Introduction

Edentulism has a negative impact not only on mastication, but also on speech, esthetics and self-image. Loss of teeth is accompanied by resorption of the surrounding alveolar bone which compromises the expected results of conventional prosthetic therapy. The reduced stability, retention and the maladaptive response to complete dentures inspired prosthodontists to seek an alternative for conventional complete dentures. Once established that osseointegration is a predictable successful treatment, it was a natural progression to use Osseo integrated implants to provide proper support and retention to complete dentures.

It was proven in literature that the mandibular two-implant over denture is a simple and effective solution and leads to significant improvement of patient-based outcomes as compared to conventional dentures.

Different techniques have been utilized to alter the surface topography of dental implants. These techniques are usually applying either additive or subtractive concepts. One of the early used techniques is the titanium plasma spray (TPS) which is an additive technique resulting in an increase of the surface area up to six times. Hydroxyapatite (HA) plasma spray is also one of the early additive techniques developed for coating dental implants with biomaterials to change their surface characteristics. The early results of this technique were very promising as it enhanced the osseointegration of dental implants.

The additive surfaces became less preferred by clinicians than the subtractive surfaces. Long term follow-up for these surfaces have shown increased risk of peri-implantitis and eventually led to a decline in their

survival rate. TPS surfaces have also shown poor response to treatment of peri-implantitis. Consequently, subtractive surfaces like Sand blasted and Acid etched (SLA), resorbable blast media (SBM), and dual acid etching (DAE), which have moderate roughness, became more popular.

Dental implant stability is a measure of the anchorage quality of an implant in the alveolar bone and is considered to a consequential parameter in implant dentistry. Implant stability can occur at two different stages: primary and secondary. Primary stability of implants is commonly considered as a key factor for achieving successful osseointegration. Primary stability of the implant can be defined as the absence of implant movement, including micromotions, immediately after insertion of the implant into the bone bed. Micromotions higher than the threshold of 50 to 100 μm can lead to formation of fibrous tissue at the bone-to-implant interface

Primary stability of an implant mostly comes from mechanical engagement with cortical bone, which is a prerequisite to undisturbed peri-implant bone healing. A secure primary stability leads to a predictable secondary stability. Therefore, the original protocol suggested a 3 to 6 months non-loaded healing period to achieve adequate stability before functional loading.

Numerous techniques have been introduced to evaluate implant stability, among which is measuring the resonance frequency analysis, introduced by **Meredith**. This technique reproducibly assesses the bone to implant contact through direct attachment of a transducer to the abutment or the implant body with the application of Osstell mentor device. This technique expresses the implant stability by reading the implant stability

quotient (ISQ), obtained through the resonance frequency analysis (RFA). The ISQ values range from 1 to 100 with higher values of the ISQ indicating higher implant stability.

So, this study was conducted to answer the question that if different surface treatment of dental implant will affect primary stability or not?

Review of Literature

Edentulism is the state of being edentulous; without natural teeth.[1] Complete edentulism is a clinical condition present especially in elderly, with a multifactorial etiology, which associates severe local and general changes, and have negative implications on self-confidence, functioning and quality of life. Scientific evidences show that complete edentulous patients may have masticatory deficiencies, and a greater risk of malnutrition, coronary artery plaque formation, diabetes, rheumatoid arthritis and certain cancers. In some cases, behavioral changes appear, with a tendency of isolation and psychosis related to extraction of the last teeth or dissatisfaction with the complete dentures.[2, 3]

Edentulous patient reports difficulty in chewing food that is hard and tough in texture, forces them to modify diets in unhealthy ways (low vegetables, low protein, and high fat). Nutritional intake is generally reduced in comparison to those with natural teeth. [4,5] Edentulism is one of the major public health problems. It fulfills the World Health Organization (WHO) definition of a physical impairment, because important body parts have been lost. It is also a disability, because it limits the ability to perform two essential tasks of life (speaking and eating). Significant changes are needed in order to compensate for such deficiencies.[6]

I. Complete denture problems:

A conventional complete denture, which is the most common treatment alternative, has many problems and patient dissatisfactions. The main complaint reasons identified in old denture wearers were related to mastication and denture stability. Conventional complete denture restores this

function, but only to approximately 1/6 of natural dentition. The mastication of hard food is especially compromised, complete edentulous patients selecting foods with softer consistency, consuming a lower quantity of fibers, proteins, fruits, vegetables, and calcium. The difficulties in obtaining a good denture stability represents a major task in the complete conventional dentures referring problems. The balance of prosthesis realized by physical means (interfacial attraction realized by adhesion, cohesion, superficial tension, suction, atmospheric pressure, prosthetic adhesives) or physiological means (muscle action, saliva) is mainly affected by the forces exhibited during the functional acts of mastication and phonation. [7]

The most difficulty with complete denture prostheses arises from the inability to function with the mandibular prostheses. Factors that adversely affect successful use of a complete denture on the mandible include the mobility of the floor of the mouth, thin mucosa lining the alveolar ridge, reduced support area, and the motion of the mandible as well. These factors alone can explain the difficulty of wearing a denture on the mandibular arch compared to the maxillary arch. [8]

The maxilla exhibits much less mobility on the borders of the denture, moreover having a stable palate with thick fibrous tissues available to support the prostheses and stand against occlusal forces. These differences explain most of the reasons why patients experience difficulty and un-satisfaction with using a complete denture on the mandibular arch compared to the maxillary arch. Despite these efforts, there still remain populations of patients who cannot manage using this type of restoration. Presently, some feel that the complete denture prostheses are below the standard of care and that the most basic restoration for the edentulous mandible should be an implant retained overdenture with two implants placed in the anterior mandible. [9]

Preliminary evidence suggests that providing edentulous people with one of the least complicated forms of implant prosthesis (two-implant over denture) will modify diet, improve their nutritional state and has a strong improve on general health.[10]

II. Implant over denture:

Overdenture is defined according to the Academy of Prosthodontic terms as "A removable dental prosthesis that covers and rests on one or more remaining natural teeth, roots and /or dental implants. Various names have been used as overlay denture, overlay prosthesis and super imposed prosthesis" [11] Implant over denture were classified according to support into:

a- Implant assisted overdenture:

This type of restoration is ideal for patients who complain of looseness and mobility of the mandibular denture but not of pain or soreness of the mucosa with use of a conventional mandibular complete denture. This complete overdenture prosthesis is made to full extensions as conventional complete denture usually and to maximize areas of support for the prosthesis. The function of the implants in this type of restoration is retention of the prosthesis and not for support of the restoration. Overall the long-term implants supporting this type of restoration have a high success rate. In its simplest form, two implants are placed between the mental foramina region. [12]

Advantages of this type of restoration are reduced number of implants, ability to convert existing removable prosthesis, and ease of repair of prosthesis. The disadvantages of this type of restoration are implants cannot diverge too much, prostheses still require support from

mucosa, and that periodic maintenance is required to replace attachments and to compensate for continued resorption of bone in posterior areas. [13]

Adequate inter arch space must be present so that a sufficient bulk of acrylic resin can resist fracture of the prostheses; areas where the attachments are placed will be weakened to accommodate the attachments. A minimum of10 mm of inter occlusal space or more, Otherwise, the resulting overdenture will be thin having minimal bulk of acrylic resin resulting in a prosthesis that is weak and may fracture easily. [14]

Since the object of this prosthesis is to be tissue borne, only one axis of rotation should exist for this type of prosthesis. If the prosthesis is not designed to move freely about an axis then premature replacement of the attachments will be required or breakage of components will ensue. [15]

Attachments used for implant overdentures (ODs) are mainly divided into the bar type and the solitary type in which the resilient type and the rigid type, depending on the movement allowance. Mainly OD attachments used are: Ball attachments with rubber O-rings and/or metal housings, bar attachments with clips, Locators, Magnets, and bar with locators cast or tapped into the framework. [16]

In a V shaped anterior mandibular ridge, if bar is placed at canine locations, it encroaches on the tongue space and if placed anteriorly, length of the bar becomes inadequate. Therefore, in such cases, ball attachments or 3-4 implants with a connecting bar supported OD is indicated. Use of a bar may complicate the procedure, increase the cost of the prosthesis, is more technique sensitive and generally require more space than individual attachments. One perceived advantage of the bar is that it can accommodate divergent implants. However, individual attachments can also be used for divergent implants.[17]

A low-profile attachment with easily replaceable retainers should be used. At present the most effective attachment is the locator attachment. The advantages of this particular attachment are that it is made for many implant systems, it comes in varying heights to accommodate soft tissue thickness, and it has a low profile. The retention can be varied with choice of plastic retentive elements which are easily replaced. One portion of the attachment is screwed directly into the implant body; this is selected to fit the thickness of the mucosa and depth of the implant with the goal to have the implant as low as possible, to expose the retentive element.[18]

B- Implant supported prosthesis:

This type the prosthesis gains its support totally from implants which indicates that all forces of occlusion are borne by the implants. This type of prosthesis could be a removable overdenture retained by an implant connecting bar with non-resilient attachments secured to four or more implants, or a fixed implant supported prosthesis including fixed hybrid prosthesis, metal-ceramic prosthesis and zirconia prosthesis supported by four or more implants. [19]

Another recent approach for supporting fixed prosthesis is All on 4 concepts, according to this concept, four implants are enough for full-mouth fixed restorations. Two of those four implants are placed in the anterior alveolar region, and the other two are placed just in front of the right and left mental foramen regions. Anterior implants are placed vertically, but posterior implants are placed approximately 30-45 degree distally inclined. These distal inclinations of the posterior implants are tolerated with angled abutments. [20,21]

However, there are some disadvantages to this approach. The acrylic resin retaining the denture teeth is porous and becomes contaminated with

oral microorganisms, thereby making it odorous. In addition, the denture resin and the denture teeth are subjected to wear. Despite these disadvantages, the design remains a popular option among clinicians. [21]

The metal ceramic fixed prosthesis is another choice consists of a rigid metal-ceramic framework and a dentition crafted with laminated porcelain. The gingival part can be fabricated of either composite resin or laminated porcelain. This prosthesis is time consuming and expensive to fabricate and requires highly trained and skilled laboratory technique. The occlusal surface can be made of porcelain or metal, depending on the presence of the opposing arch. [22]

Porcelain occlusal surfaces are prone to chipping or fracture and are difficult and time consuming to repair. Therefore, metal occlusal surfaces are preferred unless the prosthesis opposes a conventional denture or an overdenture with resin denture teeth. Nevertheless, metal ceramic prosthesis provides the patient with excellent esthetics, the materials are nonporous, and the tissue response is excellent. In addition, there is little to no wear of the occlusal surfaces of the prosthesis. [23-25]

Monolithic zirconia has been proposed as one of the alternative restorative material choices. This material is esthetic and biocompatible. Monolithic zirconia prosthesis is fabricated with CAD\CAM techniques. A prototype made of milled poly methyl methacrylate (PMMA) is fabricated, delivered and adjusted as needed. Once the protype PMMA prosthesis has been refined and adjusted intraorally, it is removed and scanned, and a duplicate prosthesis is milled of monolithic zirconia. [26]

The gingival tissues are reproduced with laminated pink porcelain, but the occlusal surfaces are composed of monolithic zirconia, which is

resistant to chipping and fracture. Wear of the opposing dentition appears to be minimal, and monolithic zirconia appears to result in less wear than porcelain surfaces. Follow up times are relatively limited, but the initial data look promising.[27-29]

Zirconia frameworks with their posterior occlusal surfaces restored with laminated porcelain, similar to metal-ceramic restorations, are susceptible to chipping and fracture of the laminated porcelain. These designs should be used with caution if opposed by either an implant supported restorations or natural dentition. [30-32]

C- The fixed hybrid prosthesis:

The hybrid restoration requires that four to six implants are placed between the mental foramina. These implants are sufficient to support a fixed restoration with cantilevers posterior to the terminal implants according to some situations. [33]

In addition the hybrid type restoration has the most documentation over a long term. [34-36] Cost for this type of restoration are higher than overdenture prostheses, however, the satisfaction of patient is also higher. Combined with fewer post-operative visits for adjustments and un-scheduled appointments, the hybrid prosthesis becomes a favorable choice for treatment of edentulous patients. [37,38]

With the documentation available supporting the equivalent success of implants between the delayed and immediate loading protocols for providing this type of restorations. [39,40] It is the authors' first choice to restore edentulous mandibles with hybrid prostheses using the immediate loading protocol. Post-operative visits are markedly reduced post insertion

of the implants and provisional restoration and patient satisfaction and comfort are increased over conventional loading protocols. Even when providing overdenture prostheses to patients, care should be taken so that the implants placed for the overdenture prosthesis do not preclude placement of additional implants to support hybrid type prosthesis. [41,42]

As such, the prosthesis lacks a denture flange. Consequently, the support for, and therefore the contours of, the lower lip and corners of the mouth may be deficient in some patients when this type of prosthesis is employed. An analysis of the smile should be performed before the treatment plan is finalized. The labial flange removed to simulate the contours provided by fixed hybrid prosthesis, and the duplicate tried in the patient. This prosthesis design has proven to be predictable if certain theoretical and biomechanical guidelines are met. The potential length of the cantilever depends on the arc of curvature of the implant configuration, commonly referred to anteroposterior spread (AP). AP spread is defined as the distance between a line drawn between the distal sides of the posterior implants and a parallel line drawn through the center of the most anterior implants.[43]

The ideal AP spread is 1 cm when four or five implants have been placed. When AP spread is 1 cm or more, the cantilever can be extended up to, but not beyond, 20 mm or up to two times the AP spread. If the cantilever extension is excessive, the load delivered to the posterior implants is magnified leading to screw fracture therefore prosthesis or implant failure. Combination of insufficient AP spread and excessive cantilever extension that don't obey to these limits may result in mechanical failures and\or implant loss secondary to implant overload of the distal implants adjacent to the cantilever.[43,44]

It may be difficult to obtain an implant arrangement with suitable AP spread in patients with square arch forms or a significant anterior loop of the inferior alveolar nerve.[45,46] In these patients, if a fixed prosthesis is desirable, short implants can be positioned posterior to the mental foramen to allow reduction of the length of distal cantilever.[47]

When implants are positioned posterior to the mental foramen, the prosthesis should be divided into sections to permit flexure of the mandible. In many patients splinting may result in significant pain and discomfort. The minimum space between the head of the implant and the plane of occlusion is 15 mm. lack of sufficient space may make it impossible for the clinician to properly design the prosthesis. Patients who are recently become edentulous, and particularly those with super eruption of the mandibular anterior teeth prior to dental extraction, may require an alveolectomy prior to implant placement. [48]

Patients with severe resorption with labio-lingual dimensions of the mandible less than 7 mm may be at risk of mandibular fracture secondary to implant placement. Some clinicians recommend that these patients have their mandibles reconstructed with bone graft prior to implant placement.[49]

III. Implant stability:

Implant stability plays a critical role for successful osseointegration. Successful osseointegration is a prerequisite for functional dental implants. Continuous monitoring in an objective and qualitative manner is important to determine the status of implant stability. Implant stability is classified into primary and secondary stability. Primary stability of implants is commonly considered as a key factor for achieving successful osseointegration Primary stability is defined as" the capacity of the implant to withstand loading in axial, lateral and rotational directions".[50] Primary stability is influenced by

the mechanical engagement of the implant with the surrounding bone after insertion, bone quality and the drilling protocol. Initial implant stability obtained after implant insertion is critical to the success of the implant. Micromotions higher than the threshold of 50 to 100 μm can lead to formation of fibrous tissue at the bone-to-implant interface. At the time of placement, the assessment of primary stability may also serve as a guide for determining treatment protocol: immediate, early or delayed loading. (51)

Secondary stability refers to the increase in stability due to regeneration and remodeling of the bone at the implant interface. Adequate primary stability is a prerequisite for secondary stability. (52)

A- Factors affecting implant stability:

1- Implant size (diameter and length)

The clinical use of several end-osseous oral implants designs has become highly predictable in recent decades. However, their use may be restricted where there are limitations imposed by the geometry and volume of the alveolar bone. These restrictions are more common in the posterior regions of the maxilla and the mandible. It is generally claimed that the best treatment in these situations is surgical modification of the patient's anatomy by bone grafting techniques, alveolar distraction or inferior alveolar nerve transposition to allow the placement of longer and wider implants. However, the adaptation of the implant to the existing anatomy through the use of short and/or narrow or wide-diameter implants should now be considered as a more appropriate procedure. (53)

The choice of implant diameter and length depends on the type of edentulism, the volume of the residual bone, the amount of space available

for the prosthetic reconstruction, the emergence profile, and the type of occlusion. Narrow diameter implants (NDIs; diameter <3.75 mm) have specific clinical indications, e.g., where there is reduced inter radicular bone or a thin alveolar crest, and for the replacement of teeth with a small cervical diameter. (54)

A study was done to compare the pull-out resistance of small and large diameter (3.25- and 4.5-mm) dental implants and the relationship of these implants to bone density. Two groups of implants, consisting of 18 implants of each diameter, were placed in the mandibles of five embalmed humans. The bone mineral density of the area surrounding the implant site in the coronal cross section was measured by quantitative computed tomography (QCT). Initial implant stability was tested with a periodontium diagnostic device and pull-out resistance was tested with a mechanical testing system. Results showed the same initial stability for the two implants. The maximum pull-out force required for the large diameter implants was 15% greater than that required for the small diameter implants, although given the small number of samples, this difference was not statistically significant. There were significant positive correlations between the pull-out resistance and the bone density for both the large and small diameter implants. Study concludes that larger diameter implants appear to have advantages over smaller ones; however, more extensive testing is needed to determine quantitatively the increased load-carrying capacity.(55)

2- Surface treatment of implants

The chemical composition or charges on the surface of titanium implants differ, depending on their bulk composition and surface

treatments. The composition and charges are critical for protein adsorption and cell attachment. Dental implants are usually made from commercially pure titanium or titanium alloys. Commercially pure titanium (cpTi) has various degrees of purity (graded from 1 to 4). This purity is characterized by oxygen, carbon and iron content. Most dental implants are made from grade 4 cpTi as it is stronger than other grades. Titanium alloys are mainly composed of Ti6Al4V with greater yield strength and fatigue properties than pure titanium. [56]

The surface chemical composition of titanium implants also affects the hydrophilicity of the surface. Highly hydrophilic surfaces seem more desirable than hydrophobic ones in view of their interactions with biological fluids, cells and tissues. Contact angle measurements give values ranging from 0◦ (hydrophilic) to 140◦ (hydrophobic) for titanium implant surfaces. [56,57]

The main clinical indication for using an implant with a rough surface is the poor quality or volume of the host bone. In these unfavorable clinical situations, early and high bone-to-implant contact would be beneficial for allowing high levels of loading. In the cases of insufficient bone quantity or anatomical limitations, short designed implants with a rough surface have demonstrated superior clinical outcomes than smooth surfaces. [57,58].

There are numerous reports that demonstrate that the surface roughness of titanium implants affects the rate of Osseo integration and biomechanical fixation. Surface roughness can be divided into three levels depending on the scale of the features: macro-, micro- and nano-sized topologies. The macro level is defined for topographical features as being