Evaluation of bone quality in alveolar crest obscured by dental implants ; A pilot study by densitometric digital analysis in mandibular bone specimen

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Introduction

The search for more detailed understanding about lesions of human body is an unending process. These endeavors are without exception in dental implant dentistry. For an instance, several parameter have been described to determine conditions of peri-implant. One of these parameter is the observation of changes in peri-implant bone levels. Since major changes take place in alveolar bone during progression of peri-implant disease and healing following implant therapy result in alveolar bone changes, this parameter is important in patients with implant prostheses as a means of precaution. Diagnoses, however, are often restricted to the assessment of implant mobility, clinical periodontal parameters(Gingival Index, Plaque Index, pocket depth, etc.), and conventional radiographic evaluation.

As focus radiography, the intraoral radiographic images have been the primary diagnostic method not only for the assessment of bone support, as well as but also for the detection and measurement of bone change. Although conventional radiographic techniques is one of the most frequently applied and non-invasive diagnostic procedures, they have shown their limitations considerably up to the present. Early stages of bone disease cannot be detected by means of routine radiographs, nor can the size of a rarefied area on the radiograph be correlated with the amount of tissue destruction[1]. And, it is not uncommon to find clinical signs of bone disease in spite of negative radiographic findings. Thus, it seems that the reasons are foreshortening or elongation of the radiographic images, variations in the contrast and density of radiograph, and difficulty in detecting bone change lies in the two-dimensional nature of the conventional radiograph[2].

For these reasons many radiographic methods[3-9] have been developed to improve accuracy in detecting changes in alveolar bone and osseous tissues bone conditions adjacent to implant. During the latest few years, reliable methods for obtaining superimposable radiographic images[3,4] of periodontal sites have been developed. This method can provide precise information about bone quality without misinterpretations of bone density due to angular variation of radiology. Although long-term longitudinal study have been done, there were no addressed buccal and lingual sides of bone quality, behind the implant except for restricted spaces between implants and osseous tissue suround the implant.

Despite the computerized method provided to be efficient and accurate for comparing bone changes adjacent to dental implants as obtained from standardized longitudinal radiographs, it also presented restricted area of bone changes, the changes detected in proximal area only. Bone conditions in behind of implant (buccal or lingual), however, and could not be detected, unless their mass was huge[10]. This was probably due to the high radiographic density of the implant, and the condition of buccal and lingual of the implant became saturated on the radiographic images consequently.

More recently, photodensitometry and digitization[4,11] have been used for the sensitive analytical technique to detect subtle changes of bone density. Photodensitometric technique is known to provide high spatial resolution and continuous measurement of optical density for analysis of dental radiographs, whereas digitization allows powerful image manipulations. Concept of our technique used this study is closer to the computer-assisted densitometric image analysis(CADIA)' rather than the classical quantitative subtraction.

For the evaluation of long-term success rates for dental implants, several criteria have been used. Although the computerized method provided to be efficient and accurate for comparing bone changes adjacent to dental implants as obtained from standardized longitudinal radiographs, it also presented restricted area of bone changes. Bone all surrounding osseous tissues of implant should be evaluated. Initial bone change started at the buccal area after implant insertion, however only interproximal bone change could be measured on radiographs as yet. Conditions of behind of implant are more important point to evaluation of success or fail of implant, however, those bone changes have not been addressed as yet.

Owing to such reasons, this study was planned (1) to find out the detective method obscured of bone destruction by dental implants through the series of superimposable intraoral radiograph, destructions adjacent to ITI® implants(especially buccal and lingual sides), (2) to propose a simplified procedure to assess those bone changes, what specific radiographic technique was easily detectable by usual intraoral radiographs, and (3) to verify of the reliability using this computerized high resolution densitometric technique.

Material and Methods

Mandiblular bone sample

A specimen from postmortem human mandible with complete edentulism was used for this bone density analysis. The dry mandibular bone was obtained from corpse subjected to educational dissection at the Department of Anatomy, University of Geneva, Switzerland. No data with regard to sample's characteristics except for bone quality (class IV ;according to classification of Lekholm and Zarb[12]) was available.

Implant insertion and bone section

Implant sites were prepared in the mandibular bone according to the surgical sequence. The basal compact bone was always perforated with the intention of further use.

The 10 ITI® (Institute Straumann, Waldenburg, Switzerland) solid screw implants (3.3mm in diameter, 8mm in length) without healing cap were inserted in the edentulous mandibular bone: Six(6) in the posterior region and four(4) in the anterior region.

After insertion of implants, the mandibular bone was cut to make 10 sectioned bone specimens with implant respectively.

Superimposable radiography

The experimental protocol was planned to compare the conventional periapical projections and the oblique occlusal projections. For this purpose, superimposable serial radiographs were taken four(4) simulated clinical situations for each sectioned bone(Fig. 1) ; making hall for implant(stage I), insertion of the implant into the bone(stage II), making bone defects on buccal or lingual side adjacent to the implant(stage III), removal the implant from the hall(stage IV). Half-rounded artificial defects were made by No.208 round low speed steel bur with 2mm diameter(Mailleffr SA, Switzerland). In each situation, two projections of perpendicular to the long axis of implant, that is, bucco-lingual(BL) and misio-distal(MD) projections as like conventional periapical views, and another two angled(25 degrees) projections to the long axis of implant, that is, oblique BL and oblique MD projections as like oblique occlusal views were used, respectively(Fig. 2). The shoulder of 3.3mm-diameter implant used this study is flared about 21 degrees. This angle is the most severe within commercially produced ITI® implants. Of course, the angle of projection will be able to change dependent on shape of implant shoulder.

In order to keep the same position and accurate(90 degrees) turn of the sectioned specimen, a thread cutter(044.511, Institute Straumann, Switzerland) was used. This instrument was inserted into the basal bone of mandible with paralleling to axis of implant. After combination with a ratchet(0.46.183, Institute Straumann, Switzerland), it was po-

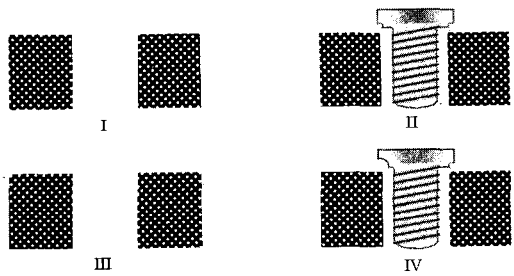

Fig. 1. Experimental x-ray taking protocol: I. making hall for implant(stage I), II. Insertion the implant into bone(stage II), III. making the bone defects on buccal and lingual adjacent to the implant(stage III), IV. removal the implant from the hall(stage IV).

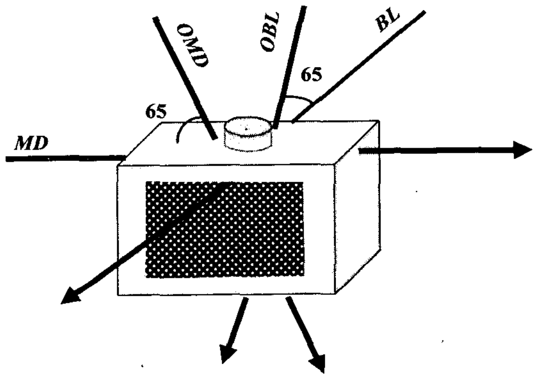

Fig. 2. Projection of x-ray beam
BL = bucco-lingual projection,
MD = mesio-distal projection,
OBL = oblique-bucco-lingual projection,
OMD = oblique-mesio-distal projection

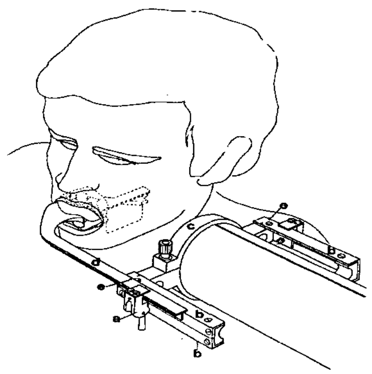

Fig. 3. The paralleling device used this study(Adapted from B.Dubrez et. al[17],) schematic representation of paralleling device in mouth and of metal collar(c) with its four rails(b) on theb) on the he x-ray tube. The plastic arm(d) can be fixed to one of the four rails through a screw(a) and a pin(e) for the orifice in the plastic arm(e)

sitioned on the table to take the radiograph. The specimen has been turned just 90 degrees for each projection, instead of turning the long cone x-ray tube. Total 16 radiographs(4 situations X 4 projections) were taken for each specimen.

Reproducible radiographs were achieved by using this standardized tool which contained an aluminum alloy penetrometer. The long cone x-ray tube (Heliodent MD, Siemens AG, Germany), and a custom-fabricated paralleling device by Graf et al[13] are shown in Fig. 3. The paralleling device is made of injected plastic and includes within the same rigid structure a film holder, a penetrometer holder made from two parallel pins, arm for connection to the cone and two supports to maintain same angulation of beam without bite try which is usually used in clinical situation. A specially designed metal collar is adapted to the x-ray cone, and a rail permits connection of the rigid T' sectioned plastic arm to the cone in a constant position by using a metallic pin and screw. The source to film distance provided by long cone and film holder was approximately 41cm in this study. All radiographs were taken with D-speed film(Ultra-speed®, Kodak, USA) with following exposure parameters : 0.16 second, 15mA, 75kV. We affirmed that exposure time of 0.16 second is more detail to contrast by previous test. They were processed with constant developing and fixing times.

Preparation of the films: To achieve the best possible placement during the digital analysis, three reference points were added in the beside of bone specimen over the film, as extend as possible. Three tiny holes were punched with a thin needle under a stereomicroscope on the first film. The second film of the series was superimposed on the first under a stereomicroscope, using the outlines of the thread cutter as a reference; the same reference points as on the first radiograph were then punched out. The same procedure was applied to the two other films of the series.

High-resolution digital analysis: The technique used for quantifying the density of bone was based on a high resolution digitization of the radiographic films and implies the use of a video camera(Kodak-Eikonix™, USA) with a maximum resolution of 4096 X 4096 pixels and up to 4096 gray levels(12 bits acquisition). The radiographs were digitized at about 1200 X 1600 pixels and all the available gray levels utilized. The camera was driven by a SUN SPARC(Sun Microsystem Inc., Mountain View, California, USA) and a specific software(LaboImage, Computing Science Center, Geneva University) was then used to

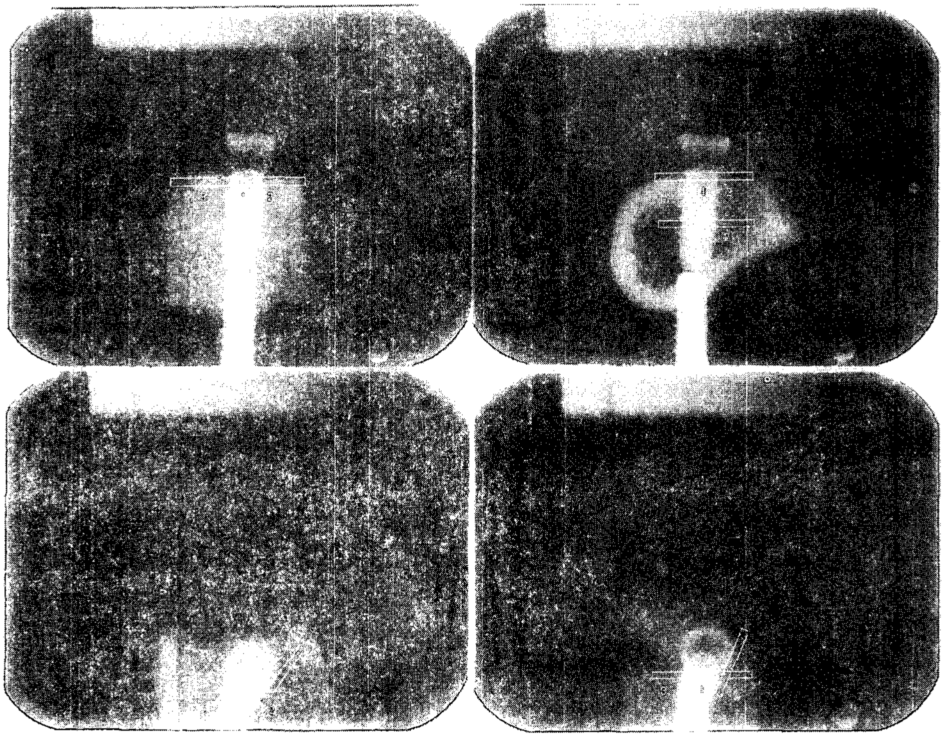

Fig. 4. Scans of interesting areas :

1) bucco-lingual (BL) projection-an horizontal scan across the crestal bone defect(R2), crestal bone defect obscured by implant(R1), and no crestal bone defect area(R3) ; 2) mesio-distal(MD) projection-an horizontal scan across the crestal bone defect(R2) and crestal bone defect obscured by implant(R1); 2nd horizontal scan in much deep area, where no bone changes were to be expected(R3-1and R3-2) ; 3) oblique-mesio-distal(OMD) projection-an horizontal scan across the crestal bone defect(R2), crestal bone defect obscured by implant(R1), and no crestal bone defect area(R3) ; a vertical scan along the lateral contour of implant(R0) ; 4) oblique-bucco-lingual(OBL) projection-an horizontal scan across the crestal bone defect(R2), crestal bone defect obscured by implant(R1), and no crestal bone defect area(R3) ; a vertical scan along the lateral contour of implant(R0)

analyze the stored images. Successive images of a series of radiographs were placed by LaboImage in identical positions with the help of precise dots punched on the films under microscophic control. Then, LaboImage in scanned the penetrometer area between identical points and was able to convert the gray levels of the original pixels into values corresponding to aluminum equivalents. This conversion was obtained for each radiograph by approximating a theoretical curve by a third degree polynomial fit of the constant part of the penetrometer. Several scans of interesting area were read an each of the four(4) series radiographs(Fig. 4).

Direct pixel by pixel comparison between the images was thus possible and any area could be analyzed by LaboImage in scanning mode. The curves provided by each series of scans were visualized graphically. Surfaces located under each successive curve were calculated by mathematical integration. Finally, the value of the surface under the stage I curve was set to 100 and each change expressed as percentage of this stage I surface.

Due to technical problems during sample handling, nine(9) specimens became available for subsequent densitometric digital analysis.

Statistical analysis

The changes of bone density in mandibular specimen were investigated after artificial defects in buccal and proximal sides adjacent to the dental implants. ANOVA, followed by Neuman-Keuls method was performed to

Table 1. Average of change of bone density (%) in mandibular skull after defect by 4 series of projection

Projection	N	R	S1	S2
BL	5	R1	-3.548(2.234)	-5.185(6.640)
	7	R2	-5.547(4.833)	-3.628(5.958)
	7	R3	-0.459(3.862)	-0.339(2.490)
MD	5	R1	-5.322(6.240)	-2.336(6.055)
	7	R2	-6.231(4.252)	-3.553(6.122)
	6	R3-1	-2.065(5.469)	2.612(1.624)
	6	R3-2	0.057(2.770)	0.972(2.486)
OMD	6	R1	-2.650(4.640)	-1.758(3.675)
	6	R2	-1.123(3.467)	-1.465(3.103)
	6	R3	-1.060(1.809)	1.120(1.590)
	8	R0	-4.106(4.667)	-3.016(3.570)
OBL	6	R1	-0.663(2.264)	0.181(2.261)
	7	R2	-2.629(4.694)	-2.640(2.302)
	5	R3	-1.072(2.886)	-0.210(1.657)
	8	R0	-5.953(3.305)	-2.641(2.673)

BL = bucco-lingual projection, MD = mesio-distal projection,
OMD = (reverse) oblique mesio-distal projection,
OBL = (reverse) oblique bucco-lingual projection,
N = number of sample, R = interesting region (R0 = unscreened defect which was analyzed by oblique direction, R1 = screened defect with implant, R2 = unscreened defect which was analyzed by horizontal direction, R3 = no defect, R3-1 = no defect in deep surface & screened with implant, R3-2 = no defect in deep surface & unscreened with implant), S1 = bone density change of defect without implant, S2 = bone density change of defect with implant,
Numbers in parentheses are standard deviations.
'+' = bone gain, '-' = bone loss

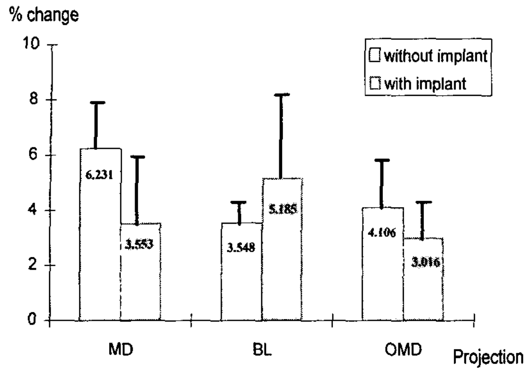

Fig. 5. Change of bone density(%) on buccal defect

MD = mesio-distal projection,
BL = bucco-lingual projection,
OMD = oblique-mesio-distal projection.
The vertical bar is standard error of mean.

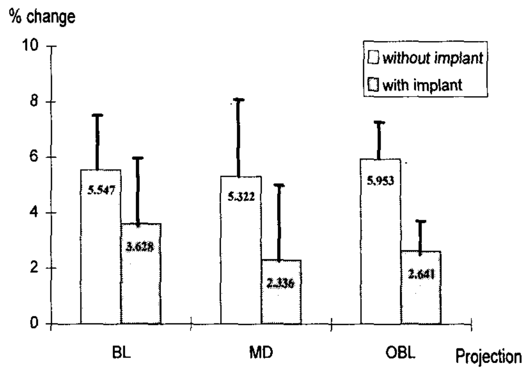

Fig. 6. Change of bone density(%) on proximal defect

BL = bucco-lingual projection,
MD = mesio-distal projection,
OBL = oblique-bucco-lingual projection.
The vertical bar is standard error of mean.

compare the statistically significant difference of the bone density obtained by each projection of radiography. T tests, F tests, and Mann-Whitney W tests were used to compare means, and standard deviations and medians, respectively.

All analyses were performed significant confidence level at 0.05.

Results

In total nine(9) implants, 144 superimposable radiographs were analyzed. Due to the discord position of radiographs, some series of them were not available for analysis. If one radiograph was not superimposed, then the whole series of four(4) radiographs (from stage I to stage IV) was not used.

Average of change of bone density in mandibular specimen after defect by all series of projection are shown in Table 1. In Fig. 5 buccal bone defect and Fig. 6 proximal bone defect are shown.

The average density change of buccal bone defect was 3.548% in BL projection and 4.106% in OMD projection with obscured by implant. In case of proximal bone defect was 5.953% in OBL projection, followed by 5.547% in BL projection, 5.322% in MD projection. However, in both of cases, the differences between projections of x-ray beam were not statistically significant in ANOVA results.

The diagnostic accuracy between defect(superficial portion) area and non defect(deep portion) area in same projection(MD) was statistically significant difference($p<0.05$) as follows: The R3-2 has lower mean(0.057%) and median (-0.285%) of bone density change than those of R2(mean = -6.230%, median = -6.07%) in S1, respectively. The R3-2 has lower standard deviation of mean(2.486%) bone density change than that of R2(6.122%) in S2. The R3-1 has lower mean(2.612%), median(2.370%) of bone density change and standard deviation(1.624%) than those of R1(mean = -2.336%, median = -0.180%, standard deviation=6.055%) in S2, respectively.

The diagnostic accuracy between projections of x-ray beam was shown as comparing R3 in BL, R3 in OMD, and R3 in OBL projection. R3 in BL has lower bone density change(0.459 3.862%) than those of others (1.060 1.809% in OMD, 1.072 2.886% in OBL). However, no statistically significant difference was shown.

Discussion

Backgrounds of concepts

Tomogram has been used with good success for the assess of implant site in pre-and post treatment. However, it is limited to use by special circumstances due to the high cost of the equipment and the availability of a trained radiologist to obtain and interpret the image[14]. In implant practice, the panoramic image and periapical radiograph commonly used to the detection of change at the adjacent to implant. Periapical radiograph to assess marginal bone level around implants has been prepared due to the increased detail obtained with intraoral film as compared with panoramic radiograph. Periapical radiograph may have limited efficacy for evaluation of bone change in area of obscured by dental implants. This is the most critical factor whenever used for detection the circumferential bone quality by intraoral film.

In dental radiography[15], images portray the trabeculae of cancellous bone as looking like a kind of lattice(Fig. 7a). And , the cancellous bone is invariably enclosed by dense compact bone which contributes to cumulative record of beam attenuation whenever it overlies the trabecular bone(Fig. 7b). If the compact bone is relatively low thickness by comparison with the cancellous bone, discernible image feature

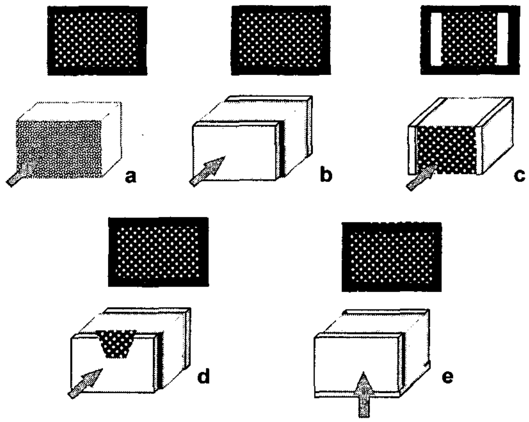

Fig. 7. Radiographic images ;
a) image through block of cancellous or trabecular bone. b) image through block of cancellous bone between two outer plates of cortical bone. Image is lighter than that of unmasked trabecular bone. c) image through block of cancellous bone at edges of which are slabs of compact bone to be penetrated in depth. d) image through simulated bony defect. e) image through one plate of cortical bone of bottom. Image is lighter than that of unmasked trabecular bone, and darker than that of masked trabecular bone by two cortical plates.

leave(Fig. 7c). This circumstance is exemplified by absence of any image of the compact bone comparing buccal and lingual aspects(Fig. 7d), another image through the cancellous bone between bottom plate of cortical bone and crest of cortical bone which is low thickness of absence due to destructive disease as in mandible(Fig. 7e). Occlusal projection instead of lateral projection may offer the solution of above problem, if the x-ray beam and long axis of the implant are properly aligned.

On the basis of above grounds, this study was focused the utility of quantitative radiography taken by intraoral films in detecting bone change obscured by dental implants. For this purpose, oblique(25 degrees) occlusal x-ray projections and conventional periapical projections were used and compared.

Considerations of experimental methods

Quantitative radiography is noninvasive method to assess alveolar bone changes, however it has been shown potentiality to make misinterpretations caused by projection errors[16,17]. From this references, three landmark points were made after developing the films to provide the repositioning accuracy in this study. The coordinates of three landmarks can offer the prerequisites for the application of the simplified mathematics formulas and rapid evaluation of the superimposability of serial radiographs.

The system described in here represents a modification of the method used by Dubrez et. a[14,11,18]. The only different thing is the instruments-the thread cutter and ratchet-were used instead of silicone bite block as used other *in vivo* studies. The instruments made a precise role to allow rotate just 90 degrees of sample in each certain position. The paralleling device, the long cone of the x-ray unit holding film and penetrometer was fixed a same position, Then, the rotate of 25 and 90 degrees to long axis of implant was performed to take all series of radiograph.

On the results of this study performed on a dried mandible, the greater change of bone density in defect area made by low speed dental bur(half depth of 2mm diameter) was shown by BL projection, even in area obscured by the implant. When comparing defected and non-defected area, more than 3% of bone density change has shown in defected area. Generally, there was 1 or 2% of bone density change in other clinical follow-up studies[4,18]. The defect sizes obscured by them were mostly bigger than the defect used in this study. It might be expected that this in vitro study using the dried skull without skin would lead to the greater sensitivity. And, the bone quality was class IV, which were thin cortical bone surrounds loose, spongy core. Hence, it was perhaps the reason why this result has shown more sensitivity rather than other in vivo studies[11,19].

Radiographic results

Reproducibility : The reproducibility of this method has been about 1% of variation[11,17]. However, non-defected area as a control group, where no bony changes to be expected, has shown more than 3% of variation in this study. This variation imply that an attempt to standardize the series of radiographic image is not so easy.

The experimental bone defects were produced using a dental round bur with 2mm diameter. The defects were located in buccal and proximal to simulate decreased bone density of alveolar bone in the region of interest. The size of defect was standardized as half depth of diameter. Nevertheless, false negative or positive results were found for the detection of the some samples. The R3-1 in S2 of MD projection is an example of false negative result. One possible explanation is that when the radiographs were analyzed, some other factors such as implant body might be involved. Of course, this problem was due to non-superimposed radiographs.

Otherwise, the R3-1 in S2 of MD projection is an example of false positive result. This situation was neither defect nor obscured by implant in deep portion. Hence, an explanation could be that the false positive results were caused by lose of bone chips during the removal of implant according to experimental protocol. Some of bone particles on the TPS(titanium plasma sprayed) surface of implant were observed whenever removal of implants from the bone samples. Therefore, the density of bone would be relatively decreased. Another reason, may account for the false positive results, seems that some parts of bone chips were perhaps broken down during the removal of implant. Although, small change of bone particles, it can be detected since the high sensitivity of this system. These might become distinct due to dry condition of the bone.

Although same digitizing analysis has been used in previous another studies[4,11,18], the defect behind obscuring factor could not be detected yet in clinical field. Within results of this study, both of the oblique projection like occlusal radiographs and conventional periapical projection appeared reasonably sensitive in detecting bone density changes obscured by dental implant. In this *in vitro* study, no healing caps or abutments were placed on the implant. For ITI® dental implant, furthermore, the thickness of neck area is relatively shallow than other part of implant in mechanical geometric. These lack of radiopaque components would allow for possibility to detect the subtle changes behind the implant. This assumption is in accordance with data by Formousis et. al[10]. They reported bone chips in buccal defect(behind the implant) of pig mandible, however, detected using by computer-assisted densitometric image analysis(CADIA), if their weight reached 14mg or more. It means that the digitizing analysis system could detect bone changes dependent on relative density against obscuring effect, while the conventional radiographs could not detect them.

Reliability: When comparing the bone density between before and after defect in situation with implant, the significant difference of median was shown in non-obscured bone defect by implant in BL and OBL projections. Otherwise, no significant difference was observed in obscured bone defect by the implant, even if great bone density changes have shown as in Table 1. It is supposed that the great standard deviation would lead to these statistical results by paired sample tests. On the other hand, a somewhat difference of mean was interestingly observed in obscured bone defect by implant in OMD projection($p = 0.09$). This result did not show the statistically significant difference of bone density change as comparison before and after bone defect. Nevertheless, this seems to be a reliable method for detect subtle bone density change.

As concerns reliability of the result in situation with implant(S2), the bone density change of non-defect area appeared 2.612% in MD projection, despite it should be 0% difference in theoretical. It is assumed that this projection would give a reliable baseline data of diagnostic error because there was only spongy cores. The each mean of bone density change in non defected area(R3) was assumed as each diagnostic error. On basis of the results, the bone density changes have shown 5.185% in behind implant, 3.628% in unscreened area by BL projection. It was about 1% greater than the amount of diagnostic error which was assumed as 2.612% in this circumstance. The similar finding was also observed in situation without implant(S1). Such an evaluation made with low-contrast would be less accurate and subjected to more variation, however, it could provide important information for clinician to make a diagnosis of implant patient. Furthermore, the abutments could be removed for radiographic evaluation, this digitizing radiographic diagnostic system could overcome the absorb of x-rays resulting in obscuring area, whenever use conventional periapical radiographs.

Conventional periapical projections versus oblique occlusal projections: Although no statistically significant difference was observed, the conventional periapical projections appeared more sensitivity than oblique occlusal projections as compared with two different projections of x-ray beam. In case of buccal defect obscured by implant(It is our interesting topic), OMD projection has shown 3.016% of density change while BL projection has shown 5.185%. In this study, the influence of the absence of titanium healing cap would lead to the remarkable sensitivity of BL projection(conventional periapical view). However, it was supposed that the sensitivity of conventional periapical view would be still questionable or low. In addition, the sensitivity will be depended on relative radiopacity of objects. On the other hand, the oblique occlusal projections were always available for viewing regardless of obscuring effect. Some paired images were found unsuitable for quantitative analysis. This frequency in oblique occlusal projection was more or less higher than in conventional periapical projection. It seems that the changes in specimen position would result in altered x-ray beam projection. Due to the inaccuracy of superimposable radiograph, bone loss may not be localized, and the potential obscuring effect of x-ray beam angulation may greater affect this result. If the angulation of x-ray beam, or superimposition of radiographs were not constant through 4 series of radiographs, interesting area adjacent to implant was difficult to be chosen without obscuring effect by radiopacity of implant. May be, it was the reason why the error of diagnosis in oblique occlusal projections(1.120%) were more greater than conventional periapical projections(0.339%).

Hausmann et. al[20] reported effect of x-ray beam vertical angulation on radiographic alveolar crestal level and noted that the beam angle variation resulted in bone score differences. This problem could be solved using a device to offer the constant relationship between the x-ray tube, alveolar bone, and film when application in clinical practice. As a prerequisite for digital analysis method, standardized radiographs must be obtained with great accuracy[21]. When comparing between non-obscured by implants(S1) and obscured condition(S2), the latter has shown about 1.6% greater bone density changes than that of the former in the same specimens. For instance, in buccal defect obscured by implant(R1) in BL projection, a -5.185% of bone density change was observed in S2, while -3.548% was shown in S1. Logically, the two conditions should have equal density, if there was no other factors which is expected to produce the bone change. One possible explanation is that the experimental protocol would affect the different results. According to protocol-drilling(stage I), place the implant(stage II), making defect adjacent to implant(stage III), and removal of implant(stage IV)-bone chips would be, more or less, lose during stage I and stage IV when removal of implant, while no change of bone chips would be expected during stage II and stage III. Nevertheless, all of the changes seen here were quite enough greater to accept the results when compared with those of their non-defected control areas which was -0.459% in S1 and -0.339% in S2.

As concerns analyzing method, despite no statistically significant difference was observed($p=0.09$ in OMD, $p=0.07$ in OBL projection), the results performed by vertical direction had higher sensitivity than by horizontal direction. The former was also more easily and simply used for analyzing the film of oblique occlusal projection during scanning procedure.

Despite of more sophisticated method, the standardization of all procedures involved in producing identical radiographs remains the disadvantage factor that may not be sufficiently reproducible in clinical trials yet. The most important factors for making a proper radiographs are the quality of the equipment including its software together with the operator or examiner's experience. Another critical factor is that the oblique occlusal projection would be limited by presence of prostheses, furthermore in case of maxillary bone loss.

Additional study on oblique occlusal projection is needed to investigate the significance of this method not only in taking the radiograph but also in analyzing methods.

Summary

Despite of technical difficulties, the combination of occlusal projection and densitometric digital analysis may ultimately provide a means of detection of subtle bone loss at the facial and lingual side of dental implant (Oblique occlusal view is more useful for ITI® dental implant due to its contour of shoulder as like tulip' flower). In this study, conventional periapical projections of x-ray beam had shown more high sensitivity to detect the bony defects than oblique occlusal projections in alveolar crest obscured by dental implants or not, even if the difference was not statistically significant. Unlike conventional periapical projections, occusal projections combined with densitometric digital analysis technique may provide a means for detection of subtle bone change at the all around of implants without obscuring effect by implant itself.

Although the results from this *in vitro* study were performed under limited circumstances, these results might afford more possibility and versatile modality of diagnosis options to clinician in the implant practice.

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