SHORT COMMUNICATION

BIOMECHANICAL CONSEQUENCES OF EXCESSIVE CROWN HEIGHT SPACE - AN APPRAISAL

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ABSTRACT
Excessive crown height space (CHS) conditions usually relate to a CHS that is more than 15 mm. An increased CHS of more than 15 mm is primarily as a result of the vertical loss of alveolar bone due to long-term edentulism. Other causes may include genetics, trauma, and implant failure. Treatment of excessive CHS before dental implant placement mainly consists of orthodontic and/or surgical methods of correction. Orthodontics in cases of partially edentulous patients is the treatment of choice considering other surgical or prosthetic methods are usually more costly and tend to have higher risks of complications. Several surgical techniques of correction of excessive CHS may also be considered. This include block onlay bone grafts, particulate bone grafts with titanium mesh or barrier membranes, interpositional bone grafts, and distraction osteogenesis. A staged approach to reconstruction of the jaws is commonly opted over simultaneous dental implant placement, especially when large bone volume gains are required. Significant vertical bone augmentation may even require multiple surgical procedures to gain sufficient volume of bone and thereby adequate CHS. The International Congress of Oral Implantologists sponsored a consensus conference on the topic of Crown Height Space in Las Vegas, Nevada, 2004. A consensus of one opinion was not developed for most issues. However, general guidelines emerged related to the topic. The current literature review is a discussion on the biomechanical consequences of excessive crown height space.

KEYWORDS
Biomechanical, Crown height space, Dental implant, Consensus, Stress

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Introduction

Dental implants are subjected to occlusal loads when placed in function. Such loads may vary dramatically in magnitude, frequency, and duration depending on the patient's parafunctional habits. Passive mechanical loads also may be applied to dental implants during the healing stage because of mandibular flexure, contact with the first-stage cover screw, and second-stage per mucosal extension.

Perioral forces of the tongue and circumoral musculature may generate low but frequent horizontal loads on implant abutments. These loads may be of greater magnitude with parafunctional oral habits or tongue thrust. Finally, application of non-passive prostheses to implant bodies may result in mechanical loads applied to the abutment, even in the absence of occlusal loads.

A force applied to a dental implant rarely is directed absolutely longitudinally along a single axis. In fact, three dominant clinical loading axes exist in implant dentistry: (1) mesiodistal, (2) facio-lingual, and (3) occluso-apical. A single occlusal contact most commonly results in a three-dimensional occlusal force. Importantly, this three-dimensional force may be described in terms of its component parts (fractions) of the total force that are directed along the other axes.

Mechanical complication rates for implant prostheses are often the highest of all complications reported in the literature.[1] Mechanical complications are often caused by excessive stress applied to the implant–prosthetic system. Implant failure may occur from overload and result in prosthesis failure and bone loss around the failed implants. Implant body fracture may result from fatigue loading of the implant at a higher force, but occurs at less incidence than most complications. The higher the force, the fewer the number of cycles before fracture, so the incidence increases. Crestal bone loss may also be related to excessive forces and often occurs before implant body fracture. Occlusal material fracture rates may increase as the force to the restoration is increased. The risk for fracture to the opposing prosthesis increases with an average of 12% in implant overdentures opposing a denture.[2] With resin veneer implant fixed partial dentures, 22% of the veneers fractured. Clips or attachment fractures in overdentures may average 17%. Fracture of the framework or substructure may also occur as a result of an increase in biomechanical forces.

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Force magnifiers are situations or devices that increase the amount of force applied and include a screw, pulley, incline plane, and lever.[3] The biomechanics of CHS are related to lever mechanics. The properties of a lever have been appreciated since the time of Archimedes, 2000 years ago. The issues of cantilevers and implants were demonstrated in the edentulous mandible, where the length of the posterior cantilever directly related to complications or failure of the prosthesis.[1] Rather than a posterior cantilever, the CHS is a vertical cantilever when any lateral or cantilevered load is applied, and therefore is also a force magnifier.[3][4] As a result, because CHS excess increases the amount of force, any of the mechanical-related complications related to implant prostheses may also increase.

When the direction of a force is in the long axis of the implant, the stresses to the bone are not magnified in relation to the CHS. However, when the forces to the implant are placed on a cantilever, or a lateral force is applied to the crown, the forces are magnified in direct relationship to the crown height. Bidez and Misch[3][4] evaluated the effect of a cantilever on an implant and its relation to crown height. When a cantilever is placed on an implant, there are six different potential rotation points (i.e., moments) on the implant body. When the crown height is increased from 10 to 20 mm, two of these six moments are increased 200%. A cantilevered force may be in any direction: facial, lingual, mesial, or distal. Forces cantilevered to the facial and lingual direction are often called offset loads. The bone width decrease is primarily from the facial aspect of the edentulous ridge. As a result, implants are often placed more lingual than the center of the natural tooth root. This condition often results in a restoration cantilevered to the facial. When the available bone height is also decreased, the CHS is increased. Therefore the potential length of the implant is reduced in excessive CHS conditions, and the implant position results in offset loads.

An angled load to a crown will also magnify the force applied to the implant. A 12-degree force to the implant will be increased by 20%. This increase in force is further magnified by the crown height. For example, a 12-degree angle with a force of 100 N will result in a force of 315 N/mm on a crown height of 15 mm.[3] Maxillary anterior teeth are usually at an angle of 12 degrees or more to the occlusal planes. Even implants placed in an ideal position are usually loaded at an angle. Maxillary anterior crowns are often longer than any other teeth in the arch, so the effects of crown height cause greater risk.

The angled force to the implant also may occur during protrusive or lateral excursions, as the incisal guide angle may be 20 degrees or more. Anterior implant crowns will therefore be loaded at a considerable angle during excursions, compared with the long axis position of the implant. As a result, an increase in the force to maxillary anterior implants should be compensated for in the treatment plan.

Most forces applied to the osseointegrated implant body are concentrated in the crestal 7 to 9 mm of bone, regardless of implant design and bone density.[5] Therefore implant body height is not an effective method to counter the effects of compromised crown height. In other words, crown/root ratio is a prosthetic concept that may guide the restoring dentist when evaluating a natural tooth abutment. The longer the natural tooth root, the shorter the crown height, which acts as a lever to rotate the tooth around an axis located two-thirds down the root. However, the crown height/implant ratio is not a direct comparison. Crown height is a vertical cantilever that magnifies any lateral or cantilever force in either a tooth or an implant-supported restoration. However, this condition is not improved by increasing implant length to dissipate stresses, unless in very poor bone quality. The implant does not rotate away from the force in relation to implant length. Instead, it captures the force at the crest of the ridge. The greater the CHS, the greater number of implants usually required for the prosthesis, especially in the presence of other force factors. This is a complete paradigm shift to the concepts advocated originally, with many implants in greater available bone and small crown heights and fewer implants with greater crown heights in atrophied bone.

The CHS increases when crestal bone loss occurs around the implants. An increased CHS may increase the forces to the crestal bone around the implants and increase the risk for crestal bone loss. This in turn may further increase both the CHS and the moment forces to the entire support system, resulting in screw loosening, crestal bone loss, implant fracture, and implant failure.

The vertical distance from the occlusal plane to the opposing landmark for implant insertion is typically a constant in an individual. Therefore as the bone resorbs, the crown height becomes larger, but the available bone height decreases. An indirect relationship is found between the crown and implant height. Moderate bone loss before implant placement may result in a crown height–bone height ratio greater than 1, with greater lateral forces applied to the crestal bone than in abundant bone (in which the crown height is less). A linear relationship exists between the applied load and internal stresses.[6][7]

Conclusion
Therefore, the greater the load applied, the greater the tensile and compressive stresses transmitted at the bone interface and to the prosthetic components. And yet many implant treatment plans are designed with more implants in abundant bone situations and fewer implants in atrophic bone volume. The opposite scenario should exist. The lesser the bone volume, the greater the crown height and the greater the number of implants indicated.

Authors contribution
Varun W: Manuscript editing, Literature search, data collection
Aishwarya S: Data Analysis, manuscript drafting

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