical stress while wearing dentures [44]

The intraoral pressure patterns in the oral cavity vary depending on whether the behavior is parafunctional, like bruxism, or functional, such as speaking, swallowing, and mastication [45].

The cautious occlusal interactions that come next to the insertion of new denture may result in A habitual nonfunctional traumatic contact occur between antagonist arches due to the activation of elevator muscles and exertion of forces. It is possible to regulate force in complete dentures so that applying forces would successfully improve the functions over time.[46]

7-AESTHETIC, BEHAVIORAL, AND ADAPTIVE RESPONSES

Aesthetic of a denture can be defined as a pleasing harmonious facial expression that the denture should restore to the patient by the establishment of the correct vertical dimension of occlusion restoring the physiological muscle length so that the patient is more comfortable, satisfied, and accepting of the denture[47]

Virdiya et al illustrated that to compensate for facial contour and restore appearance for patients suffering from flaccidity of facial muscles resulting in sunken cheeks and seeking enhancement in their esthetic conventional complete dentures were fabricated modified by the insertion of detachable cheek plumpers for maxillary and mandibular dentures The dentures and cheek plumpers were fabricated separately using magnets were incorporated into the buccal flanges of the dentures.[48]

The orbicularis oris muscle is essential for denture esthetics so for proper repositioning of the orbicularis oris, three factors have been important to consider:

- 1- Labial flange thickness, dependent on the accuracy of the impression
- 2- The position of the teeth (anteroposteriorly) is dependent upon the proper thickness of the labial flange.
- 3- Restoration of Proportion of correct vertical dimension and restore the normal physiological length of the muscle which allows the normal facial expression. [47]

The occlusal rims should be properly contoured as a guide for the arrangement of teeth and adequate support of the musculature. [49]

One of the important factors that help us in the establishment of ideal occlusion is the orientation of the occlusal plane. Anatomical teeth were used to create balanced occlusion that is

compatible with functional movements of the stomatognathic system and the occlusal plane should be oriented to impose satisfactorily esthetic and function. Clinically anatomical landmarks typically used were buccinator groove, lip commissure, lateral borders of the tongue, and retromolar pad region that assist in the orientation of the occlusal plane. [50]

There are many concepts for teeth selection for aesthetic reasons Chu's esthetics scale plays an important role in the selection of anterior teeth.

Teeth, ridges, and muscles are essential for supporting cheeks which are the most visible region of the face so play an important role in facial aesthetics. loss of molars, total edentulism, and an age-related decrease in muscular tone are the main causes for Concavities and hollowing of the cheeks which deteriorate facial esthetic[51]

General Considerations for the Arrangement of the Teeth

Maxillary Anterior Tooth Arrangement

1. The facial midline indicates the position of the midline of the teeth.
2. the incisal edge of the maxillary anterior teeth determines esthetics and phonetics by positioning it in alignment with the smile line of the patient while the cervical portion, or necks, of the teeth and the fullness of the maxillary denture base position determines the lip support (fullness of the lips) (Figure 1-1).
3. The labial surfaces of the maxillary anterior teeth should generally be placed slightly labial to the surface of the labial flange. When viewed from the tissue side of the denture, (Figure 1-2).

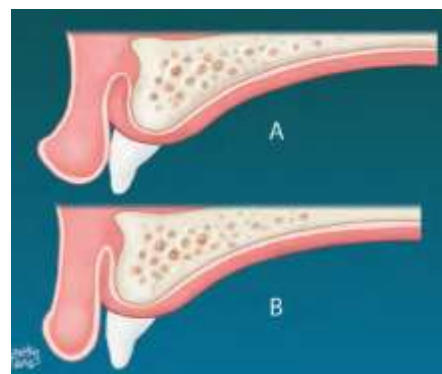


Figure 1-1: show the difference in the position of the incisal edge and cervical portion with the lip between diagram A and diagram B.



Figure 1-2: a small amount of tooth should extend beyond the denture flange when viewed from the tissue side of the denture.

Mandibular Anterior Tooth Arrangement

1. In centric occlusion, it is often preferred to have some horizontal and/or vertical spacing between the opposing anterior teeth when placing the mandibular anterior teeth. This arrangement will reduce early anterior teeth contact, to avoid undue forces on the weaker anterior residual ridges. And will minimize unwanted horizontal overlap of the opposing anterior teeth.
2. The incisal edges of the mandibular teeth should not be placed forward of a plane perpendicular to the center of the labial vestibule. Because of potential undesirable cantilever forces.
3. They should not be positioned over the anterior land area of the cast (Figure 1-3).



Figure 1-3

Posterior Teeth arrangement

The technician either starts to position with the upper or lower posterior teeth.

In general, positioning the palatal cusps of the maxillary posterior teeth over the crest of the lower residual ridge allows maximum stability of the lower denture. To minimize mandibular denture dislodgement during function, the point to

which denture teeth should be ended is when the residual ridge begins to slope up toward the retromolar pad. (Figure 1-5).

- 1- a non-balanced occlusion, the mandibular posterior teeth are arranged on a flat occlusal plane with the long axes of the posterior teeth arranged perpendicular to the plane of occlusion (Figure 1-4).



Figure 1-4

- 2- For balanced occlusion, a curved template is used to arrange the posterior teeth to create an anterior-posterior and medial-lateral curvature of the occlusal surfaces (compensating curve) to form the excursive contacts necessary for a balanced occlusion (Figure 1-5).

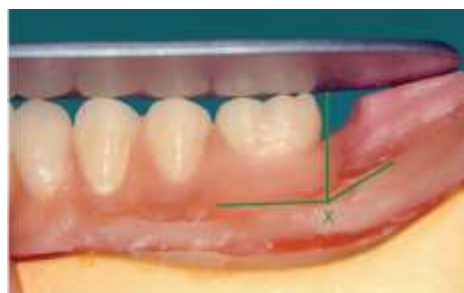


Figure 1-5

- 3- Posteriorly the mandibular molars, particularly the second molar, should be positioned almost directly over the remaining residual ridges (Figure 1-6)

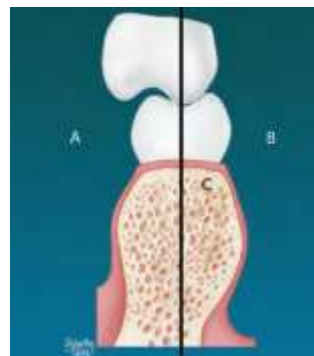


Figure 1-6



- 4- The central grooves and centers of the marginal ridges of the teeth should lie in one continuous line, which may be straight or have a slight curvature (Figure 1-7)[52]



Figure 1-7

ARRANGEMENT PATTERN FOR DIFFERENT JAW RELATIONSHIP

Class I (normal): Whether the concept of arrangement is balanced, non-balance or lingualized, The arrangement pattern for class I maxillary first molar is positioned, into maximum intercuspation through lingual cusp contact of the maxillary first molar in the central fossa of the mandibular antagonist (Figure. 1-8)



Figure. 1-8

Class II (retrognathic) malocclusion:

Multiple occlusal contacts is an important goal with class II patients. Primarily because of esthetics, most skeletal class II patients will posture the mandible in a more anterior position at rest so a substantial vertical and horizontal overlap of the anterior teeth of dentures is essential for the phonetics and the appearance of Class II patients. The appearance in the patient's mouth is totally normal and acceptable. [53]

For posterior teeth to get balanced occlusion between upper and lower posterior teeth, and the stability and comfort of the prostheses, Lingualised occlusion scheme has been suggested in patients with severe class II malocclusion. [54]

Class III (prognathic): the anterior teeth are arranged in an edge-to-edge relation because a reverse overjet is unacceptable. [55]

The posterior teeth are arranged in a cross-bite relation. Either all the posterior teeth can be in crossbite arrangement or it can be restricted to molars, cross-bite is the technique where the upper posterior teeth and lower posterior teeth are interchanged, each other with contra lateral sides [56]

Comes from the fact that both the arch and the side of the teeth interchange in this arrangement (Figure. 1-9) to locate the posterior teeth within the neutral zone. Hence a cross-bite arrangement becomes logical. [56]



Figure. 1-9

II. DISCUSSION

Introducing dental prostheses will likely alter the oral structures' biomechanical state concerning stimulus transfer and distribution [57].

The arrangement of artificial teeth is considered to be an art based on biomechanical factors. Occlusion should function effectively without trauma to supporting tissues in normal or abnormal jaw relations. [58]

The residual ridge and overlying mucosa play a major role in the support and retention of conventional, tooth, and implant-assisted RDPs. The thickness of mucosa, denture adaptation, arrangement of artificial teeth, and amount and direction of occlusal forces can influence the load transmitted to supporting structures. [59]

However, a dentist should always correlate the anatomy with the biomechanical factors while fabricating the denture. The teeth arrangement step of denture fabrication is the primary challenge, but it is one of the requirements for getting a suitable stable denture [60]

When making complete dentures, the occlusal plane forms a basis for the ideal arch arrangement of artificial teeth to fulfill the necessary esthetic and mechanical requirements and, helps the functional balance of the tongue and cheek muscles which are responsible for directing the food bolus between the occlusal surfaces of the teeth, enhancing denture stability during function. [61]



From his observation of different studies Abduo found that in general, anatomical teeth are preferred over flat teeth from the point of view of subjective and objective estimation. Therefore, the null hypothesis that denture success does not rely on tooth form was rejected. According to patients' subjective evaluations[62]

Shetty found that flat teeth arranged in MO monoplane cause more prognathic mandibular appearance in 87.5% of patients. Further noticeable advantages of anatomical teeth were less cheek biting, speech improvement, and good hygiene.[63]

Numerous occlusal patterns are available and the preference between them is valid according to many studies

When evaluating the arrangement of posterior teeth for conventional bilaterally balanced occlusion CBBO; LBBO=lingualized bilaterally balanced occlusion concepts shows similar clinical outcomes. [64]while results reported by Abdulrazzaq et al., who showed that LO attributes a better function and comfort in comparison with BO.[65]

The objective Finding reported by Matsumaru found that LBBO is advantageous for patients with severe ridge resorption in terms of masticatory efficiency and preservation of intercuspal position. [66]

The biological adaptability of the stomatognathic system is well established the association of psychological (progressive comfort and acceptance) and neurophysiological (neural plasticity which allows adaptation to changes in dental status) factors allows, for 2–4 weeks, for most patients to develop confidence and competence with their oral rehabilitation (particularly removable appliances).[67]

III. CONCLUSION:

Restoring the oral cavity inner structure will help recreate (or shape) the external facial features by replenishing the mass that supports the external muscles and enabling a more natural esthetic.

To fulfill the success of rehabilitation with complete denture certain factors should be addressed for each patient to come up with satisfying level of retention and stability as being the main requirement for successful outcome

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