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REVIEW

Optimization of complete denture treatment for flat ridges with various occlusal schemes in distributing stress and masticatory force

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ABSTRACT

Edentulism impacts an individual's ability to chew and digest food effectively, leading to a decline in quality of life. This issue worsens with flat ridge conditions, which increase mucosal stress distribution under masticatory load. Excessive stress beyond the pressure-pain threshold results in poor masticatory performance, emphasizing the importance of selecting an ideal occlusal scheme for such ridge conditions. The basic concept of occlusal schemes aims to preserve residual ridge integrity and prevent further damage over time. Lingualized and monoplane occlusions are schemes that can be used in flat ridge complete dentures to evenly distribute stress and reduce masticatory load. The stress distribution between dentures and the underlying dental mucosa is critical for understanding the relationship with the patient's pressure-pain threshold. Therefore, in vitro measurements can simulate stress distribution and masticatory force assessments. This literature review discusses the measurement of stress distribution and masticatory force on flat ridge complete dentures with different occlusal schemes. (IJP 2025;6(1):65-70)

Introduction

Edentulism refers to the absence of natural teeth.[1,2] When complete, it results in a state of full edentulism where no natural teeth are present in the oral cavity.[2] This condition is a common oral health problem in the elderly, significantly affecting masticatory ability and lowering the quality of life.[3] Tooth loss impacts mastication, speech, and facial aesthetics, often making individuals look older.[4] Salivary flow, biting force, the height and form of residual alveolar ridges, and the stability and retention of complete dentures are some of the factors that affect masticatory function.[5] Mastication becomes increasingly impaired when the edentulous mucosal area is reduced due to ongoing resorption, as seen in flat ridges. The smaller the mucosal area, the greater the difference compared to the periodontal ligament area in dentate patients, leading to concentrated chewing forces over a much smaller area in flat ridge cases.[6]

Complete dentures play a crucial role in rehabilitating fully edentulous patients by improving masticatory ability, addressing psychosocial issues, and enhancing oral health.[7] From a biomechanical perspective, well-distributed occlusal forces over a maximum denture-bearing area minimize excessive pressure concentrations, thereby slowing the progression of residual ridge resorption.[8] Excessive occlusal pressure increases bone resorption rates, especially when forces exceed the balance between bone formation and resorption.[8,9] Therefore, limiting excessive ridge resorption—which may compromise the stability and retention of removable dentures as well as the overall denture-wearing experience—requires an understanding of the amount and pattern of pressure given to the oral mucosa.[9]

Complete dentures are supported by mucosa, which transfers occlusal forces to the underlying bone.[8] The oral mucosa has physiological and mechanical capacities that, when subjected to excessive pressure, can cause pain or discomfort. This occurs due to injury to both soft and hard tissues, and will affect masticatory performance when wearing a denture.[9] The highest pressure that the mucosa can withstand before experiencing discomfort is known as the pressure-pain threshold (PPT).[10] Pain caused by excessive pressure on the mucosa can be mitigated by reducing the load transmitted to the ridge and minimizing movement resistance.6 Selecting a particular occlusion scheme, such lingual or monoplane, is one approach to accomplish this; nevertheless, there are worries that various occlusion schemes may also have an impact on masticatory function and appearance.[11,12] The quantity and direction of pressure received by the periphery are strongly correlated with the occlusal contact between the teeth during centric and eccentric motions of the jaw.[13]

Prior research has documented the denture mucosa's maximal allowable capacity under masticatory pressure.[10,13] It is still unclear how pressure and pain threshold relate to one another in the oral mucosa of denture-wearing edentulous people. Although recent research has looked into the relationship between hydrostatic pressure and soft tissue-induced alveolar bone resorption, much remains unknown regarding the oral mucosa's physiological and

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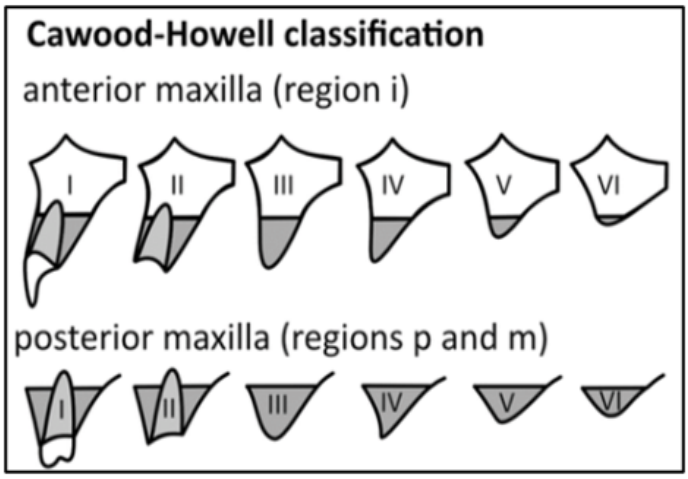

Figure 1. Bone classification according to Cawood and Howel

mechanical capabilities. Prior research measured the pressure produced under detachable prostheses using a variety of techniques, including finite element analysis (FEA), strain gauges, transducers, and tactile sensor sheets. Because of this, it is challenging to compare the findings of different investigations.[9,14] Considerate the relationship between the denture and the patient's pressure-pain threshold requires an awareness of the range of pressure distribution that exists between the denture and the underlying oral mucosa.[8]

The purpose of this review is to discuss the measurement of stress distribution and grinding force on flat-iron complete dentures with different occlusion schemes to obtain preliminary data which is then applied to actual clinical conditions and future clinical studies.

Literature Study

Complete Edentulous

Complete edentulism has a high global prevalence, affecting 0.1-14.5% of individuals under 50 years and 2.1-32.3% of older adults.[15] After tooth extraction, alveolar bone resorption causes continuous changes in shape and reduction in size.[6] Progressive remodelling of the residual alveolar ridge will occur rapidly especially in the first year after tooth extraction in patients with edentulous in the mandible rather than maxilla, with the average rate of resorption varying depending on the individual.[16] The alveolus bone undergoes changes in shape from its initial location, becoming low, rounded, or flat. These changes occur not only on the alveolus bone surface in the vertical direction but 6 also in the labio-lingual/palatal direction.[17]

Tooth loss reduces chewing efficiency, limiting food choices to softer, easily chewable options. Chewing efficiency in complete denture wearers is reported to be less than one-sixth of that in individuals with natural teeth; consequently, edentulous individuals without dentures experience significantly poorer masticatory efficiency.[18] Patients wearing a complete denture will experience masticatory changes associated with increased masticatory cycles, longer masticatory times, and decreased chewing averages. A full denture has traditionally been the preferred prosthetic treatment for addressing this, with the goal of rehabilitating edentulous patients to enhance comfort, appearance, occlusal and facial support, masticatory function, and pronunciation.[15]

Biomechanic of complete denture support

The surface area of the edentulous mucosa available to bear the load from complete dentures is smaller compared to dentate patients. Studies estimate the average edentulous mucosal surface area to be 22.96 cm^2 in the maxilla and approximately 12.25 cm^2 in the mandible. Additionally, the mucosa has limited adaptability to denture use.[18] Mucosal elasticity causes denture instability during functional and parafunctional movements, with chewing and swallowing being the most common vertical activities. However, lateral or tilting movements have the most damaging effects, causing denture displacement and uneven load distribution across the supporting tissues.[6,19,20] Prolonged heavy loads can damage the mucosa and alveolar bone, necessitating dentures with broad bases that fit closely against the mucosa to distribute masticatory forces evenly.[6]

The alveolar ridge include the denture-supporting mucosa, submucosa, periosteum, and residual alveolar bone. Residual ridge changes occur after tooth extraction and denture use. Natural teeth supported by alveolar bone receive tensile forces via the extensive periodontal ligament area, whereas edentulous residual ridges bear vertical, diagonal, and horizontal forces from dentures over a much smaller surface area compared to the natural periodontal ligament.[19]

Flat ridge

Three fundamental requirements must be met for complete dentures to be successful: support, stability, and retention. Compared to upper jaw dentures, lower jaw dentures have more difficulty achieving these characteristics. This is because, in comparison to the upper ridge, the lower residual ridge experiences greater resorption and offers less retention and support. Mandibular bone resorption is four times higher than maxillary bone resorption, based on Atwood and Tallgren research.[21]

Cawood and Howell refined Atwood's classification of bone such as: Class I: Dentate; Class II: Immediately post-extraction; Class III: Well-rounded bone with adequate height and width; Class IV: Knife-edge bone with adequate height but insufficient width; Class V: Flat bone; and Class VI: Depressed ridge with basal area loss.[17]

After tooth extraction, sharp edges become rounded due to external osteoclastic resorption, leaving a well-rounded residual ridge. The knife-edge gradually narrows and eventually turns into a knife-edge as resorption from the labial and lingual aspects proceeds. The knife-edge gets shorter and eventually disappears as the process continues on, turning into a flat, rounded, or flat ridge. The

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ridge will eventually resorb and turn into a depressed ridge.[21]

Occlusal Scheme

The occlusal surfaces of the denture transmit masticatory forces during chewing to the residual ridge's supporting tissues. The size, form, and occlusal plan of the posterior teeth as well as the denture design all affect how these forces are transmitted. The health of the supporting tissues beneath the entire denture is significantly influenced by the distribution of masticatory pressures along the underlying ridge. The quantity and direction of pressure on the residual ridge are strongly correlated with the occlusal contact between the teeth during centric and eccentric motions of the jaw.[12] One of the most important considerations when creating a complete denture is the occlusion scheme selection. Complete dentures frequently employ a variety of occlusion methods, including lingualized, monoplane, and bilateral balance.[6,12]

The bilateral balanced occlusion scheme uses anatomical factors to provide a more natural appearance and good masticatory efficiency. The lingualized occlusion uses anatomical factors in the maxilla and non-anatomical factors in the mandible so that the pre-molar area remains natural in appearance. Monoplane occlusion uses non-anatomical annuli throughout so that lateral movement reduces pressure on the mucosa.[6] The different shapes of the annuli help in reducing the load to be transmitted to the bone and also minimize resistance during movement, but have the impact of reduced masticatory efficiency, less aesthetic appearance, and modifications to the annulus need to be made.[6,22] This will be more obvious if the occlusion scheme chosen is a monoplane scheme with all non-anatomical annuli.[23]

Masticatory Performance

The act of chewing food in order to swallow and digest it is called mastication.[24] Wearers of complete dentures typically chew longer, chew more frequently, chew slower, and swallow larger food particles.[25] These behaviors have an impact on their overall health, raising their risk of physical frailty, cognitive decline, and a lower quality of life.[26] According to studies, people who wear complete dentures have a harder time chewing hard foods than people who have natural teeth,[26,27] and their masticatory ability is only around 50% that of people who have natural teeth.[27-29] Thus, it's critical to preserve and control masticatory function to avoid malnutrition in those wearing complete dentures.[27]

Mastication performance in denture-wearing patients is determined by many factors, such as tooth loss, residual ridge, maximum bite force, tongue, and lip function, salivary secretion, denture experience, and denture stability and retention.27 The larger surface area of the denture pad will result in greater retention. Adhesion, cohesion, interfacial surface tension, air pressure, and capillary attraction are a few of the retention variables that work between the denture and the denture pad's mucosal tissue. Important physical elements in denture retention include cohesion and adhesion. The amount of retention produced by bonding is directly proportional to the area covered by the denture base. The molecular strength limit gives an effect of 10-6 cm (0.000001cm), therefore, arch shapes that have a large bearing area will result in greater retention.[30]

Because the height and shape of the residual ridge are essential for maintaining the denture and preventing denture detachment, poor residual ridge morphology is a major problem for physicians seeking to accomplish successful total denture therapy.28 Residual ridge resorption causes the ridge height to diminish, which reduces the bracing and salivary retention in addition to the denture support area. Furthermore, because the residual ridge's morphology is connected to the distribution of stress in the denture bearing area, it has been demonstrated that this complicated morphology significantly affects the denture's functional performance.[27] There are various factors that affect masticatory performance, it is important to develop accurate assessment methods to understand how well edentulous patients can chew food with a complete denture.

Conventional techniques that are often used to assess mastication performance are the comminution method which uses test food that is crushed by chewing, and the resulting particles are then sieved using sieving techniques,[31] or the use of fuchsine beads and spectrophotometry, or silicone cubes with multiple sieves.[23] In addition, there is also a mixing ability method that uses a special test food in the form of chewing gum with two colors, the patient is asked to chew and observe the color change in the gum,[32] or with an aroma sensor that uses chewing gum with a special aroma that will be measured after chewing is complete using an odor sensor.[33]

Measurement of stress distribution and bite force

Borelli (1681) conducted one of the first investigations in the field of bites force assessment, using a weighted thread looped across the lower teeth of an open jaw. Sauer (1870) used a similar method over two centuries later, substituting a hard metal strip across the molars for the string. The experimental methods used to measure biting force in the past and present can be divided into three categories: piezoelectric sensors, strain gauges and induction methods, optical approaches, and gnathodynamometers and other mechanical devices.[34]

Bite force measurement techniques have advanced significantly over the last 70 years, with a shift away from mechanical tools (such as manometers, pneumatics, and gnathodynamometers) and toward electronic ones like the strain gauge. Howell and Manly (1948) described one of the first electronic bite force measurement systems. This device uses the principle of inductance, which is the movement of silver foil towards an inductance coil under bite pressure. Force gauges can now be smaller because to the usage of electronic gadgets. This makes it possible to employ strain gauges that are placed in fully restored teeth or dentures. Additionally, there is a beam-type version where bite pads are positioned between each tooth and the strain gauges are fixed on a cantilever. By using several strain gauges linked to the dental bridge, the measurement device's lower size also enables the simultaneous measurement of bite and per-tooth forces.[34]

Discussion

The marginal surface area of the edentulous is an important parameter for analyzing and assessing tissue cushioning in the jaw edentulous with regard to better denture retention and stabilization and for pre-prosthetic treatment plans and reconstructive surgery. Retention is an inherent quality of a denture, which serves to resist the force of forces that dislodge it along its attachment direction. Retention variables including adhesion, cohesion, and interfacial surface tension increase retention when the denture bearing surface area increases.[30]

Zarb et al. stated that the support area of the alveolus bone ranged from 22.96 cm2 in the upper jaw and 12.25 cm2 in the lower jaw.6 In the lower jaw, resorption occurred four times greater than in the upper jaw. Atwood and Co. stated that the average resorption was 0.4 mm in the lower jaw and 0.1 mm in the upper jaw. Alveolar bone resorption was greater in the horizontal direction (29-63%; 3.79mm) than in the vertical direction (11-22%; 1.24mm buccally, 0.84mm mesially, and 0.80 distally) at six months post extraction. Ashman stated that the bone height of the alveolus is reduced by 40-60% at 2-3 years post extraction.[35] The posterior region of the mandible also has the greatest risk of resorption as the result of the large concentration of occlusal pressure.[36]

The surface area of the maxillary complete denture is larger (3831mm2) than that of the mandible (2924.63mm2) resulting in a statistically greater mean pressure value (212.82 ± 136.9 kPa) on the buccal ridge of the mandibular complete denture.[7] This correlates with the clinical condition where patients wearing a set of removable complete dentures report feeling more pain pressure on the mandible than the maxilla.[34] The magnitude of alveolus bone loss requires special attention due to the minimal area of tissue support.[17] Physiologically, the periosteal plexus vessels, which provide blood to the mandible, are prone to rupture under pressure, resulting in pain and discomfort. Inflammatory cells will become involved if the pressure continues, resulting in hydrostatic pressure that is higher than capillary pressure. The resorption condition of the margins will come from the nutrient supply being hindered, which will cause increasing resorption.[13,37]

The occlusion scheme and position of the posterior tooth annulus are important factors to achieve denture stability and masticatory efficiency.[11] The healthy tissues receive the masticatory pressure exerted on the denture's occlusal surface. Numerous studies have demonstrated that the shape of the residual ridge affects the use of various posterior denture annuities. The fundamental idea behind the various occlusion strategies that have been researched is to prioritize maintaining the residual ridge's integrity and stopping it from degrading further over time.[12]

In an in vitro study conducted by Ohguri et al11 on the effect of occlusion scheme on pressure distribution in complete dentures said, in monoplane occlusion, the force required to crush soft food or carrots is greater than that in full balanced occlusion and lingualized occlusion. In Madallil et al.'s study,[12] there was no discernible pressure difference between the lingualized occlusion scheme and the fully balanced occlusion during centric occlusion. This may be due to the position of the mandibular posterior teeth of both experimental dentures and the point of application of occlusal force was almost the same. In comparison to fully balanced and lingualized occlusion, the overall disparity in pressure distribution was far reduced in monoplane occlusion.

These findings corroborate studies by Swoope and Kydd that found that variations in the denture's cusp shapes and occlusal surface areas were associated with denture base deformation. Reduction of the posterior denture cusp angle resulted in a significant decrease in the pressure value of the complete denture base.[38] This is in line with the research conducted by Chandratara et al.[39] that non-anatomical dental preparations produce uniform and dispersed stress areas. Whereas in anatomical dental preparations, stresses tend to be concentrated only in certain areas of the photoelastic model. The stress intensity is more in anatomical teeth than non-anatomical teeth, which may increase the possibility of bone resorption rate.

In the fully balanced, lingualized, and monoplane occlusion schemes, virtually little pressure was observed on the maxillary buccal shelf of the nonworking side while imitating unilateral mastication. The denture teeth may be moved from the buccal shelf as a result of this.[12] These results are supported by a study conducted by Frechette et al. in which, it was studied that with each denture tooth, the pressure on the residual ridge of the working side increased by 30-80% in unilateral mastication.[40] Based on the results of a study conducted by Fatola et al37 using FEA, The lingualized occlusion scheme only displayed one small area that exceeded the PPT, despite the fact that the monoplane occlusion scheme displayed the lowest stress distribution when compared to other occlusal schemes. Taking into account aesthetic concerns and masticatory efficiency, the researchers came to the conclusion that the lingualized occlusion scheme is the best occlusal scheme for denture fabrication with resorbed alveolar ridge, given that the average masticatory load needed for chewing is around 50 N.

Evaluation of the occlusion scheme aims to provide better stress distribution to the supporting tissues. The maxillary residual ridge is the primary stress bearing area, and the rugae is the secondary stress bearing area. The primary stress bearing area in the mandible is the external oblique ridge or buccal shelf.[41] In a study conducted by Inoue et al[41] showed that during centric occlusion, the pressure value in the maxillary buccal area was greater than in the palatal area. A decrease in pressure was found on the buccal slope working side and non-working side when using the lingualized occlusion scheme compared to the completely balanced occlusion. This indicates that lingualized occlusion provides lingual resultant force on the buccal slope to improve the stability of the lever in the mandibular denture.

In a study conducted by Paraz et al[9] found that the highest stress value was on the buccal ridge, followed by the retromolar pad,

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buccal shelf, and anterior part, the same as the direction of the right unilateral masticatory load. Whereas in the direction of the left unilateral masticatory load, the highest stress value is on the buccal ridge, followed by the retromolar pad, anterior part, and buccal shelf.

Therefore, it is important to examine the stress distribution and masticatory forces exerted on the oral mucosa to minimize excessive resorption of the alveolar ridge on the flat ridge with various occlusion schemes.

Conclusion

Management of edentulous cases, especially flat ridge conditions, requires a deeper understanding of how the occlusal scheme can play a role in maximizing the patient's masticatory performance while preserving the ridge mucosa and underlying alveolar bone from further pain and resorption. Therefore, studies that offer standardized data applicable to the denture mucosa's pressure distribution are required. Understanding the relationship between the patient's pressure-pain threshold and the pressure distribution range on the denture and oral mucosa is essential.

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