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High Crown to Implant Ratio as Stress Factor in Short Implants Therapy

SUMMARY

Background/Aim: *The purpose of this study was to report the outcomes of crown to implant ratio (C/IR) measurements of single-tooth short implants. The specific aim of this study was to evaluate the effect of C/IR on crestal bone loss, assessing the success of short locking-taper implants treatment.*

Materials and Methods*: The cohort study was based on a sample of 33 patients, 14 males and 19 females. They were treated by at least one hydroxyapatite-coated Bicon implant, restored with Integrated Abutment Crown cementless technique and porcelain fused to metal crowns. The study was conducted between 2010 and 2015. Patients were recalled after 1-year and 2-year period time. Periapical, panoramic radiographs and clinical photos were obtained. The outcome measures were C/IR, crestal bone levels and the success of short implants therapy.*

Results*: After all the measurements were done on the first day of implant loading and at last visit, the mean C/IR was 1.85 (range, 0.95 to 3.20) and the mean change in the mesio-distal crestal bone levels was -0.73mm. No significant correlation was found between the C/IR and the risk for crestal bone loss nor the risk for implant failure.*

Conclusions: *A high C/IR has no significant effect on crestal bone levels (r= -0.151, p= 0.230) and on failure of implant treatment (p= 0.631) after the insertion of single-tooth locking-taper and implant restorations.*

Keywords: crown-to-implant ratio; short implants; integrated abutment crowns

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Introduction

The effect of a high crown to implant ratio (C/IR) on single tooth locking-taper screwless implants is an often discussed issue among clinicians. It is well known that the ratio between the crown and root (C/RR) of the natural tooth is 0.5 (1/2). However, the ideal C/IR is not established yet[1].

The greater the crown height, the greater the moment of force or lever arm with any lateral forces[2,3]. Forces may be increased by 20% for every 1 mm of the increase in crown height[4,5]. A high C/IR will introduce significant moment arms on the implant and surrounding crestal bone when the implant restoration is subjected to lateral forces[2]. The greater the moment of force, the greater stress of alveolar ridge would be, leading to crestal bone loss[2]. Clinical studies have not established a significant correlation between high C/IR and crestal bone loss on single-tooth implant restorations[1]. The effect of the high C/IR on single-tooth locking-taper screwless Bicon implants has not been evaluated yet[1].

The purpose of this study was to report the outcomes of the C/IR measurements. The specific aim of this study was to evaluate the effect of C/IR on crestal bone loss, assessing the success of short locking-taper implants treatment.

Materials and Methods

Study Design

The present study included a total of 33 subjects, 14 males and 19 females, who had at least one hydroxyapatite-coated Bicon implant, placed between

2010 and 2015, mostly restored with a single-tooth Integrated Abutment Crown (IAC)[6]. The IAC is a technique in which a single-tooth implant is loaded with a cementless restoration, in which the abutment and the crown are a single unit. The connection between the implant and the abutment-crown complex (unit) is a locking-taper or cold welding mechanism[7,8]. Patients were recalled after 1-year and 2-year period. Periapical and panoramic radiographs, as well as clinical photos were obtained. The intraoral radiographs (MyRay-ZEN-X, 5VDC USB 500mA) were taken with the use of long-cone technique and MyRay Sensor Positioning System (parallel technique) to optimize projection geometry.

To calibrate the measurements, the length of the implant was measured using the intraoral radiograph measuring the distance from the implant abutment interface to the apex of the implant - measured implant length (MIL). The actual implant length (AIL) was available from the manufacturer. The margin of error was calculated by the ratio AIL/MIL.

To adjust measurements for calibration error, the digital measurements were replied by the margin of error for that radiograph.

Study Variables

1. **Crown-to-implant ratio (C/IR)**[1]: The endosteal implant height (EIH) was calculated from the first bone-to-implant contact (FBIC) to the apex of the implant on both mesial and distal sides and, therefore, only the implant height situated within bone was taken into account for the calculation of C/IR.
   The supraosteal crown height (CH) was assessed from the most incisal or occlusal point of the crown to the FBIC on both mesial and distal sides, in millimetres. Thus the crown, implant abutment and implant surface located coronal to the FBIC were included in the determination of CH. To acquire the mesial C/IR, the mesial CH was divided by the mesial EIH. The distal C/IR was also determined, and then an average mesiodistal C/IR (avC/IR) was measured for each implant (Figure 1).

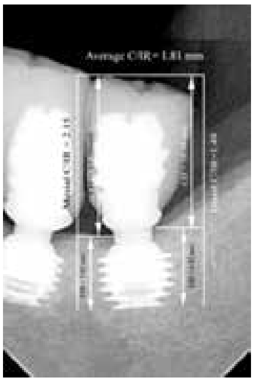

Figure 1. To obtain C/IR, endosteal implant height (EIH) divided by supraosteal crown height (CH) on both mesial and distal sides. An average mesiodistal C/IR was obtained per implant restoration

2. **Demographics**: The patient's gender and age were recorded at the moment of implant placement.
3. **General health status**: General health of the patients was classified according to the American Society of Anesthesiology (ASA) system[9]. Patients were categorized as ASA I (healthy) and ASA II (mild systemic disease).
4. **Current tobacco use**: Yes or No.
5. **Anatomic considerations**: In this category we included tooth type (incisor, canine, premolar, molar) and the implant position (maxilla, mandible, anterior, posterior).
6. **Type of bone**: Type of bone was assessed according to Misch[10] (D1, D2, D3, D4).
7. **Adjacent structures**: The proximity of the implant relative to teeth or other implants: The following categories were used: no teeth, one natural tooth, two natural teeth, one implant, two implants and one natural tooth/one implant.
8. **Crestal bone levels:** The crestal bone changes were obtained from the intraoral radiographs (periapicals) on the day of the insertion of the definitive restoration, 1-year and 2-years after loading. The radiographs were taken with a parallel technique to optimize projection geometry. Crestal bone levels (CBL) were measured mesially and distally. The linear measurements were obtained from the implant-abutment interface (IAI). A positive number suggested an increase in crestal bone level. A negative number suggested a bone loss overtime.
9. **Implant failure**: Failure was defined as a need for removal of the implant.

Results

The sample consisted of 33 patients, 14 males (42.42%) and 19 females (57.58%), mean of age (47.87±14.97). A total of 66 Bicon implants were placed: 60 implants (90.91%) in the posterior areas and 6 (9,09%) in anterior areas, which were restored with 59 Integrated abutment Crowns and 6 single-tooth metal-ceramic crowns. The most common location for all implants was the posterior mandible with 32 implants (48.5%), posterior maxilla with 27 implants (40.91%), followed by anterior maxilla with 6 implants (9.1%). No implants were placed at the anterior mandible.

Thirty patients were categorized as ASA I (90.91%) and 3 patients were categorized as ASA II (9.09%). The distribution of samples according to tobacco use - 6 of patients were smokers (18.18%) and 27 of them were non-smokers (81.82%). One implant was placed in D2 bone (1.51%), 43 implants (65.15%) in D3 bone and 21 implants (31.82%) in D4 bone. Two implants (3.0%) were adjacent by one tooth, 24 implants (36.4%) were adjacent by two teeth, 9 implants (13.6%) by one implant, 10 implants (15.2%) by two implants and 20 implants (30.3 %) were adjacent by one tooth/one implant. The follow up for all the implants were 24 months (Figure 2).

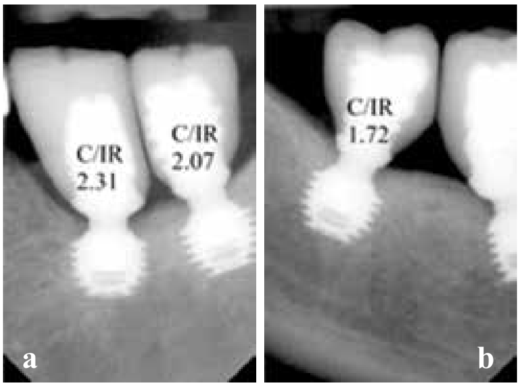

Figure 2a and 2b: Crown insertion

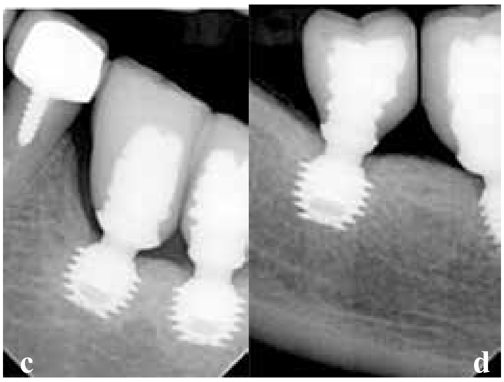

Figure 2c and 2d: Periapical radiographs after 2 years

Figure 2e and 2f: Clinical photos of IACs 36, 37 and 46, 47

During this study, two implant failures were documented. One implant placed in a smoker patient (cigarettes), with agenesis of two maxillary laterals, failed after loading. The implant was replaced after 5 months, without further complications. The other failed implant was placed in the posterior mandible in a non-smoker patient. It failed after insertion of the Integrated Abutment Crown and was no longer replaced.

Correlation between C/IR and Clinical Variables

Based on the Kendal's tau correlation coefficient, there was no significant correlation between the outcome and variables as: gender (p= 0.472), health status (p= 0.268), tobacco use (p= 0.352), bone quality (p= 0.376), adjacent structures (p= 0.562) and treatment result (p= 0.631). Based on the Kendal's correlation coefficient, there was a statistically significant correlation between the average of C/IR and patient's age (r=0.335, p=0.006) (Figure 3).

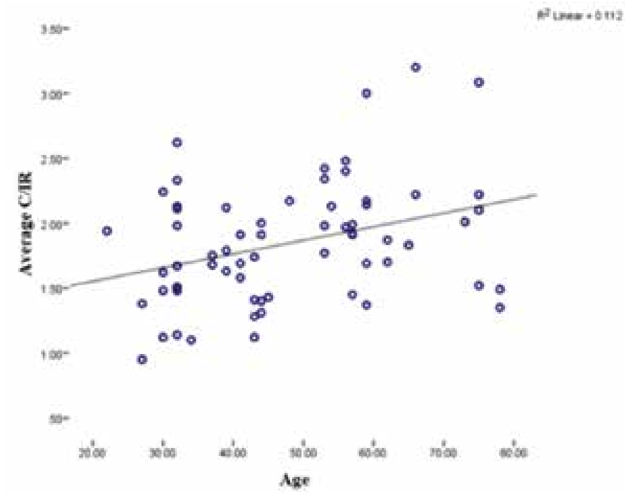

Figure 3. The correlation between the average C/IR and patient's age

Based on the Kendal's tau correlation coefficient, there was no statistically significant correlation between the C/IR and the treatment results. The average C/IR was 1.85 (range 0.95 to 3.20) (Figure 2). The average value of crestal bone level after loading was 0.5 mm and the average value of crestal bone level at the last visit was -0.23 mm. The mean mesio-distal change in crestal bone levels was -0.73 mm during 2 years of follow up. Based on the Pearson's correlation coefficient, there was no statistically significant correlation between the average value of C/IR and the mean mesio-distal change of crestal bone levels (r= -0.151, p=0.230).

Discussion

It has been proposed by Misch, that the higher the crestal stress, the higher the risk of crestal bone loss, and the higher the stress factor throughout the implant, the greater the risk for implant failure[11]. Increasing C/IR amplifies the moment arm for any offset occlusal loads[2].

Some studies of splinted external-hex machined-surface implants have detected increased peri-implant bone loss related to stress from superstructure design and parafunctions[12,13]. Different studies have reported reduced bone loss in cases of increased stress from larger C/IR's on single-tooth sintered porous-surface implants[14].

In other investigations increased C/IR did not lead to an increased risk of crestal bone loss or to an increase in implant failures or crown failures, after the insertion of single-tooth locking-taper implants restorations[1,15]. Evidence indicates that further studies should be conducted in order to estimate the effect of mechanical overload on peri-implant bone around single-tooth implants of different designs.

According to Brånemark, acceptable bone loss in the first year after the implant placement is 1-1.5 mm and 0.2 mm after the first year. The results of this study confirm that C/IR is not a significant risk factor for the crestal bone loss (0,73 mm after two years) after the insertion of single tooth locking-taper implant restorations. There was a significant correlation between the average of C/IR and the patient's age (p=0.006, r=0.335). In older patients, the C/IR was higher, which indicates the reduction of the alveolar crest and a higher clinical crown. In clinical cases like this we may use shorter implants in areas that have limited bone available instead of a long implants. The clinical significance of this finding is that locking-taper screwless implants may be restored with single tooth restorations while the clinical crown length is almost twice longer the clinical implant length or 3.7 times the crown-to-root ratio of the natural tooth. Resolving cases with short implants when limited bone is available, reduces need for sinus lift, bone augmentation, grafting and other surgical procedures[15] that involve complications, time and money.

A high C/IR did not lead to a statistically significant increase in implant failure. This results are consistent with the results of other researches; Schulte et al.[16] reported 16 failures of 889 locking-taper single-tooth implants and concluded that there was no clinically significant difference beetwen C/IR of the implants that were in function and those implants that failed. Urdaneta et al. concluded that larger C/IR (up to 4.95) was associated with a significant increase in prosthetic complications but had no significant effect on crestal bone levels on single-tooth locking-taper implants[1]. Their study showed that increased C/IR had a significant effect on the loosening of maxillary anterior of IACs and in the fractures of 2-mm-wide titanium abutment posts used for restorations in posterior areas. The results of Urdaneta et al.[1] supported the hypotheses that the longer occlusal high moment arm, resulting from larger C/IR, might have increased microrotation/rocking[2] and might lead to the lossening of maxillary anterior IACs and the fracture of 2-mm-wide titanium abutment posts. These complications could be avoided by splinting multiple adjacent implants. Splinting implants increases resistance to lateral loads, decreases the risk of implant's component fractures[17] and reduces abutment screw loosening and screw-retained implant restorations[18]. Taking in consideration screw-retained implant systems, it is possible that increased C/IR could play a significant role in a screw loosening or screw fracture, since both prosthetics and abutment screws have a smaller cross-sectional area than implants (typically about 2 mm)[11, 19].

Thus, when making treatment plan respecting the areas with a very high C/IR, splinting of multiple implants and using implant components wider than 2-mm should be taken into consideration as treatment option.

Conclusions

A higher crown-to-implant ratio did not lead to a high risk of crestal bone loss or to an increase in implant failures after the insertion of single-tooth locking taper restorations. The clinical significance of this finding is that locking-taper screwless implants maybe restored with single tooth restorations when the clinical crown length is almost twice longer then the clinical implant length, or 3.7 times the crown-to-root ratio of the natural tooth, or when the clinical crown length is up to 3.2 times the clinical implant length.

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