Assessment of Stresses Induced around Mini and Conventional implant Supporting Kennedy Class II Partial Denture (Strain Gauge Analysis)

Thesis

Submitted to Removable Prosthodontic Department, Faculty of Dentistry Ain Shams University, for partial fulfillment of the Master Degree in Oral and Maxillofacial Prosthodontics

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2019

سورة البقرة الآية: ٣٢

INTRODUCTION

Removable partial denture continues to be an essential prosthetic consideration in the rehabilitation of partially edentulous individuals, especially when edentulous ridges posterior to the remaining natural teeth are to be restored.

Unilateral distal extension removable partial denture designs present a challenge among prosthodontics. The idea behind different designs is to control the amount of stresses transmitted to the supporting tissue via the removable partial denture. These stresses, if exceed the tolerance limit, they become detrimental to the teeth and residual ridges. Theoretically, stresses transmitted to the denture supporting structures are the result of denture movement, insertion and removal. Hence, proper selection of the design that suits each case according to its own merits may to some extent control the adverse effects of the stresses induced by removable partial dentures.

Several techniques have been introduced to control stresses induced by distal extension bases, among which is recording of the supportive form of the edentulous areas, mesial placement of the supporting rests, using retainers exhibiting stress releasing action and recently using osseointegrated implants as posterior artificial abutments [1,2].

The placement of a distal dental implant was recommended whenever possible in an attempt to solve the problem of dual support associated with distal extension removable partial dentures. This enhances

support, retention and stability and reduces the rate of bone loss, in an attempt to obtain stable and durable occlusion [2].

Implants with smaller diameter compared to the conventional and commonly used implants were recently introduced. Mini implants are currently used to support various definitive restorations [3]. Several studies were carried out to assess and evaluate the application of mini dental implants. However, their application and role in supporting and retaining distal extension partial dentures needs further investigations. This study was thus attempted to assess the stresses induced by partial overdentures supported by mini dental implants versus conventional one.

REVIEW OF LITERATURE

Removable partial dentures remain the treatment of choice for patients, especially those with distal extension bases, financial concerns, technical and biologic conditions that contraindicate treatment with fixed prostheses or implant supported prostheses [4, 5].

The primary objectives of partial denture design should be the preservation of the remaining teeth and their supporting structures in a healthy condition, at the same time replacing the missing teeth and improving aesthetics, phonetics, mastication and patient satisfaction[6].

Many patients require replacement of missing teeth and associated structures to enhance appearance, improve masticatory efficiency, prevent unwanted movement of teeth (over eruption/drifting), and/ or improve phonetics. Because of the attendant advantages of removable prostheses on teeth and implants, the indications for treatment using removable partial dentures (RPDs) are wide and varied. Long-span edentulous spaces make it difficult to provide fixed prostheses resulting in poor prognosis. In these situations, tooth-supported RPDs or implants (using fixed or removable solutions) provide alternative long-term solutions. RPDs are also the best practice therapy for many clinical scenarios, such as replacing lost hard and soft tissues, which result in a need for esthetic support of the orofacial structures, transitional prostheses for the failing dentition, and long edentulous spans[7].

Distal extension removable partial denture is defined according to the Academy of prosthodontic terms as: “A Removable dental prosthesis

that is supported and retained by natural teeth at one end of the denture base segment and in which a portion of the functional load is carried by the residual ridge" [3]. Distal extension cases are the most common clinical situation among the various partially edentulous conditions. The mandibular distal extension cases are more common than maxillary ones due to the general pattern of tooth loss [8, 9].

In the United Kingdom, the Adult Dental Health Survey in 2009 found that "nearly one in five adults wore removable dentures of some description (partial or complete)" [10]. This includes the 6% of adults with complete edentulism as well as the 13% of people who use a combination of dentures and natural teeth. Because the maintenance of oral health has improved, people are losing fewer teeth, resulting in an increased need for treatment of partial rather than complete edentulism.

Functional denture stability, retention, positive support and patient comfort are important factors for successful treatment with removable partial denture [11].

Properly designed partial dentures are an adjunct to the maintenance of oral form and function where circumstances contraindicate replacement by fixed partial dentures [12].

According to Kennedy's classification of the removable partial dentures, Kennedy class II is a unilateral edentulous area located posterior to the remaining natural teeth [3].

I. Problems of Kennedy class II cases:

1. Problems in support:

Support is defined as the quality inherent in the dental prosthesis acting to resist the displacement towards the basal tissues or underlying Structures [3].

The problem of support in distal extension cases mainly arises due to absence of posterior abutment**.** The denture is thus dependent on the residual ridge for posterior support and on abutment teeth anteriorly [6, 13, 14]. The main problem facing the prosthodontist in treatment of extension bases removable partial dentures is the distribution of functional stresses between the two different supporting oral structures (edentulous ridge and abutment teeth) with different viscoelastic behavior [15-17].

The intrusive range of the mucosa covering the ridge is about 500 μm, which is 25 times greater than the measurement of 20 μm obtained when the same force is applied to the teeth. The greatest difficulty occurs in the transition area where tooth support ends and mucosa support begins in the tooth-tissue region adjacent to the edentulous space. When functional occlusal load is applied to the denture base, an axis of rotation is created; the denture tends to rotate about its most distal abutment, inducing heavy torsional stresses on the abutment teeth, and possible traumatization of the ridges [18, 19].Hence, a class I lever is thus created in which the abutment tooth plays a role of both the fulcrum and the resistance [20].

Tooth-tissue supported partial denture could inversely influence the health of the abutment in the form of gingival margin inflammation, and

deepening of the pocket depth which affects its bony support and causes tooth mobility [21].

Light tipping action on the teeth may lead to an extreme compression of the periodontal ligament leading to ischemia and loss of cellular element which could be followed by alveolar bone resorption [21, 22]. Moreover, direct pressure beyond the physiologic tolerance of bone may lead to interference with the external blood supply leading to bone resorption and sometimes may lead to bone necrosis [22].

Vertical support for RPDS is provided by any unit of the partial denture that rests on a tooth surface which is termed a rest. Rests should be always located in rest seats which are teeth surfaces properly prepared to receive them. Rests serve in transferring portion of the functional stresses to the teeth, while the remainder of the load is absorbed by the edentulous ridge where firm and positive contact between rest and rest seat minimizes vertical displacement of the prosthesis and prevents injury of the soft tissues [6, 23].

The viscoelastic reaction of the supporting soft tissues plays an important role in the evaluation of design concepts for removable partial dentures in patients with distal extension ridges [24, 25]. Excessive pressure on the oral mucosa interferes with the blood circulation in both the mucosa and alveolar bone. This decreases the oxygen supply to the osteocytes which produces some acids as citric acid. These acids induce decalcification process on the bone surface resulting in reversible bone loss that may become an irreversible process [26].

Consequently, when functional pressure is applied to the distal extension base removable partial denture, it moves towards the mucosa tissues and rotates around the fulcrum line connecting the two main occlusal rests, with the greatest movement taking place at the most posterior extent of the denture base. The resultant rotational forces are extremely damaging to the abutment teeth and must be controlled if clinical treatment is to be successful [(6)].

2. Problems in retention:

Retention can be defined as "the quality inherent in the dental prosthesis acting to resist the forces of dislodgment along the path of placement" [(3)].

Removable partial dentures must have sufficient retention to resist reasonable dislodging forces. The retention which can be obtained mechanically by placing retaining elements on the abutment teeth is termed primary retention, while secondary retention depends on physical means and frictional resistance, it is provided by the intimate relationship of minor connector contact with the guiding planes, denture bases and major connectors with the underlying tissues. The secondary retention is proportionate to accuracy of the impression registration, accuracy of the fit of the denture bases and total area of contact involved [(6)]. Retention also depends upon the collective action of physical forces arising from adhesion, cohesion, and interfacial surface tension [(13, 27-29)].

Absence of adequate posterior retention in distal extension bases makes the free distal ends of these bases subjected to vertical forces that

tend to displace the entire denture along its path of insertion or rotate the denture about an axis passing through the tips of the distal retaining clasps. Movement along the path of insertion should be prevented by the use of effective direct retainers, while the rotational movement can be prevented by rigid components of the denture base placed anterior to the axis of rotation which is called indirect retainers that uses the mechanical advantage of leverage by moving the fulcrum line farther from the rotational force therefore the clasp tip is placed in an undercut relative to this force [13, 14, 27, 30].

Retainers for distal extension bases must have a stress releasing effect. The retainer must be able to flex or disengage when the denture base moves towards the tissues during function to prevent torque on abutment teeth [31, 32]. Commonly used flexible clasps are the wrought wire clasp arm, combination clasp (wrought wire retentive arm and cast bracing arm) [6] bar type clasps especially those with an I-bar retentive arm [33]. On the dentulous side, a cast clasp commonly an embrasure clasp is used in cases of unmodified Kennedy class II to provide cross arch stabilization together with efficient retention [34].

An indirect retainer is required to restrict the rotational movement of the denture base away from the basal seat tissues. The indirect retainer should be placed as far from the fulcrum line as possible [6,13] and preferably, not be placed anterior to the canines to avoid the harmful slunting force to the labial direction on the incisor teeth in positive to prepared rest seat[35].

Various designs of intracoronal and extracoronal attachments were suggested for retaining the distal extension base removable partial denture [36].Also, it was revealed that the muscular control of the tongue and the cheek is of importance for the retention and success of lower free end saddle dentures [37].

3. Problems in stability & bracing:

Stability is defined as "the quality of the removable dental prosthesis to be firm and steady to resist displacement by functional horizontal or rotational stresses, while bracing is defined as the quality of the removable dental prosthesis that resist horizontal component of masticatory forces" [3].

As mentioned earlier, the distal extension base removable partial denture rotates when forces are applied to the denture base. Since it can be assumed that this rotation may create horizontal and lateral forces, the partial denture framework should incorporate stabilizing components which are rigid to stabilize the denture against horizontal movement. The purpose of those stabilizing components is the distribution of stresses equally to all supporting teeth without overworking any tooth [38].

Furthermore, in distal extension base removable partial dentures, it is advisable to provide cross-arch stabilization by placing on the intact side of the arch [39]. The maximum ridge coverage by the denture base minimizes the effect of the lateral forces providing additional resistance to horizontal movement [40].

Stability is achieved by using rigid reciprocal clasp arms, rigid minor connectors and proximal plates contacting guiding planes prepared on the

proximal surfaces of the abutment teeth [41]. Rigid reciprocal clasp arms are placed above the height of contour of the abutment. Rigidity of the reciprocal clasp arms not only reciprocate the opposing retentive clasp arm but also prevent lateral shifting of the prosthesis when lateral stresses are applied[6].

4. Torque on the abutment teeth:

The abutment tooth adjacent to distal extension base is subjected to load in vertical, antero-posterior and lateral directions, in addition the abutment is subjected to rotation or torque action. These forces cause premature breakdown of its supporting tissues. [9] The magnitude of stresses transmitted to the abutment teeth depends on the length of the span of the edentulous ridge, the quality of ridge, type and design of the direct retainer and the occlusal pattern [20, 42].

5. Residual Ridge Resorption (RRR):

Alveolar bone loss in the edentulous jaw is a continuous physiologic process that proceeds throughout life. However, it was reported that initiation of residual ridge resorption is always preceded by loss of teeth together with their periodontal ligament [43, 44].

The rate of residual ridge resorption is also affected by:

- Biological factors: which include sex, age, and hormonal balance.
- Anatomic factors; which include size and form of the residual alveolar ridge and bone type.

- Mechanical factors; which include frequency, magnitude, and direction of forces applied to the alveolar ridge [45, 46].

In a sterophotogrammetic study of alveolar ridge changes with distal extension partial dentures, a 10 % loss of bone volume was detected twelve months after denture insertion [47].

It was reported that abnormal and excessive forces exerted by ill-designed prostheses especially occlusal errors result in inflammation of the mucosa and interference with the external blood supply leading to irreversible resorption of the bony denture foundation[22, 48, 49].

II. Treatment modalities for Kennedy class II cases

Several treatments modalities have been proposed to reduce, control and distribute the stresses induced to distal extension bases supporting structures [9, 13, 20].

1. Conventional removable partial denture

Clasp retained RPDs serve as a simple and popular treatment option for partially edentulous patients [50]. Treatment with conventional RPDs is a non-invasive and low-cost solution for the prosthetic rehabilitation of Kennedy class II patients having functional or aesthetic need for the replacement of posterior teeth [51].

The cast partial denture has been the option of choice for free end saddle cases because the lack of posterior abutments as in Kennedy Class II cases obviates the possibility of fixed bridgework. Cast frameworks are rigid retentive, and add stability to the RPD. Clasp design in distal extension

denture bases is extremely important, as it secures proper fit of the framework in relation to the teeth and supporting tissues. Clasps designs vary and must be chosen so as to avoid destructive lever effect on the abutment teeth [20, 52].

It was reported that the long-term serviceability of prosthetic treatment with RPDs is related not only to morphological and oral conditions but also on proper RPD design [53]. In Kennedy Class II cases, Absence of a saddle usually complicates the RPD design. For this reason retention, stability and reciprocation are achieved by clasps on the edentulous side, together with rigid clasping on the opposite side of the dental arch. [9]

Recently clasp retained RPDs are fabricated using 3D CAD-CAM/RP (computer-aided design/computer-aided manufacturing/rapid prototyping) technologies with software package developed specifically for RPD design [54]. The accuracy of digital processes was verified by the successful fitting of the RPD framework [55]. A simulation of stress distribution to the artificial teeth, saddle and residual ridge under occlusal force was successfully performed by a study using the 3D CAD system, the artificial teeth were then arranged in locations where the lowest amount of stress was encountered. This resulted in uniform distribution of loads and decreased forces applied to the DEB supporting structures [56].

Harmful effects can arise from the wearing of RPDs in a variety of ways: from the plaque which is likely to accumulate around any RPD, from direct trauma by individual components of the denture, from excessive functional forces which will be transmitted by an ill-designed prosthesis

and from errors in the occlusion. If the patient, with the help of the dental team, can maintain optimal plaque control then the hygiene-related complications of wearing RPDs, such as caries and periodontal disease, can be avoided. However, frequent technical maintenance of RPDs is still required if optimal oral function and health are to be preserved. When tissue damage does occur it is sometimes referred to as the 'biological price' of wearing RPDs [48].

2. Telescopic partial overdentures

Removable partial dentures retained by telescopic crowns is an alternative treatment option to a conventional clasp retained RPDs [57]. Rigid telescopic crowns and conical telescopic crowns having stress breaking effect, have been used to connect natural teeth to partial overdentures [2].

It was reported that using telescopic retainers in distal extension partial dentures helps in transmitting occlusal forces in the direction of the long axes of abutment teeth causing the least damaging forces on the supporting structures [58]. In addition, they may also act as indirect retainers to prevent dislodgment of the RPDs away from the edentulous ridge [59].

Despite all the benefits of telescopic partial overdentures, there are many drawbacks such as increased cost, complex laboratory procedures, increased number of dental appointments and difficulty to achieve esthetics. Also retention diminishes after repeated insertion / removal cycles and readjustment of retentive forces is difficult [60].

3. Fixed partial overdentures