Journal of Research in Medical and Dental Science
2021, Volume 9, Issue 11, Page No: 140-145

Available Online at: www.jrmds.in
eISSN No.: pISSN No.2347-2545

Stumbling Blocks for Hybrid Denture

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ABSTRACT

Edentulism is associated with a reduction in quality of life. Over the years with the advancement in implant ology and its prosthesis, implant-supported fixed or removable prosthesis revolutionized the opportunity for rehabilitation of the edentulous patient. Many factors led to the emergence of a complete arch prosthesis supported by 4-6 implants known as hybrid dentures. Despite the long term success rates for 10-15 years, hybrid dentures require maintenance and repair to keep the prosthesis functional and stable in the mouth as there are various complications seen like denture tooth wear, fracture of the denture teeth or the veneering acrylic, lost fillings in screw-access openings and mobile prostheses mainly due to screw loosening, fractured screw, etc. In recent times due to the evolution of the dental field in implantology it is necessary to know the complications encountered during fabrication of implant supported prosthesis. Hence, this research paper aims to review the existing literature on the complications in hybrid dentures.

Keywords:

Hybrid denture, Occlusion, Cantilever, Framework

HOW TO CITE THIS ARTICLE: Minal Tulsani*, Deepak Nallaswamy, Vaishnavi Rajaraman, Divya Rupawat, Sanjana Devi, Stumbling Blocks for Hybrid Denture J Res Med Dent Sci, 2021, 9(10): 140-150Stumbling Blocks for Hybrid Denture, J Res Med Dent Sci, 2021, 9(11): 140-145

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Received: 05/11/2021
Accepted: 19/11/2021

INTRODUCTION

Complete edentulism has seen to be decreased in the new era, but the various studies have shown an increase in the number of patients requiring treatment due to greater life expectancy which has led to an increase in population. One of the most common treatment options for completely edentulous patients has been complete denture as it restores both esthetic and function. But complete dentures come with their set of limitations like instability, decreased chewing ability, difficulty in swallowing, discomfort; all of these together can directly affect the quality of life of an individual [1]. The use of dental implants has gained success due to the large attribution of an orthopaedic surgeon and a Swedish professor Per-Ingvar Brane mark who turned an accidental discovery into a dental revolution. Disadvantages of complete dentures and demand for fixed prosthesis has led to the use of prosthesis retained by dental implants as one of the treatment options, with implant yielding excellent survival rates after 5 and 10 years. In suggested the use of 6-8 implants for mandibles and 14 implants for maxilla for implant-supported fixed prosthesis for completely edentulous patients. Clinicians faced difficulties in the placement of more than 4 implants per jaw due to various factors like deficient bone height/width, maintenance of oral hygiene and increased cost. In certain cases, approximation of anatomic factors like the mandibular canal and maxillary sinus leads to risk. Increased surgical morbidity, increased biological complications like bone loss, etc are also considered limitations for a clinician. All these factors led to the emergence of a complete arch prosthesis supported by 4-6 implants to maximize the use of the remaining atrophic ridge. The prosthesis fabricated when using 4 implants in the mandible and 6 implants in the maxilla are called hybrid dentures as it resembles a flangeless denture which is retained mainly by the support of the implants as there is no contact between the prosthesis and the remaining alveolar ridge [2]. Hybrid denture represented one of the unique aspects in the reconstruction of the edentulous arches as the implants are placed only in the anterior region and the prosthesis is given in the posterior region with the support of a cantilevered bar/framework. Various types of prosthesis were tried for hybrid dentures like all acrylic, metal framework with acrylic resin veneering, and metal-ceramic. Out of these, the most commonly used is the metal framework with acrylic resin veneering as it has shown to transfer less stress on the implants especially on the working side during eccentric movement. Despite the long term success rates for 10-15 years, hybrid dentures require maintenance and repair to keep the prosthesis functional and stable in the mouth as there are various complications seen like denture tooth wear, fracture of the denture teeth or the veneering acrylic, lost fillings in screw-access openings and mobile prostheses mainly due

to screw loosening, fractured screw, etc. This increased amount of tooth fracture is seen because of lack of mechanical retention for teeth and acrylic in the metal bar/framework, decreased number of implants (as reduced number of implants increase the stress concentration in the abutment/bar), existence and length of the cantilever, opposing dentition, the material used in opposing prosthesis (if any), type of occlusion, etc. Other reasons for tooth fracture or deboning can be contamination of the two joining surfaces mainly by wax, the difference in composition of teeth and denture material, the aging process, the difference in the processing method of teeth and denture resin, and reduced ridge lap surface area for bonding. Occlusion is one of the main factors influencing the biomechanics of force distribution which can affect teeth fracture, as denture teeth act as a single unit force applied to one denture tooth gets distributed to complete prosthesis. Posterior tooth morphology and occlusal schemes have been altered to reduce the impact of lateral forces on the denture. Bilateral balanced occlusion (BBO) has been said to improve the distribution of occlusal loads throughout the arch with working and nonworking cusps in guidance. But it has been suggested that BBO cannot be maintained due to the differential wear rate of the teeth. The alternative occlusal scheme is canine guided occlusion (CGO), this scheme protects the posteriors in eccentric movement and anterior in centric. However, there is no evidence to support that the CGO scheme is successful in conventional or implant-supported complete dentures or hybrid dentures. Despite the presumptions made about both occlusal schemes, there has been limited evidence suggesting the success of either of the occlusal schemes over another, either in terms of function, complications, or quality of life. The aim of this research paper is to review the existing literature on the prosthetic complications in hybrid dentures.

REVIEW OF LITERATURE

Hybrid denture

Edentulism is associated with a reduction in quality of life. Successful management of edentulism remains an issue of concern for the edentulous patient and dentist. For a long time, conventional denture therapy was the only treatment available for restoring esthetics, function, and social well-being of edentulous patients. Over the years with the advancement in implantology and its prosthesis, implant-supported fixed or removable prosthesis revolutionized the opportunity for rehabilitation of the edentulous patient. Implant-supported overdentures have gained high success, but there are some edentulous patients who reject any type of removable prosthesis. The fixed prosthesis was introduced to solve the problems caused by unstable and uncomfortable mandibular dentures [3]. Fixed options for implant-based rehabilitation of the edentulous patient have been documented for both maxillary and mandibular arches with a variety of opinions impacting the implant number, position, and distribution within each arch, inter arch distance. These prostheses can be implant-supported fixed denture prosthesis or hybrid prostheses, CAD/CAM-based restorations with metal or zirconia frameworks, monolithic zirconia implant-supported fixed prostheses. The most important factor determining the material and the type of the prosthesis is the amount of crown height space. If the crown height space is >15 mm then the metal porcelain prosthesis will have a bulky metal framework. An alternative to this metal porcelain fixed restoration is a hybrid prosthesis. It refers to fixed removable rehabilitation for completely edentulous arch using four to six implants with screw-retained prosthesis constructed using a smaller metal substructure, denture teeth, and acrylic resin i.e it is a flangeless denture which is retained using implants as there is no contact between the gingival tissue and the prosthesis. The original design of the hybrid prosthesis was a gold alloy framework attached to the implants with the help of copings, this was designed by a Swedish investigator. Advantages of hybrid denture include reducing the impact of dynamic occlusal forces due to its acrylic denture teeth and base, low cost, high esthetics, reproduction of gingival color, easier to repair in the case of porcelain fracture because the denture tooth may be replaced with less risk than adding porcelain to traditional porcelain–metal restoration, it can be given on combination of tilted and axial placed implants, etc abutments because of bone loss.

Complications of hybrid denture

Estimated that about 33% of denture repairs involve tooth debonding. found that the most frequent complication with implant-supported prostheses after mucositis was the fracture of acrylic teeth of the implant-supported hybrid prosthesis. A systematic review including 17 studies showed that 70% of the prosthesis presented with some form of acrylic veneer fracture after 15 years of follow up and this review showed that certain prosthesis showed multiple veneer fractures. Reasons for acrylic veneer fracture were considered as insufficient material thickness, deformation module of the framework when distal cantilevers are present and poor resin bonding, and insufficient support from the metal framework. Fracture of such prostheses is most commonly located at the teeth level since the gingival-colored portion of the prosthesis is expected to receive relatively less mechanical stresses compared to the tooth portion of the prosthesis (i.e. the incisal edges of anterior teeth and functional cusps of posterior teeth). However, the fracture in the gingival portion of the prosthesis can also happen when the mechanical force is transferred vertically toward the cervical area of the prosthesis (Figure. 1). These gingival portion fractures would be encountered more in patients with Parafunctional habits or with poorly designed prostheses or improper occlusion. In a study done by Purcell et al 2015, maxillary complete denture was opposed by mandibular hybrid prosthesis, the most common complications found were maxillary complete denture relining, posterior tooth fracture in mandibular hybrid prosthesis and screw

loosening. There were no framework fractures observed in the period of a 9-year follow-up. A similar fracture of the acrylic teeth and base was seen in 37% of the cases in the 5 year follow-up period when the mandibular hybrid denture was opposed by a maxillary complete denture. Similar findings were reported in several other publications.

Figure 1: Fracture of the hybrid denture at the gingival level.

Thermocycling was found to decrease resin to metal bond by aging the resin, diffusing water between the resin and metal, and can also result in stress at the resin metal interface due to differences of coefficient of thermal expansion between both materials.

Factors affecting complications of hybrid denture

Cantilever: Many studies evaluating the biomechanical aspect of mandibular implants supported by bars have shown that the bar helps in the best distribution of vertical force onto the implants. Short distal cantilevers have shown no influence on force patterns [4]. But cantilever length is important to be evaluated when deciding to fabricate implant-supported acrylic screw-retained hybrid prosthesis. When cantilever prosthesis is given on splinted implants class 1 lever action is seen most commonly. When 100N load is applied on two 10mm apart splinted implants with a distal cantilever of 20 mm, this load is resisted by the tensile force of the mesial implant (200N) and the compressive force of the distal implant (300N) which acts as a fulcrum (Figure 2). When the distance between two implants is reduced but the position and amount of distal load remain the same, the force on the implants increases. Tensile force on the anterior implant increases by 2.5 times whereas compressive force on the distal implant increases by 2 times **(31)** (Figure 2).

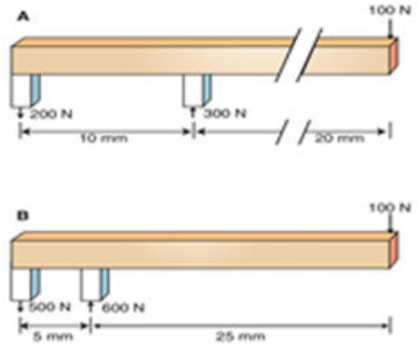

Figure 2: Force distribution in implants with different AP spread.

The tensile force has detrimental effects on the bone, implant, and prosthesis. When implants are placed in porous bone or when the number of implants is less the cantilever length should be reduced. The distance between the center of the most anterior implant and the line drawn joining the distal part of the posterior implant is called the anteroposterior spread. Greater is the AP spread, less detrimental forces act on implants that are applied on the distal end of the prosthesis **(31)**. AP spread and cantilever length can vary according to the shape of the arch as well (Figure 3).

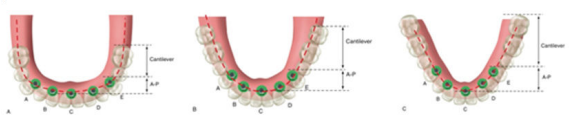

Figure 3: Arch shape affects the anteroposterior (A-P) distance. A, The square arch form is less than 5 mm. B, The ovoid arch form often has an A-P distance of 5 to 8 mm. C, A tapered arch form has the greatest A-P distance, larger than 8 mm.

A cantilever length of 15-20mm leads to increased stress on implants, causing overloading of implants. Micro fracture of the bone, and/or bone resorption occurs as a consequence of these increased stresses. The compressive stress in the 15 mm cantilever prosthesis was 33% more than that in the 5 mm cantilevered prosthesis. Hybrid prosthesis without cantilevers resulted in the reduction of the peri-implant bone strain during the healing period, compared with cantilevers. The cantilevered prosthesis has been shown to have significantly more bone loss when compared to non-cantilevered prostheses. And it is seen that implant frameworks were vulnerable to fracture, especially at the junctions between distal abutments and cantilevered segments. Moreover, the researchers found that anterior tooth fracture was more common than posterior tooth fracture (Fig 4) **(12)**. This could be due to the axial implants being located more anteriorly in the cantilevered group because of which the patient might incise more anteriorly which maximum bite forces. This increased bite force in anterior teeth may induce more crown fractures seen in the cantilevered group compared to non cantilevered groups.

Figure 4: Anterior tooth fracture in the hybrid denture.

Reported that increased prosthetic screw loosening is also seen while loading cantilevers as it increases the load distributed onto the implants in a full-arch hybrid prosthesis. Similarly, and reported screw loosening among the common prosthetic complications of cantilevered hybrid mandibular fixed complete-arch dental prostheses opposing maxillary complete denture. This could be due to unfavorable occlusal loading on the cantilever extension which might lead to loosening of abutment and prosthetic screws. Thus almost all the authors recommend the cantilever length of 1.5 times of the anterior-posterior spread of the implants.

Framework

Another important aspect to consider when fabricating implant-supported fixed removable complete prosthesis is the design and material of the framework stated that framework can be designed in two ways, first in which the bulk of the prosthesis will be attained by a metal framework and the acrylic teeth are supported by minimal denture base and second in which the bulk of the prosthesis will be attained by acrylic denture base with minimal sized metal framework. Fabrication of framework for hybrid denture followed the following criteria like adequate bulk of metal bar for the strength of the prosthesis along with adequate retention of denture teeth and denture base resin, adequate access for patients to follow oral hygiene procedures, minimal display of metal bar for the esthetic appearance of the prosthesis mainly from the facial aspect, etc. Initially, the hybrid framework was made using gold alloy and then the gold pattern was cast with silver palladium alloys stated that no equation could describe the functional deformation pattern of a hybrid framework with a cantilever. He stated a formula according to which the deformation (D) of the hybrid framework was inversely proportional to height and width of the cantilever (H, W), modulus of elasticity of the material used (E), and directly proportional to the amount of force applied onto the framework by opposite occlusion (F) and length of the cantilever (L).

$$D = F \times L \times \text{constant} / E \times W \times H$$

The rate of framework fracture was higher when both the arches received fixed and almost all the fractures occurred at the beginning of the cantilever arms. The incidence of framework fracture for hybrid denture prosthesis was 8.8% when the opposing dentition was complete denture. While when the opposing dentition was either natural teeth or fixed prosthesis, the incidence of fracture was 13.3%. The framework is most vulnerable for fracture at distal to the distal implant and hence it should have adequate height to withstand the forces on the cantilever section as 70% of the occlusal forces were borne by the cantilever sections. To avoid the fracture of the framework the cantilever length should be a maximum of 20 mm, increase the cross-sectional area of the metal bar with at least 3 mm of vertical bulk to increase the rigidity of the framework, use of metal alloys which have higher tensile and yield strength and the most important being the framework design. Framework fracture may be avoided with optimal, mechanically designed frameworks. Four framework designs are L-beam, I-beam, Elliptical, Oval. The I-beam design has been shown to have the smallest maximum normal stress and least deflection of all. The elliptical bar has been shown to have the most deflection and the L-beam has the largest maximum normal stress. Therefore, to strengthen the cantilevered portion of the hybrid framework I-beam design has been proposed as it minimizes permanent deformation under stress by maximizing resistance to occlusal loading, also with minimum increased bulk and weight, it provides rigidity and strength to the framework. The framework must be designed properly so that they provide adequate space for acrylic resin i.e minimum of 1.5-2 mm to minimize potential fracture of denture base. Retentive elements for denture base materials like nailhead retentive elements, retentive loop, undercuts placed in the framework should be designed as integral parts of implant frameworks but care should be taken that it doesn't interfere with tooth placement. Retentive undercuts should be present near the junction of acrylic and metal finish lines. Resins are mechanically attached to the framework, so finish lines help to minimize the seepage of intraoral fluids into the resin metal junction and minimize the staining. A study done by showed that the maximum force was required to separate the acrylic resin from primed metal with beads and lowest from a smooth metal plate. The framework can be made from a large range of metal alloys ranging from conventional noble alloy or titanium alloy or base metal alloys. Recently, Zirconia frameworks have been shown to have promising alternatives. Many studies have shown that rigid material can minimize the deflection of the framework and they have shown that the least deflection of the framework is seen by the cobalt-chromium framework and generates the least amount of force on implants, this is seen due to the accuracy and passive fit of the framework, and the acrylic bonding has seen to be better with base metal alloy when compared to noble and titanium alloys.

Modifications for framework

To avoid the acrylic chipping or debonding from the metal framework many metal modifications were made. Titanium framework made up with different processing methods were compared for acrylic chipping, the results showed that Selective Laser Melting (SLM) titanium framework has less incidence and severity of acrylic chipping when compared to Computer Numerical Controlled (CNC) titanium framework. The acrylic around the CNC framework initially cracks around the distal implant and is then followed by acrylic chipping. Apart from different methods of processing of the

framework, many surface treatments have been tested for their effect on deboning of acrylic resin. When crack propagation travels along this inherent surface area, clinical problems of microleakage, water inhibition, bacterial contamination, and staining can lead to failure. When chemical bonding is incorporated, this flexure along the increased surface area interface is mitigated, resulting in an altered path of least resistance that includes cohesive failure. So, chemical modifiers applied to the metal surface can help in decreasing problems resulting from thermocyclic changes. Airborne-particle abrasion cleans, roughens, increases the surface energy, and increases the wet ability of substrates. Particles used in this process vary depending on the desired effect. The most common particle utilized in dentistry when abrading metals is aluminum oxide. It's cheap, abundant, and can be purchased in a variety of particle sizes. The tribochemical silica coating technique is a well-established resin metal bonding system and was introduced in 1989. This system requires the use of a silane coupling agent to provide a chemical bond as well as micromechanical retention by air-borne particle abrasion. Particles used for air abrasion in the silica-silane bonding system also affect the shear bond strength. When aluminum oxide particles are used for air abrasion along with silane the shear bond strength increased by 60%, while when silica modified aluminum oxide particles are used for air abrasion alone the shear bond strength increased by 68%, a significant difference from airborne-particle abrasion alone Primers used in dentistry are applied to increase the adherence of one material to another. Metal alloys, before bonding, typically receive a primer coat to increase chemical linking to the polymer. These primers are applied after airborne-particle abrasion and contain molecules that bind to the metal on one end and the resin on the other. Metal primers perform differently when applied to different types of metal. In a study, 5 types of metal primer were evaluated on 3 different metals i.e titanium, titanium alloy, cobalt-chromium alloy the results of this study stated that application of any primer improved the bond strength of acrylic to any metal used. Fingers and projections increase support of the teeth, but present a challenge for fabrication and repair; they also use larger quantities of raw titanium alloy too. There exists a commercial drive to create a substructure that, when applied clinically, could be used for any space scenario encountered and could be repaired easily.

Acrylic resin

Acrylic resins were introduced in 1937 and are the dominant acrylic used for the fabrication of partial/ complete dentures and for hybrid dentures, it is commonly used because of its simple processing method and low cost of fabrication. Even though resin has been in use for 80 years, denture fractures and debonding of acrylic teeth remain a major complication in prosthodontics. Estimated range of denture repair involving teeth debonding and denture fracture was about 22-30% . Tooth debonding is mainly seen due to direction of force encountered during mastication, contamination of the two joining surfaces mainly by wax, the difference in composition of teeth and denture material, aging process, difference in the processing method of teeth and denture resin, and reduced ridge lap surface area for bonding while denture fracture is seen due to fatigue caused by repetitive masticatory and flexural loads. Property of denture material can be improved by adding various agents like rubbers, fillers, glass fibers, zirconia and recently various nanoparticles in form of nanotubes or nanofibers have been added to improve the chemico-mechanical properties of acrylic resin. Various studies have tried to modify the monomer content to increase the mechanical properties of the resin. Modifications like vertical groove, horizontal slot, round groove, T shaped tunnel (Figure. 5), diatoric cavity, sandblasting, ethyl acetate, bonding agent, etc have been tried to improve the bond strength between the denture teeth and resin.When the mechanical modifications of denture teeth are compared, T-shaped slots or grooves prepared on the ridge lap area of the denture teeth have shown to have the highest bond strength value. The denture teeth having cingulum ledge lock modification fractured instead of debonding from the denture base (Fig. 5). When the chemical modifications of denture teeth are compared, denture teeth that were primed with monomers have shown better bond strength than sandblasted denture teeth.

Figure 5: Cingulum ledge lock modification (left), T-shaped tunnel (right).

Occlusion

Occlusion is one of the most important aspects of clinical dentistry in oral rehabilitation. In edentulous patients, occlusal disharmony is observed frequently. When new set teeth come in contact there might be some displacing forces that can lead to discomfort or neuromuscular alterations which can lead to emotional disturbances. Therefore, a suitable occlusal scheme is a critical doctor in determining success especially while rehabilitating completely edentulous patients. Two occlusal schemes most commonly used are bilateral balanced occlusion and canine guided conclusion. Bonwill introduced the concept of bilateral balanced occlusion (BBO) (Figure. 6). BBO exists when there are simultaneous contacts between the posterior teeth on both sides even in eccentric movements. BBO was most commonly used for complete denture and implant-supported overdenture as it permits even distribution of force and provides primary stability during functional loading [5]. It is difficult to maintain bilateral balanced occlusion due to different wear patterns of the teeth. Canine-guided occlusion (Figure. 6) is commonly used in the dentate population. According to this occlusal scheme there is maximum intercuspation in centric and eccentric there is

posterior disocclusion and only canines come in contact. Indications are multiple implants supporting bridgework and occluding with fixed prostheses or natural teeth. With fixed prostheses rigidly supported by multiple implants, the concept of canine guidance can be applied unless a complete denture is worn in the opposing jaw. It is strongly suggested that the lateral guidance of the working side should not be exclusively on a single tooth or implant. While canine-protected lateral guidance is easy for the technician to build up, a group function may have a better protective function for the implants and may distribute loading forces equal to the supra structure.

Figure 6: Bilateral balanced occlusion (left) and Canine guided occlusion (right).

Conclusion

Balancing contacts as built up with complete dentures may also contribute to load distribution, but they must be avoided on a cantilever. Canine-guided occlusion has been shown to induce significantly more stress on the implants compared to bilateral balanced occlusion. In implant prosthodontics, a specific evidence-based occlusal philosophy has not yet been developed. However, there are a few specific rules, which may favour optimum load distribution onto the implants. The greater the number of implants placed and therefore the greater the rigidity of the prosthetic connection achieved, the more the occlusal scheme may resemble canine guided occlusion. From a biomechanical point of view, however, balanced occlusal guidance as utilized with complete dentures might favour equilibration of occlusal loads due to simultaneous contacts on the working and non-working sides.

REFERENCES

1. Rozier RG, White BA, Slade GD, et al. Trends in oral diseases in the u.s. population. J Dent Educ. 2017; 81:eS97–109.
2. Goiato MC, Ribeiro PDP, Garcia AR, et al. Complete denture masticatory efficiency: A literature review. J Calif Dent Assoc. 2008; 36: 683–686.
3. Lemos CAA, Verri FR, Batista VE de S, et al. Complete overdentures retained by mini implants: A systematic review. J Dent. 2017; 57:4–13.
4. Zhang L, Ding Q, Liu C, et al. Survival, Function, and Complications of Oral Implants Placed in Bone Flaps in Jaw Rehabilitation: A Systematic Review. Int J Prosthodont. 2016; 29:115–25.
5. Brånemark PI, Svensson B, van Steenberghe D, et al. Ten-year survival rates of fixed prostheses on four or six implants ad modum Brånemark in full edentulism. Clin Oral Implants Res. 1995;6:227–231.