原 著

The Panoramic Radiograph Is Reliable for the Diagnosis of Peri-implant Bone Loss

YUKINO KAMIGAKI, SHIN OGURA*,
HIROSHI IWATA** AND TAKASHI YOSUE

インプラントの経過観察におけるパノラマ X 線写真の有用性

神 垣 友 希 乃 小 倉 晋*
岩 田 洋** 代 居 敬

要約：本研究は、インプラント周囲の骨吸収を診断するときのパノラマ X 線写真の有用性の検討を目的としている。対象は 34 名 / 117 本の下顎臼歯部のインプラント体を平行法 X 線写真とパノラマ X 線写真を 10 年間にわたり検討した。平行法 X 線写真 (D score) とパノラマ X 線写真 (P score) の測定値を全症例、パノラマ X 線写真上でインプラント体の不鮮明であるもの (V group)、鮮明にみえるもの (N group) に分けて検討した。その結果、D score と P score が有意に相関を示した。その一致度を詳しく分析するために、Bland-Altman 分析を行ったところ V group においては加算誤差 -0.43 ~ -0.32 と大きく示されたが N group では -0.09 ~ -0.03 と非常に小さかった。パノラマ X 線写真上でインプラント体の不鮮明であるものは診断に注意が必要であるが、下顎臼歯部においてインプラント周囲の骨吸収の診断はパノラマ X 線写真でも有用であると考えられた。

Abstract : This was a retrospective study involving 34 patients with a total of 117 implants at the mandibular posterior region, who underwent implant treatment at The Nippon Dental University Hospital and were followed up for 10 years using the paralleling technique and/or the panoramic radiograph. The measurement scores from the paralleling technique radiographs (D score) and the panoramic radiographs (P score) were obtained to determine peri-implant bone loss. These were examined separately for all cases, for cases in which the image was vague (V group), and for cases in which the image was sharp (N group). Regression analysis showed correlation between the D and P scores in all groups. To analyze the relationship between these scores in detail, Bland-Altman analysis was adopted. Bland-Altman analysis showed a fixed bias in the V group, in which the P score was much smaller than the D score (-0.43 ~ -0.32). On the other hand, only a slight fixed bias was observed in the N group, and the difference was considered negligible (-0.09 ~ -0.03). In conclusion, the panoramic radiograph is shown to be reliable for the diagnosis of peri-implant bone loss at the mandibular posterior region, unless the image of implants is indistinct.

Key words : panoramic radiograph (パノラマ X 線写真), peri-implant (インプラント周囲), bone loss (骨吸収)

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Introduction

The follow-up of implants from the dental radiology perspective involves examination of the state of peri-implant bone loss. It is generally considered that the paral-

leling technique radiograph is reliable for such purposes as it provides an accurate depiction of peri-implant bone loss¹⁾. However, this procedure involves substantial discomfort for the patient, as a film must be placed in the oral cavity and the use of adjunctive instruments is nec-

Department of Oral and Maxillofacial Radiology, School of Life Dentistry, The Nippon Dental University (Chief: TAKASHI YOSUE) 1-9-20, Fujimi Chiyoda-ku 102-8159, Japan.

* *Oral Implant Center, The Nippon Dental University Hospital (Chief: SHIN OGURA)*

** *Division of Oral Diagnosis, The Nippon Dental University Hospital (Chief: HISAO YAGISHITA)*

日本歯科大学生命歯学部歯科放射線学講座 (主任：代居 敬教授)

* 日本歯科大学附属病院口腔インプラント診療科 (主任：小倉 晋教授)

** 日本歯科大学附属病院歯科放射線・口腔病理診断科 (主任：柳下寿郎教授)

essary to achieve parallelism between the target object and the plane of the film^{2,3)}.

On the other hand, it is widely considered that the panoramic radiograph is not reliable for the diagnosis of peri-implant bone loss¹⁾ because the low image sharpness, induced by various factors, hinders accurate diagnosis of peri-implant bone loss. However, this procedure involves little discomfort for the patient, and has the additional benefits of enabling diagnosis of the patient's status throughout the oral cavity^{2,3)} and allowing for patients with many implants to be followed up with a single radiograph. Therefore, we examined the reliability of the panoramic radiograph for the diagnosis of peri-implant bone loss.

Materials and Methods

This study protocol was approved by the ethics review boards of The Nippon Dental University Hospital (NDU-T2014-46).

Thirty-four patients with a total of 117 Brånemark implants at the mandibular posterior region (males: 17 patients with 56 implants; females: 17 patients with 61 implants) who underwent an implant treatment at The Nippon Dental University Hospital and who were followed up for 10 years. Among them the cases which the paralleling technique and the panoramic radiographs were performed simultaneously was examined.

The radiography procedure and method of peri-implant bone loss measurement on the radiograph was performed according to the methods described by Iwata et

al (Fig. 1)⁴⁾. In brief, the main measurement was the vertical distance from the reference point (the narrow site of the shoulder of the implant body) to the top of the alveolus bone. The amount of peri-implant bone loss thus represents the difference in the vertical distance at the time of each follow-up from that at the time of loading. The measurements were corrected based on the major axis of the thread. The paralleling technique device was HELIODENT (Sirona Dental Systems; Bensheim, Germany), and the panoramic radiography device was Veraviewepocs (J. Morita Co.; Kyoto, Japan).

Four dental specialists (with acquired qualifications in oral and maxillofacial radiology and/or dental implants) who have over 10 years of experience in the diagnosis of peri-implant bone loss examined the measurement scores from the paralleling technique radiographs (D score) and the panoramic radiographs (P score). Scores were analyzed separately for all cases (All group) (D score and P score were 391 respectively), cases in which image indistinctness was observed in the implant on the panoramic radiographs (V group) (D score and P score were 205 respectively) (Fig. 2A, B), and cases in which no such image indistinctness was observed (N group) (D score and P score were 186 respectively) (Fig. 2C). In this study, "image indistinctness" was defined as an image that poses difficulty in diagnosis, owing to factors such as superimposition of the labial/buccal and lingual images, a ghost image of the opposite site, and geometric distortion.

Statistical analysis was conducted by determining the

Fig. 1 Radiography with improved Rinn XCP instruments

a: indicator arm; b: aiming ring; c: guide rim; d: bite block; e: film; f: prosthetic guide pin The prosthetic guide pin that is screwed into the abutment is put through the hole of the guide rim, so that the bite block is fixed to the abutment. The indicator arm and aiming ring are then attached to the bite block.

test of significance of Pearson's correlation coefficient between the D and P scores, and the degree of coincidence between these scores was examined by Bland-Altman analysis. A difference was considered to be significant when the p-value was <0.01 .

Results

The D and P scores and Bland-Altman plots of the All group, V group, and N group are shown in Figures 3, 4, and 5, respectively. In Fig. 3, the limit of agreement

Fig. 2 Representative examples of radiographs and the potential factors contributing to image complexity that affect measurement

- A: Because the implant that was installed in the alveolar bone on the buccal-lingual side was thick, accurate diagnosis of the state of peri-implant bone loss cannot be accomplished, although accurate diagnosis of the thread is possible.
- B: Because the implant was installed on the buccal or lingual side at a slant by an intraoral state, accurate diagnosis of the state of peri-implant bone loss cannot be accomplished because the thread is out of focus.
- C: With no image indistinctness, the panoramic radiograph could facilitate accurate diagnosis of the thread and the state of peri-implant bone loss.

Fig. 3 Measurement score (A) and Bland-Altman plot (B) from the paralleling technique radiographs (D score) and the panoramic radiographs (P score) in all cases (All group).

Fig. 4 Measurement score (A) and Bland-Altman plot (B) from the paralleling technique radiographs (D score) and the panoramic radiographs (P score) in cases showing image indistinctness in the panoramic radiographs (V group).

(LOA) value was $-0.94 \sim 0.49$ and the mean was -0.22 . Similarly, in Figure 4, LOA value was $-1.16 \sim 0.42$ and the mean was -0.37 , and in Figure 5, LOA value was $-0.50 \sim 0.38$ and the mean was -0.06 . Test of significance of correlation coefficient were significant in all groups ($p < 0.01$). LOA value was lowest in the N group and highest in the V group. All 95 % confidence interval (95 % CI) values were negative, as shown in Table 1, indicating a fixed bias toward a lower P score than D score. A substantial fixed bias was observed in the V group, thus reflecting deviation between these scores owing to image

indistinctness produced by the panoramic radiograph. All slopes of the regression lines were considered to be negligible.

Discussion

The main success criterion used in the follow-up of implants is a marginal bone loss rate of less than 0.2 mm annually^{5,6}. Furthermore, a very strict interpretation of the radiograph is required because of the difficulty in obtaining accurate assessments of this criterion⁷. Because the paralleling technique has the advantage that the vertical angle of X-ray irradiation is small and image indistinctness is minimal, it is considered reliable for the diagnosis of peri-implant bone loss¹. However, the patient experiences substantial discomfort during the procedure. Although the use of the panoramic radiograph could resolve this issue, it induces image indistinctness such as projections of the cervical spine and hyoid bone, distal eccentric projection of the premolar, and upward projection of the structure of the lingual side^{2,3}. Nevertheless, the use of the panoramic radiograph does have the added advantage of providing a widespread image over the mandibular inferior border from the orbital lower region; therefore, only a single radiograph is required for patients with several implants installed.

Several studies have addressed the reliability of the panoramic radiograph⁸⁻¹³, however, no study has yet examined its reliability in the context of the real-time clinical follow-up of implants. In addition, there are few reports overall focusing on postoperative evaluations of radiographs from the viewpoint of dental radiology. Therefore, we examined the reliability of the panoramic radiograph for the diagnosis of peri-implant bone loss. In this study, the panoramic radiographs were taken in the condition that the Frankfort plane of patients was parallel to the floor. Then, the reproducibility of panoramic radiographs kept to be sufficient for diagnosis.

Fig. 5 Measurement score (A) and Bland-Altman plot (B) from the paralleling technique radiographs (D score) and the panoramic radiographs (P score) in cases with no image indistinctness observed in the panoramic radiographs (N group).

Table 1 Showed Pearson's correlation coefficient and Bland-Altman analysis

	Pearson's correlation coefficient ($p < 0.01$)	LOA	Bland-Altman analysis			
			fixed bias		proportional bias	
			95% CI	presence/absence	r	presence/absence
All group (n = 391)	0.5	$-0.94 \sim 0.49$	$-0.26 \sim -0.19$	presence	0.16	absence
V group (n = 205)	0.26	$-1.16 \sim 0.42$	$-0.43 \sim -0.32$	presence	0.04	absence
N group (n = 186)	0.79	$-0.50 \sim 0.38$	$-0.09 \sim -0.03$	presence	0.14	absence

The result of the regression analysis showed a significantly correlation between the D and P scores in all groups. However, the correlation coefficient can only show the level of correlation, and does not provide information about the actual degree of agreement between the measurements. Therefore, to analyze the relationship between these scores in detail, the reliability of measurements was examined by using Bland-Altman analysis¹⁴⁾, which estimates measurements from the bias of the distribution of the points plotted on the graph. Bland-Altman analysis showed no evidence of proportion bias, although fixed bias was observed in all groups. In particular, the fixed bias in the V group was -0.43 to -0.32, indicating that the P score was very small compared with the D score. In the V group, besides the previously described image indistinctness, accurate diagnosis of the quantity of peri-implant bone loss might also have been prevented owing to factors such as the implant overlapping with the mandibular ramus, an implant installed on the buccal or lingual side at a slant by an intraoral state (Fig. 2A), or an implant installed in the thick alveolar bone on the buccal-lingual side (Fig. 2B). One report¹⁵⁾ indicated that the projection angle for the major axis of the implant should be less than 9 degrees to accurately measure bone loss. On the other hand, another study¹²⁾ showed that the implant at the mandibular posterior region should require particular attention because this region is prone to deviation of the axis. Such scenarios would have affected the depiction of the state of peri-implant bone loss. Therefore, particular attention should be paid to cases in which there is image indistinctness of the implant on the panoramic radiograph. Then, the paralleling technique is necessary to take for cases in which image indistinctness of the implant are apparent on the panoramic radiograph. The fixed bias of the N group was smaller than the V group (-0.09 to -0.03). The P score were slightly smaller than the D score; these results indicate that when the image layer of panoramic radiography is appropriate and there is no indistinctness in the image, it is indicated that the panoramic radiograph can be a reliable tool for the diagnosis of peri-implant bone loss (Fig. 2C).

For periodontitis patients, the presence or absence of image indistinctness at the site of interest is often not assessed accurately because there is currently no standardization criterion such as the thread. However, in implant patients, the sharpness of the thread can be used

to accurately assess the presence or absence of image indistinctness. Although some studies have reported¹⁶⁾ that the thread of the implant is a reliable measure for assessing image indistinctness, others¹⁷⁾ have shown that the accuracy is inferior in clinical practice. In addition, the appropriate positioning of the patient within the image layer was reported to be essential for obtaining a panoramic radiograph that can be used for accurate interpretation including the diagnosis of peri-implant bone loss^{18,19)}. In our hospital, we perform standardized radiography procedures and obtain highly reproducible radiographs⁴⁾. Therefore, we considered that we would be able to obtain reliable information on secular changes even from the panoramic radiograph. In this study, even though conducted clinically, it was thought that the use of the thread would be appropriate as the main criterion for assessment of image indistinctness.

Although not confirmed by subjective symptoms and intraoral views, there are many lesions that can be detected on a radiograph²⁾. Therefore, the advantages of using the panoramic radiograph to perform not only the follow-up of the implant but also maintenance throughout the oral cavity at the time of follow-up of implants are substantial. In addition, the use of the panoramic radiograph has the added advantage of reducing the patient's discomfort and minimizing the number of times radiography must be performed for patients with many implants. We are planning to use the panoramic radiograph as the primary method of the follow-up of implants in our hospital. This will also allow the dental radiologist to perform more in-depth intraoral diagnosis of the patient at the time of follow-up of implants.

Although it has long been considered that the panoramic radiograph is not reliable for the diagnosis of peri-implant bone loss, we have here shown its reliability at the only mandibular posterior region. In the future, we plan to further analyze the disadvantages of panoramic radiography at other parts and its applications for the diagnosis of peri-implant bone loss.

Conclusion

We conclude that the panoramic radiograph is reliable for the diagnosis of peri-implant bone loss at the mandibular posterior region; however, caution must be exercised for cases in which image indistinctness of the implant is apparent on the panoramic radiograph.

Conflicts of interest: None.

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