Short Dental Implants – A Review Of Clinical Performance, Biomechanical Aspects And Risk Factors For Survival

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INTRODUCTION

Implant supported prosthesis are gradually becoming the norm for restoration of missing teeth.[1] The posterior edentulous arches are a biologically and mechanically challenging area for rehabilitation with implant supported prostheses. These regions have unfavourable bone quality and lesser bone volume as compared to anterior edentulous sites compelling the operator to place shorter implants. The poor bone quality limits the number of implants placed thus increasing bending forces on individual implants. Furthermore, occluding force increases the closer the teeth are placed to the temporomandibular joint.[2]

The obsolete protocol of placing the longest possible implant within anatomical limitations has lead authors to employ procedures like distraction osteogenesis, bone grafting, guided bone regeneration, sinus floor elevation and mandibular nerve repositioning to gain adequate residual ridge height at these sites. These techniques have a variable degree of success and require considerable dexterity and skill from the operator. Short dental implants open up an exciting portal out of complicated surgical procedures involved in implant site preparation in posterior atrophic arches.

Short Dental implants (SDI) are a more cost-effective alternative that reduces treatment time and rules out complications related to surgical and grafting procedures. Authors in their studies have quoted different lengths, however considering 10mm as the standard length; an implant less than 10mm in length is considered a Short Dental Implant and is usually applied in alveolar ridges with decreased bone height[3]

The biomechanical rationale in support of SDIs is that loading bearing forces are concentrated on the crestal portion of the implant and an increase of implant length from 7 to 10mm does not significantly improve its anchorage. [4] Instead with an increase of every 1mm in the implant diameter, the functional surface area increases by 30-200% thus improving the load dissipation ability of the implant.[5] Recent Finite Element Analyses has demonstrated that implant length had no effect on stress concentration on crestal bone around an implant, hence a SDI may be a sound choice.[6]

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Friberg and Jemt [2,7] were among the early authors to note high failure rates in both arches with short fixtures (7mm). Early failure rate was pronounced in resorbed arches with poor bone quality. However, the implants used in this study were of narrow diameter and had a smooth machined surface. SDIs are designed to provide an increased Bone-to-implant contact by virtue of an increased diameter. Newer SDIs overcome such limitations by incorporation of surface modifications like acid-etching that increase the surface area for osseointegration.

This article is a review of the many aspects of risk factors for success and performance of SDIs under various clinical scenarios.

RISK FACTORS

The risk factors for failure of SDIs may be broadly divided into endogenous (systemic or local) and exogenous (operator or biomaterial-related) factors.[8]

Endogenous factors-

SMOKING

Mezzomo et al[9] in a meta-analysis on success rate of single crowns found a higher failure percentage in studies wherein smokers were included as compared to studies that excluded them. Strietzel & Reichert found a significant association between heavy smoking (>10 cigarettes/day) and frequency of implant loss.[10]

SYSTEMIC DISEASES

Most studies exclude pregnant women, immunocompromised patients and those under medication from their sample size. This impairs the assessment of implant survival in such patients. For single crowns supported by SDIs no statistically significant difference was found in the failure percentage in systemically compromised patients.[9]

BRUXISM

Twail et al.[11] found more incidences of prosthetic failures like veneer fractures and screw loosening in bruxer groups, however no statistically significant difference was found on inter group comparison between buxer, non-bruxer and occasional bruxer groups.

PERIODONTAL DISEASE

The biological failure proportion of studies that included periodontal patients did not show a statistically significant upward trend as compared to studies that did not include periodontal patients. Marginal bone loss in periodontal groups however, was found to be significantly higher. Perimplantitis and persistent periodontal disease are major risk factors for the loss of integration of SDIs.[9]

BONE QUALITY

Studies have failed to find an association between high failure rates and low quality bone.[10,12,18] On the other hand, higher failure rates were associated with machines surface implants as compared to rough surface implants in poor quality bone.[11] The density of the bone directly correlates to the strength of the bone, with less density demonstrating strength reduction of 50 -80% compared to high density bone types.[13] Weng et al.[14] noted a 25% failure rate of SDI (machined surface) supported prostheses in the posterior maxilla, failures occurring within 18 months of loading. Hence rougher surfaces for implants are preferred in poor bone quality. Finite element analysis has found that maximum Von-Mises stress variability was minimal when the diameter of SDIs was within 5.5 and 7.1mm. Peak stress on the implant-bone interface is seen to increase with reduction in bone density.[3] Osteopenic bone has thin cortices and reduced spongiosa hence needs larger diameters for optimal load bearing capacity. Implant diameter in excess of 4mm and length more than 9mm are optimal properties for screwed implants in type IV bone[15]

OPERATOR RELATED RISK FACTORS

Operator related risk factors include the surgical technique, prosthetic design and loading protocol undertaken in the placement of the implant.

SURGICAL TECHNIQUE

Misch et al[16] proposed employing a one stage approach in D2 bone by adding a permucosal extension at the time of surgery and a two-stage approach in D4 bone. While, a two-stage implant placement approach has been suggested by some authors[17], no significant difference has been found in failure rates between single-stage and two-stage implants. Also, in fully edentulous patients two-stage implants are preferred.[4,9,18] Esposito et al [19] concluded that a submerged approach may be preferable in implants that do not achieve optimal primary stability and in completely edentulous cases.

CROWN/IMPLANT RATIO

The crown height is a vertical cantilever and when increased from 10 to 20mm, the force on the implant is increased by 100%. An angled prosthetic load is also a force magnifier on the implant. Hence, detrimental effects of non-axial forces on crestal bone increase with increase in crown height.[16] A high crown- to- implant ratio was assumed to have a negative biological effect on crestal bone loss.[20] Peri-implant bone resorption is similar in all implant-to-crown ratio groups, even when increased by 2 to 3 times, provided non axial forces were controlled.[11] Rossi, Tawil, Mertens and Deporter et al. claimed that increased C/I ratio placed no deterimental effects on the health of the implant.[11,20,21,22] Nedir and Birdi et al.[23,24] evaluated crown-implant ratios ranging from 1.05 to 1.80 and 0.9 to 3.2 respectively to find no detrimental effects on surrounding bone. Current research has rejected crown-implant ratio as a major biomechanical risk factor as long as occlusal contacts are placed as close as possible to the long axis of the implant and favourable force orientation and load distribution is maintained.[11]

Crown height space on the other hand, is a more reliable indicator of detrimental effects on marginal bone when crown height spaces exceed 15-mm length.[25] For each additional millimeter of crown height, stress concentration at the implant neck may increase by 20%.[26] Hof et al [27] observed greater bone loss in the anterior maxilla with increased crown-to-implant ratio than the posterior areas. This may be possibly explained by off-axis loading at the implant-bone interface.

PLATFORM SWITCHING

Platform switching shifts the stress concentration zone from the crest bone-implant interface to the axis of the implant, thus reducing stress levels at the cervical bone area.[28] Telleman et al.[29] from the results of a randomized control trial found that 1 year post loading inter proximal bone levels were better maintained at implants restored according to the platform switching concept.

IMPLANT NUMBER AND SPLINTING

Factors contributing to marginal bone loss around dental implants include surgical trauma, faulty implant positioning, occlusal overloading or non-axial loading.[30-32] Stress level in bone around splinted implants is found to be lower than bone around unsplinted implants by a factor of 9.[33] A positive influence of splinting and number of splinted implants has been observed on success rate of SDIs in atrophic posterior arches up to a 10 year follow up period.[16,20,27,34,35] Placement of additional implants increases the effective surface area for stress distribution. Hence, one implant for each missing premolar and two for each missing molar were suggested.[16] To further capitalize on functional area, these must be splinted.

WIDTH OF OCCLUSAL TABLE AND TYPE OF OCCLUSION-

Within 5.4 and 8.3mm the width of the occlusal table did not significantly affect peri implant bone loss.[11] Axial forces distribute stress more evenly throughout the implant as compared to bending moments. Occlusion should be mutually protected and prostheses should be free of non axial loading.[11,16]

CANTILEVER FORCES

The length of the posterior cantilever in the mandible is directly related to complications and/or failure of the prosthesis.[36,37] Romeo et al [38] found no detrimental effects of cantilevers, provided cantilever length was appropriate and occlusal function was under control. Mesial and distal cantilever lengths limited to 2.75 +/-1.65 and 2.24+/-1.60mm respectively have found to cause marginal bone loss within acceptable limits.[11]

LOADING PROTOCOL

Most authors follow and recommend a delayed loading protocol for SDIs. Rossi et al[21] conducted a study using SLActive straumann 6mm implants that were early loaded (6 weeks after insertion). These implants yielded high survival rates and moderate loss of bone after two years of loading. However, long-term follow-up, larger sample size and randomized trials are required to provide concrete evidence for incorporation of early loading protocols into clinical use.

BIOMATERIAL RELATED FACTORS

Implant length, implant diameter, surface topography and implant thread pitch are important parameters that influence the selection of the most fitting implant in a given clinical situation.

IMPLANT LENGTH-

Implant length is defined as the length between the implant neck and the implant apex. Increase in implant length has found to have minimal beneficial effect on load distribution around the crestal portion of the implant.[6] Mezzemo et al[9] in a meta-analysis stated that short implants supporting single crowns obtained similar if not superior survival rates as compared to standard length implants. Few studies exist on implants of 5 and 6mm length, thus limiting the data obtained from systematic reviews. A two year trial of implants of four millimeter length with SLActive surfaces has yielded survival rates of 95.7% after 1 year and 92.3% at the end of the trial. [34] Ling Sun et al.[18] have reported highest survival rate for implant lengths of 7.5 and 9mm. But no statistically significant difference exists based on length.

IMPLANT DIAMETER

For every 1mm increase in diameter, functional SA is increased by 30 – 200% along with BIC.[5] Sato et al[39] on the basis of an in vitro study stated that wide implants are capable of bearing larger loads and perform better than implants of smaller diameter under tensile forces. Wider diameters of implants are hence referred for reduced bone density. This however, is limited by the bucco-lingual width of the residual ridge.

IMPLANT SURFACE

Griffin and Cheung[40] suggested "the implant maximized surface area as the main contributing factor to the high success rate". Rougher surfaces offer extensive area for osseointegration and have better bone-implant-contact as compared to machined or acid – etched surfaces.[16-18] Various surface modified implants like SLActive surfaces[21,34,41], TiOblast implants, Astra Tech[20] and bioabsorbable HA blasted implants [16] have shown better results as compared to the poor results seen with machined surface implants[7].

IMPLANT THREAD PITCH-

Thread pitch is defined as the distance between adjacent threads or the number of threads per unit length in the same axial plane and on the same side of the axis.[5] Hence, the greater the implant pitch, the greater the surface area available for osseointegration and load dissipation. Another implant thread geometry parameter worth consideration in this context is thread depth.[16]

Misch[16] has suggested a protocol for the reduction of stress at the bone-implant interface for SDIs, they include-

1) no cantilevers on the prostheses
2) no angled forces to the posterior restorations
3) splinting multiple implants together
4) implant surface modification
5) increase implant thread pitch

INDICATIONS

Annibali et al.[4] in a systematic review reported successful results for short dental implants, with a pooled survival rate of 99.1% and a low incidence of biological and biomechanical complications after a mean follow-up period of 3.2+/- 1.7 years.

Studies have evaluated the efficiency of 6mm v/s 10mm implants supporting fixed partial dentures in augmented bone[41], 6mm v/s 11mm implants combined with sinus floor elevation supporting single crowns[42] and 6, 5mm implants rehabilitating bilateral atrophic posterior arches v/s longer implants in augmented bone [43,44] to find similar if not better performance of SDIs with fewer post-operative complications in comparsion to conventional implants in augmented bone. Based on the results of randomized control trials and clinical studies the following indications of SDIs in atrophic arches can be put forth[41-44]:

1) implant supported single crowns
2) implant supported fixed partial dentures
3) implant supported overdentures

The need for long term follow-up studies is quintessential to evaluate the effect of bone loss on the survival of the SDIs. While the loss of 2mm of crestal bone has minimal impact on the stability of a 10 mm or longer implant, a similar bone loss pattern on a 7mm implant for example leaves behind a considerably lesser bone volume for load dissipation.

The assessment of failure rates of SDIs should consider the poor quality of bone that is commonly observed in atrophic arches indicated for SDIs, in comparison to bone found in regions indicated for conventional implants and rather be compared to the outcome of implants placed in grafted sites.[5]

ADVANTAGES OF SDIs-[16]

- Lack of bone grafting reduces cost and duration of treatment.
- Surgical risk of sinus perforation, mandibular paresthesia is eliminated along with decreased chances of overheating the osteotomy site or damage to dilacerated adjacent tooth root.
- No need for additional inventory and decreased surgical complexity
- Implant placement in smaller interarch space

LIMITATIONS

The reversed crown to implant ratio, may not be an esthetic concern in the posterior quadrants, however, it may not be acceptable in the anterior maxilla. Here the morbidity related to an autologous bone graft for reconstruction must be considered.[20] Other than this, there is a draught of data on results of long term clinical trials of SDIs in poor quality bone. Also management of atrophic ridges that have horizontal ridge insufficiency with SDIs is a question that still remains unanswered.

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