In vitro mechanical performance of implant supported anterior esthetic crowns using abutments with different angulations

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Dedication

To my Great Father

To my Dearest Mother

To my Lovely Husband

To my beloved Sons

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List of Contents:

List of Figures:

List of Tables:

Until the 1980s the missing single tooth was most often replaced with a fixed or removable partial denture. Insertion of these conventional prostheses usually requires preparation of one or more abutment teeth. Today, when the abutment teeth exhibit no caries or previous restorations, such irreversible preparation may be considered unacceptable. Placement of single tooth implants in such situations is both functional and esthetic. Implant-supported single tooth replacements are not problem free. The anatomic configuration of the osseous structures may dictate placement of implants, and the position and angulation of the teeth adjacent to the edentulous space must also be considered. Because of these limitations, implants may not be placed in the original position of the root of the missing tooth; thus angled abutments have been designed to correct the improper angulation of implants (1).

Abutment angulations' is one of the numerous biomechanical variables involved in implant dentistry that need scientific evaluation. Many clinical, in-vitro, and numerical studies investigated the relation of the abutment angulations' to the load transfer to the surrounding bone (2–4). Each implant/prosthesis design introduces different load transition from the implant to the alveolar bone during mastication, swallowing and speaking. While implants tolerate vertical forces well during occlusion, non-axial forces induce shearing stresses that are often disastrous for the prosthetic component or the bone-implant interface (5-7). The load transfer from implant to surrounding bone depends on type of loading, bone-implant interface, length and diameter of implants, shape and characteristics of implant surface, prosthesis type, and quantity and quality of surrounding bone (8).

Angulated abutments may be used to overcome non-ideal implant location due to a lack of bone (9). However, the high stresses created by using angulated abutments at the cervical zone of an implant could be a dominant factor influencing the success of the restoration (10). A recent review reported that identical vertical loads applied to pre angled abutments produced higher stresses at the coronal zone of the implant compared with regular abutments (10). Concern about the survival of implants loaded by means of angulated abutments has largely been dispelled (11), and angulated implant placement to optimize the available bone is seen as an advantage (12). Angulated abutments up to 45° have been used and did not compromise the long-term survival of implants (12). Factors may have contributed to the high survival rate include that the implants were placed without compromising labial or palatal bone, and that longer implants were placed, maximizing the use of available bone (12).

Using angulated abutments with different types of restorative materials to construct the overlaying crowns are significant factors in determining the amount and distribution of the stresses loaded onto the superstructure and implant under functional forces (13). Superstructures on dental implants commonly consist of a metal framework veneered with ceramic or composite facings or metal free restorations.

In spite of the advantages of all-ceramic restorations, including esthetic appearance, biocompatibility, and durability, such materials present with some disadvantages (14,15). The potential of brittle catastrophic fracture and high stress transmitted to implant system due to high modules of elasticity (16,17). Demand continues within the dental profession for restorations exhibiting high strength, natural color, good wear resistance, marginal integrity, and ease of fabrication. Recently, developed Nano-ceramic restorative material is a unique

CAD/CAM block based on the integration of nanotechnology and ceramics. The material is said to offer the ease of handling of a composite material with a surface gloss and finish retention similar to a porcelain material. It contains blend of Nano-particles agglomerated to clusters and individual bonded Nano-particles embedded in a highly cross-linked polymer matrix. It is a combination of aggregated zirconia/silica clusters. The fracture toughness of the Nano-ceramic material is statistically greater than Feldspathic materials and direct composites, while being less brittle than Feldspathic glass-ceramics [(18)].

However, at present, little valid data are available in the scientific literature related to mechanical performance of esthetics restorations over angled abutment, as marginal fit and fracture resistance are considered crucial factors in the success and longevity of the restoration [(19)], thus the research subject was chosen to assess the fracture resistance, marginal adaptation of esthetics restorations over angled abutment and *in vitro* strains on implants supporting cement-retained fixed restoration which may affect the long term success of implant supported fixed prosthesis.

Historical prospective and success rate of dental implant:

The history of dental implants can be traced back to ancient Egypt, where carved seashells and/or stones were placed into human jaw bone to replace missing teeth. Other documented examples of early implants are those fabricated from noble metals and shaped to recreate natural roots [(20)].

Dental implants have a history of several centuries starting with the early civilizations more than 2,000 years ago in South and North America and regions of the Middle Asia and Mediterranean. Archeological findings have indicated that these civilizations replaced missing teeth using carved stone, shells, bones and gold [(21,22)].

Around 1930s, archaeological excavations in Honduras revealed that the Mayan civilization had the earliest known examples of dental implants, dating from about 600 AD, when a fragment of mandible with implants was found. The specimen had three pieces of shells carved into tooth shapes placed into the sockets of three missing lower incisor teeth. Later on, it was also observed that there was compact bone formation around two of the implants [(23)].

In the middle Ages, dental implantation was performed by using allografts and xenografts. However, this practice didn’t become very popular, since it was identified as the reason for infectious diseases and even deaths [(22,23)].

Modern dental implant history starts during World War II when in the years of service in the army, Dr. Norman Goldberg thought about dental restoration using metals that were used to replace other parts of the body. Later on in 1948, in association with Dr. Aaron Gershkoff, they produced the first successful sub-periosteal implant [(24)].

One of the most important developments in dental implantology occurred in 1957, when a Swedish orthopedic surgeon by the name of Per-Ingvar Brånemark began studying bone healing and regeneration and discovered that bone could grow in proximity with the titanium (Ti), and that it could effectively be adhered to the metal without being rejected (25). Therefore, Brånemark called this phenomenon 'Osseo integration', and he carried out many further studies using both animal and human subjects. In 1965, he placed the first Ti dental implants into a 34-year-old human patient with missing teeth due to severe chin and jaw deformities. Brånemark inserted four Ti fixtures into the patient's mandible, and several months later he used the fixtures as the foundation for a fixed set of prosthetic teeth. The dental implants served for more than 40 years, until the end of the patient's life (22,25).

In 1982, the US Food and Drug Administration approved the use of Ti dental implants, and in 1983, Dr. Matts Anderson developed the Procera (Nobel Biocare, Zurich, Switzerland) computer-aided design and computer-aided manufacturing (CAD/CAM) method of high precision, repeatable manufacturing of dental crowns (26).

Today, approximately 450,000 Osseo integrated dental implants are being placed every year, with an expectation of 95% success rate (in the case of single tooth replacement with an implant supported crown), with minimum risks and associated complications (23). Adel reported the success of 895 implant over an observation period of 5-9 years after placement. Eighty-one percent of maxillary and 91% of mandibular implants remained stable (27). The higher rates of implant failure associated with maxillary therapy may be related to the biomechanical complications of dental implants and restoration, where mechanical stress may exceed the limits of physiological tolerance,