Effect of Fabrication Techniques of Implant Supported Prosthesis with Two Span Lengths on Vertical Marginal Adaptation

Thesis

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The discovery of the tenacious affinity between living bone and titanium oxides, termed osseointegration, propelled dentistry into a new age of reconstructive dentistry [1]. Dentists have been able to provide different treatment options' utilizing the osseointegrated tooth simulates, which improved the quality of life for many patients. For more than thirty years implant dentistry has provided patients with numerous new treatment alternatives .Starting from single implant restorations, fixed bridges, and onto construction of complete overdentures with dramatic improvement in both stability and retention.

Yet the procedure is not free of complications, in-fact, six major categories of complications have been reported: surgical complications implant loss,bone loss, peri-implant soft tissue complications, mechanical complications, and esthetic/phonetic complications [2]. Of the mechanical complications a large number has been reported including loss of retention, resin and porcelain veneer fracture, overdenture fracture, opposing prosthesis fracture, prosthesis screw loosening, abutment screw loosening and implant fractures [2].

Prosthodontic implant placement have dictated the use of differentfixed partial dentures (FPD) designs to overcome certain problems and limitations such as: alignment problems, esthetic restrictions, need for extensive bone grafting, and other critical considerations such as anatomical restrictions [3].

Different designs and materials have been advocated in the dental literature, solving many of the abovementioned problems including the use of FPD with different span lengths.

The options for restoration of edentulous areas with fixed dental prostheses (FDPs) have changed with the introduction ofnew materials and techniques. Clinical decisions are not limited to the selection of abutments; there is also a need to choose the type of material, fabrication method, and structural design.

Dental implantation is a rapidly growing up field in dentistry, lately it has become an excellent treatment modality for partially and completely edentulous patients.
Achieving successful Osseo-integration is considered one of the most serious challenges confronting the oral implantologists, and according to ***Schenk and Buser***[4], the Implant material, surface property, design features, primary stability and adequate load areconsidered the prerequisites for a successful Osseo-Integration.

Factors affecting success rate of implant supported prosthesis:

Despite the high success rates reported by a vast number of Clinical studies, early or late implant failures are still unavoidable[5].

Late implant failures are observed after prosthesis delivery and are mainly related to biomechanical complications. There is a consensus that, the location and magnitude of occlusal forces affect the quality and quantity of induced strains and stresses in all components of the bone-implant prosthesis complex [6-15].

When evaluating the biological effects of an applied load, it is essential to determine its source. An implant-supported prosthesis may be under the influence of external (functional or parafunctional forces) and/or internal (internal or external preload) forces [8, 16, 17].

In all incidences of clinical loading, occlusal forces are first introduced to the prosthesis and then reach the bone-implant interface via the implant. Focusing on each of these steps of force transfer is important to gain insight into the biomechanical effect of several factors such as:-

Force directions and magnitudes.
Implant design (geometry, number and length).
Number, distribution and angulation of supporting implants.
Prosthesis type, design and material.
Superstructure fit.
Condition of the opposing arch (prosthesis versus natural dentition).
The mechanical properties of the bone- implant interface.
Bone density.
Age and sex of the patient.
Stiffness of food.

<u>Effects of prosthesis material and fabrication technique:</u>

The design and material of dental superstructures influence the loading of dental implants, and hence the deformation of the bone [18].

The type of prosthesis affects the mode of implant loading. In cement-retained implant restorations, the occlusal surface is devoid of screw holes and the occlusion can be developed that responds to the need for axial loading. Screw-retained fixed prosthesis or overdentures, however, are subjected to off-set loads that cause a substantial increase in bending moments [19-21]. Only a few studies appear on related literature and there are controversies.

It was claimed that shock absorbing materials could be effective for an implant system in minimizing the strains transferred to the supporting structures.***Skalak R*** [22] predicted that the use of acrylic resin teeth would be useful for shock protection on implants and ***Bra°nemark et al*** [23] have also recommended the use of acrylic resin as the material of choice for the occlusal surfaces of implant-retained prostheses. The resiliency of this material was suggested as a safeguard against the negative effects of impact forces and microfracture of the bone-implant interface.

The literature, however, is inconclusive on its effect on shock absorption [24-29].In fact, acrylic resins are burdened with technical and subjective disadvantages, for example, due to their low wear resistances, premature contacts often occur after several months of prosthesis delivery. On the other hand, gold and porcelain surfaces are believed not to provide force absorption, but they are also frequently used . Ceramic materials are commonly used for veneering implant-supported prostheses as they provide great improvements to the esthetics of implant restorations [30].

Ciftçi and ***Canay***[31]performed a study to examine the effect of veneering materials on stress distribution around implant tissues in implant-supported fixed prosthetic restorations, where five different materials were investigated: porcelain, gold alloy, composite resin, reinforced composite resin, and acrylic resin veneering materials using the 3-dimensional finite element analysis method. They found that stress seemed to be concentrated at the cortical bone around the cervical region of the implant, and that gold alloy and porcelain produced the highest stress values in this region. Stresses created by acrylic resin and reinforced composite resin were 25% and 15% less, respectively, than porcelain or gold alloy.

However, porcelain is not a shock-absorbing material, and forces developed at the occlusal surface will be directly transmitted to the prosthesis, the implant, or the bone interface, unless they are interrupted in some way [31, 32], and as mentioned before one of the concepts developed to distribute the stresses more evenly around dental implants is to dampen the occlusal forces with the use of shock-absorbing materials, such as acrylic and microfilledresins [22-34].

Studies comparing the shock absorbing behaviour of different veneering materials found that, when harder and stiffer materials were used, a higher impact force was transmitted to the fixture and with a shorter rise time. Conversely, the more resilient the material, the longer was the rise time and the smaller was the stress [36, 37].

Gracis et al.[36]carried out a study to assess the shock-absorbing behavior of five restorative materials used to veneer test crowns used on implants and subjected to an impact force. The materials included were gold alloy, a noble metal ceramic alloy, porcelain, a laboratory-processed, light-activated microfilled resin, and a heat and pressure-polymerized polymethyl methacrylate resin. The results revealed that the two resins reduced the impact force by about 50% when compared to porcelain or the alloys.

Shock-absorbing elements could act as a damping structure in reducing the height of the peak stresses under dynamic loading conditions, and they are thought to act as stress-distributors, whereby forces could be diverted to other locations in the bone or around the implant [34]. Acrylic resin was found by other studies to absorb more of the applied loads than porcelain, with less stress transferred to the supporting structures, thus the type of veneering material can determine the way stresses generated by *static* or *impact forces* are conducted to the lower structures [31,32,34,35,36], with shock-absorbing materials expected to lead to more uniform stress distribution [29-37].

However, the effectiveness of shock-absorbing systems remains controversial, since some finite element analysis studies found no significant difference in the stress levels or distribution at the bone–implant interface between different veneering materials.

Conserva et al [38] conducted a study to measure (in vitro) the chewing load forces transmitted through crowns made of different prosthetic restorative materials onto dental implants, where a masticatory robot capable of reproducing the mandibular movements and the forces exerted during chewing was used. The forces transmitted to the simulated peri-implant bone during the robot mastication were analyzed using four different occlusal materials: three resin composites and one glass ceramic crown. They found that the ceramic crowns transmitted significantly greater forces (up to 63.06%) than the composite crowns tested, and concluded that composite crowns are better able to absorb shock from occlusal forces than crowns made of ceramic material.

It was also found that the level of bone resorption around implants was lower when a shock-absorbing system (polyurethane elastomer) was used [39].

Duyck et al [40] performed a study to investigate (in vivo) the influence of prosthesis material on the loading of implants that support a fixed partial prosthesis where three-unit fixed partial prostheses on three implants and two-unit fixed partial prostheses on two implants were selected. Additional tests were conducted when the three-unit prostheses were supported only by two implants, thereby creating an extension pontic. Both metal and acrylic resin prostheses were made. Strain gauged abutments were used to measure the load on the supporting implants during controlled load application of 50 N on several positions along the occlusal surface of the prostheses. The results revealed asignificantly better distribution of bending moments with the metal prostheses in comparison to the acrylic resin prostheses observed in the case of the three-unit prostheses on two implants and there was no other difference in load or load distribution with the different prosthesis materials was noted. The conclusion was that there is an increased risk for bending overload of the implants that are closest to the point of load application only in the case of acrylic resin long span prostheses or acrylic resin prostheses with extensions.

Tiossi et al,[41]performed a study to examine the influence of crown material in implant-supported prostheses on bone strain distribution. Where porcelain veneered and resin veneered crowns were included in the study and concluded that the softer resin veneer helped to spread the load more evenly amongst the supporting implants, thus reducing the strains in the simulant bone block. Conversely, using the harder porcelain veneer resulted in the load being concentrated within one or two implants, thus leading to higher strain values.

The metal ceramic restoration

In many dental practices, the metal ceramic restoration is the one of the most used fixed restorations. Generally metal ceramic restoration is indicated on teeth that requires complete coverage as well as on artificial abutments of implant supported prosthesis. However if esthetics considerations are paramount an all ceramic crown has a distinct cosmetic advantage over the metal ceramic crown, nevertheless, the metal ceramic crown is more durable with superior marginal fit. Whereas the all ceramic restoration cannot accommodate a rest for a removable prosthesis. The metal ceramic crown can accommodate cingulum and acclusal rests. The need for superior strength and retention dictates the use of metal ceramic restorations. The MCR combines to a large degree the strength of a cast metal and esthetics of an all ceramic crown as natural appearance can closely matched by staining and special characterization. From the disadvantages that both preparations require significant amount of tooth reduction in addition in MCR the facial margin require subgingival placement which increase the potential of PDL disease in comparison to ceramic restorations. The MCR may have inferior esthetics but it can be used in high stress situation.

Long-term success of fixed single and multiple unit prosthodontic restorations depends, to a considerable extent, on the accuracy of fit between restoration and prepared tooth structure. With the commonly applied\ lost-wax-casting technique in the production of metal castings or frameworks, their accuracy is greatly influenced by the dimensional properties of investment and casting alloy [42 - 44]. In addition, casting imperfections, such as porosities or impurities due to the presence of corrosion- prone mixed crystals, can cause the quality of cast restorations to be severely impaired. Likewise, poor solder joints, under dimensioned or nonhomogeneous metal frameworks can affect the quality and, thus, the long-term success of crowns and fixed partial dentures (FPDs). With the aid of x-ray defectography, it was possible to demonstrate that roughly a third of all cast restorations exhibit manufacturing-related deficiencies [45].

Milling of dental restorations from a block of base material, such as metal, ceramic or resin is proposed as an alternative for fabricating restorations. This technology promises results of greater accuracy and structural homogeneity. With quality as the objective, the significant advantage in using milling technology lies in the fact that cold working of rolled structures and ceramic materials will always yield homogenous material structures. To produce milled restorations with accurate fit, digitization of the prepared tooth surface and converting the data into control signals for computer-assisted milling is requested.

Dental Ceramics:

Current developments in materials and techniques have attempted to overcome disadvantages of the traditional methods used to construct the ceramic crowns. Computer-aided design/ computer-aided manufacturing (CAD/CAM)-based techniques and prefabricated yttrium oxide partially stabilized Zirconia ceramic are now also recommended for posterior use [46]. Veneered Zirconia FDPs are considered esthetically superior to metal ceramic restorations .An advantage of this material is purported to be its unique crystal structure, preventing fracture formation along the crystals [47]. The development of CAD/CAM technology has focused on precise and consistent manufacturing of Zirconia ceramics. CAD/ CAM technology relies on exact dimensional predictions to compensate for sintering shrinkage, is an economical and reproducible method, and, in addition, has demonstrated improved marginal fit[48-58].

The Zirconia-based ceramics most recently developed contain yttrium cation-doped tetragonal zirconia polycrystals (Y-TZP). This material can efficiently arrest crack propagation [59, 60]. Tensile stresses acting at the crack tip induce a transformation of the metastable tetragonal zirconium oxide phase into the thermodynamically more favorable monoclinic form. This transformation is associated with a local increase of 3% to 5% in volume. The increased volume results in localized compressive stresses being generated around and at the crack tip, which counteract the external tensile stresses acting on the fracture tip [61]. this phenomenon, known as transformation toughening, results in excellent mechanical properties that are advantageous in prosthetic dentistry [62].

Various investigators have examined the marginal adaptation of CAD/CAM ceramic FDPs [63-71]. Currently, it is known that these systems produce higher quality restorations by using industrially prepared ceramic production time [72-75]. Nevertheless, although one of the objectives of computer-aided technology is to increase the accuracy of the manufacturing process, there are few publications that exclusively analyze the influence of CAD/CAM systems on the marginal adaptation of Zirconia crowns.

Provisional Restoration:

Generally, provisional restorations are a crucial diagnostic tool, in collaboration with the patient, to adjust variables in treatment results.

Provisional restorations play several roles during the implant integration period. They maintain the position of the adjacent and opposing teeth and optimize the health of hard and soft tissues surrounding the implant [76]. In addition such provisional allow evaluation of esthetic parameters before treatment is finalized and play an important role in immediate and early loading protocols [77]

Güth J.F et al.[78] stated that Manufacturing under industrial conditions permits high-density-polymer-based restorations which offer favorable mechanical behavior and biocompatibility. In addition, the restorations can undergo reshaping, adding, removing and repolishing procedures during the pretreatment. These improved properties are better than those of traditional indirect provisional materials and allow new treatment approaches, such as an extended pretreatment phase. To rehabilitate patients with a partially edentulous maxilla, conditioning the soft tissue is a key element for a successful treatment in the esthetic zone. The creation of interdental papilla, which is dependent on the bone height, and therefore, on the gingival response to the restoration conditioning must be carefully assessed. However, clinical evaluation is a great challenge in the absence of a pretreatment phase with a provisional restorative treatment. Accordingly, high-density, polymer-based provisional restoration can provide the opportunity to evaluate the newly defined restoration design in terms of function, phonetics, and esthetics.

long-term interim prostheses require materials that are more durable because of their longer periods of service. The chair-side fabrication of temporary restorations is associated with a couple of short-comings, affecting the mechanical strength; such as mixing procedures and filling the over impression might lead to an incorporation of voids. CAD/CAM technologies – used to fabricate temporary restorations – may solve some of these issues; using resin-based blanks cured under optimal conditions exhibit increased mechanical strength and prevent porosities within the restorations. In addition, this technique reportedly reduced the chair-side time and produced superior results [79, 80].

Computer aided design/Computer aided manufacture (CAD/ CAM):Computer-aided design (CAD) and computer-aided manufacturing (CAM) technology systems use computers to collect information, design, and manufacture a wide range of products. These systems have been in general use in industry for years, but dental CAD/CAM applications were not available until the 1980s. During the last few years, exciting new developments have led to the success of contemporary dental CAD/CAM technology. Several methods have been used to collect 3-dimensional data of the prepared tooth using optical cameras, contact digitization, and laser scanning. Replacement of conventional milling discs with a variety of diamond burs has resulted in major improvements in milling technology. Another vital factor has been the development of alumina