Quantitative assessment of alveolar bone density change after initial periodontal therapy using digital imaging

Kyung-Hyun Ahn, Jae-Duk Kim, Byung-Ock Kim

Dept. of Periodontology College of Dentistry, Chosun University

I. Introduction

Elimination of inflammation and preservation of dentition are the primary goals of periodontal therapy. Scaling and root planing therapy has been used as a primary therapeutic procedure in moderate cases as well as in presurgical preparation for more advanced cases[1)]. Scaling and root planing therapy result in probing depth reduction with a gain of attachment levels and this clinical improvement is associated with qualitative changes in the subgingival microbiota[2)].

Progression of periodontal diseases and healing following therapy result in alveolar bone changes. Radiographs are the only noninvasive method of detecting changes in the periodontal alveolar bone[3)]. But, Lang[4)] reported that conventional radiographic interpretation was limited for a reliable and predictable assessment of the alveolar bone status. Although several attempts[5,6)] have been made at standardization of exposure geometry, conventional radiographic techniques will present considerable limitations. Interpretive radiography requires that 30% to 60% of the mineral content of the bone has to be lost in order to visualize a change on a radiographic image but subtraction radiography could be used to identify bone change of 5% mineral loss[7)].

It is important to establish criteria for standardization of dental radiographic films involving projection geometry and radiographic processing so that more accurate diagnostic information can be secured. Recently, a computer assisted densitometric image analysis system(CADIA) has been tested clinically for its validity in quantitatively assessing radiographic alveolar bone density changes in digital subtraction images[8, 9, 10, 11, 12, 13, 14, 15, 16)]. Payot et al[17)]. measured the alveolar bone density changes within furcation areas of mandibular molars by means of computer-assisted photodensitometry of standardized radiographs. Eickholz[18)] reported statistically significant bone gain at 6 and 12 months after GTR therapy than conventional surgery using subtraction analysis. Brägger[8)] reported that alveolar bone density lost 4-6 weeks post-surgically at interdental crest sites exposed to periodontal flap procedures, which was increased for up to 6 months due to remodel-

교신 저자 : 김병옥, 광주광역시 동구 서석동 421번지 조선대학교치과대학 치주과학교실, 우편번호: 501-825

ling in the healing phase using CADIA.

The clinical aspects of healing after subgingival instrumentation have been documented in several longitudinal studies[19, 20, 21, 22], but most of the observations did not include quantitative data concerning alveolar bone density after initial periodontal therapy. The purpose of the present study was to assess the changes of alveolar bone density after initial periodontal therapy(scaling and root planing under local anesthesia) using digital imaging with copper stepwedge.

II. Material and Method

1. Subjects

Patients admitted to the Department of Periodontics, Chosun University Dental Hospital were selected for this study. The clinical and radiographic data were obtained from 5 patients who were diagnosed chronic adult periodontitis. 5 patients(2 female, 3 male) were between the ages of 43 and 52 years, with a mean of 47.4 ages. They neither receive any dental treatment nor had taken any antibiotics during the 6 preceding months.

Clinically, the interproximal sites in a premolar and molar area were confirmed by the presence of a pocket depth of at least 5mm with intrabony defect. Patients were clinically monitored prior to treatment and 8 weeks post-treatment. Gingival index(GI) and plaque index(PI) were scored from each tooth. Probing depth(PD), gingival recession(GR) and clinical attachment level(CAL) were measured on each interproximal area to the nearst millimeter.

The patients were first given oral hygiene education and scaling. They were repeatedly checked for maintenance of optimum oral hygiene during performing the periodontal treatment of the whole mouth, the sites were treated by subgingival scaling and root planing under local anesthesia with frequent subgingival rinses with physiologic saline.

2. Standardized intraoral radiographs and image processing

Standardized radiographs of the 40 sites were taken at baseline, 2 weeks, 4 weeks, 6 weeks and 8 weeks after initial periodontal therapy using Rinn XCP device with custom-made acrylic biteblocks.

As a densitometric reference, a copper stepwedge adhered on top of the film was used for the standardization of film density during exposure. A copper stepwedge with 10 steps of 0.03mm copper in thickness was formed by folding a sheet of copper foil. Radiographs were taken with E-speed intraoral films(Kodak Co., U.S.A.) and X-ray machine (Siemens Co., Germany) operating at 65kVp/ 7.5mA. These films were processed with automatic processor(DüRR Dental, Germany).

The radiographic images were processed with power Macquintosi 7200/120 computer(Apple computer Inc., U.S.A.) and 15?color monitor(Apple computer Inc., U.S.A.). The radiographic images were input by the use of computer-connected Quick Scanner(Minolta, Japan) backing up to 2800 dpi. The input images were digitized to apply for 640×480 pixel resolution and 256 grey level. The image analysis was operated by NIH image program(ver.1.56, National Institutes of Health, U.S.A.).

3. Image assessment of copper equivalent values

All the radiographic images with copper stepwedge were input into computer by scanner, then average grey scale of regular area on each stage of copper stepwedge were obtained using NIH program in the monitor. The grey scale of copper stepwedge with 10 steps ranged from 0.03mm to 0.3mm and conversion equation of wedge thickness were made out. And determinant coefficient(r^2) which represents the confidence of all prepared conversion equation was found out. Region of interest(ROI) was placed in the middle between the base of the defect and the alveolar crest. The images are converted into the copper equivalent image by conversion equation and density changes of ROIs were measured as copper equivalent values(mmCu). Also, difference of alveolar bone density between maxilla and mandible was compared.

4. Statistical analysis

The measurements of the 5 clinical parameters (PI, GI, PD, GR, CAL) at 8 weeks after treament were compared to those measured before treatment by using paired *t*-test. The alveolar bone density changes were compared by using one-way ANOVA and Scheffe test. The difference of obtained data between maxilla and mandible was analyzed by student *t*-test.

III. Result

1. Clinical parameters

The PI, GI and PD were significantly decreased at 8 weeks after treatment($P < 0.05$). The GI was increased slightly at 8 weeks($P < 0.05$). The gain of clinical attachment levels was obtained at 8 weeks($P < 0.05$)(Table 1).

2. Result of copper equivalent values image

In input images taken in the same radiographic condition, values of copper stepwedge measured in 10 steps were converted to copper equivalent val-

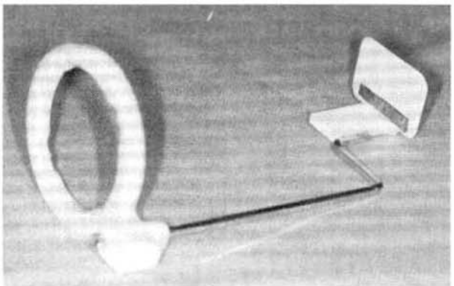

Figure 1. Rinn XCP device with copper stepwedge

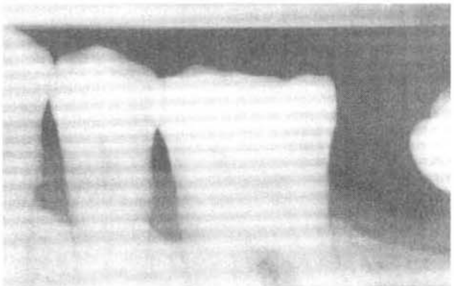

Figure 2. Radiograph with copper stepwedge

Table 1. Comparison of parameter between baseline and post-treatment (Mean±SD)

Parameter \ week	Baseline	8 weeks
PI	1.65±0.48	0.63±0.49*
GI	1.95±0.22	0.85±0.43*
PD	5.40±0.67	4.31±0.77*
GR	0.90±0.67	1.25±0.81*
CAL	6.30±1.18	5.56±1.28

* $P < 0.05$: significantly different from the baseline

Table 2. Copper equivalent values(mm) of longitudinal bone changes with the passage of time (Mean±SD)

value / week	copper equivalent values(mm)		
	Mx	Mn	Total
Baseline	0.1229±0.0397	0.1075±0.0202	0.1168±0.0353
2 weeks	0.1071±0.0319	0.0988±0.0209	0.1037±0.0289
4 weeks	0.1313±0.0277	0.1256±0.0207	0.1290±0.0260
6 weeks	0.1525±0.0297	0.1469±0.0174	0.1502±0.0264*
8 weeks	0.1763±0.0316	0.1656±0.0167	0.1720±0.0283*

*P<0.01 : significantly different from the baseline
Mx : Maxilla
Mn : Mandible

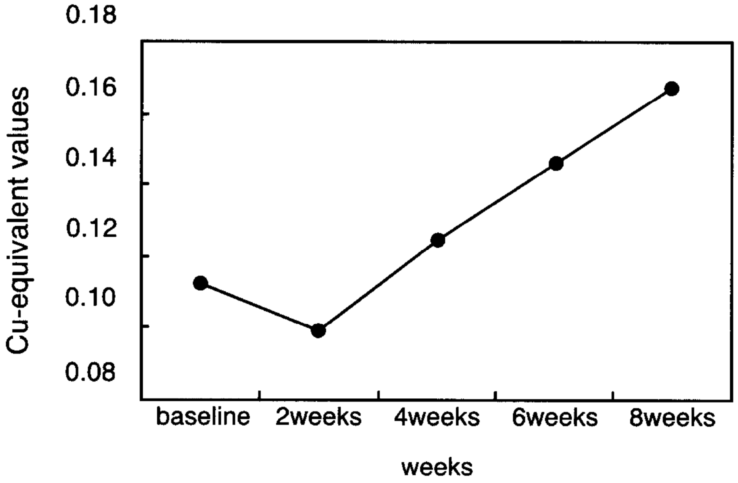

Figure 3. Copper equivalent values(mm) of longitudinal bone changes with the passage of time

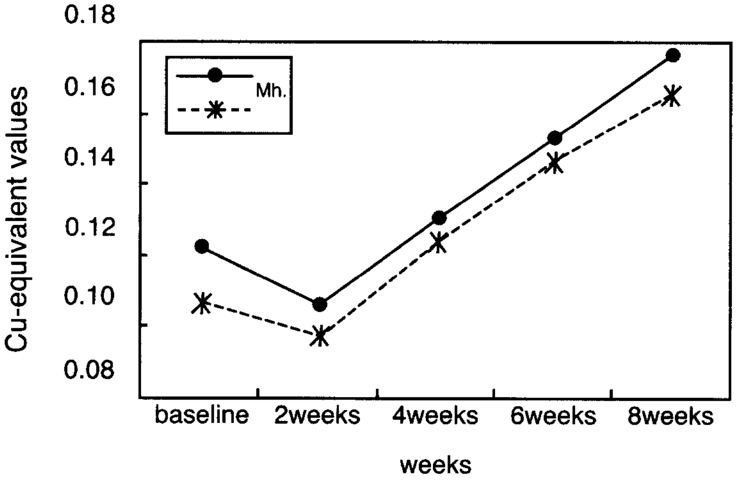

Figure 4. Copper equivalent values(mm) of longitudinal bone changes with the passage of time between Mx. and Mn

ues. The determinant coefficient r^2 was 0.9934 on the average and the distribution of r^2 ranged from 0.9902 to 0.9986.

Copper equivalent values of alveolar bone around each tooth showed a tendency to decrease at 2 weeks but to increase gradually from 4 weeks after treatment(Table 2). Copper equivalent values were significantly increased, compared to baseline and at 6 weeks and 8 weeks after treatment($P<0.01$). Copper equivalent values between maxilla and mandible were not significantly different($P>0.05$).

IV. Discussion

Clinical soft tissue measurement provides clinically important information regarding probing depth reduction and relative gains in attachment levels[23]. Soft tissue measurements do not provide any information regarding the hard tissue response to treatment. Radiographic analysis has played an important role in determining treatment outcome because it offers the only noninvasive method of evaluating the hard tissue response to treatment.

Mellonig et al.[24, 25, 26] have been made to compare clinical bone fill with the change in density in regions of interest placed in the base of the defect. They found the highest correlation between CADIA and absolute bone fill when placing the ROI in the middle of the defect and consistently demonstrated that there was very little change identified in the base of the defect. The present study measured the ROI in the middle of the defect.

In the present study, change of alveolar bone density could be calculated by incorporationg a radiographic reference in the original radiographic image. Commonly, aluminium stepwedge and copper stepwedge could be used as radiographic reference[27, 28]. Recently, copper stepwedge has been used as radiographic reference because it is thinner than aluminium for dental application[29].

In the present study, patients showed interproximal bony lesions in their premolar and molar area. All the sites were treated by subgingival scaling and root planing under local anesthesia and their clinical and radiological parameters measured. The present study confirmed the clinical and radiologic response to subgingival scaling and root planing in patients properly motivated. A significant changes in clinical parameters measured were observed at 8 weeks after initial periodontal therapy. Theses changes obtained in the premolar and molar areas are similar to those observed by Badersten et al.[19, 30, 31] in their studies concerning the incisor and canine region.

The present study found that alveolar bone density showed a tendency to decrease at 2 weeks after initial periodontal therapy but to increase gradually after 4 weeks. Significant increase was observed after 6 weeks. Brägger[8] reported that alveolar bone density within furcation was increased over 1 month after scaling and root planing, which was kept over 12 months using CADIA. Okano[32] reported that significant bone density increase was observed over 1 month after initial periodontal therapy using digital subtraction, and Wilderman[33] reported that osteoblastic activity reached its peak 1 month after osseous surgery. While Fourmousis[34] proposed that scaling and root planing combined with tetracycline fiber therapy result in increased bone density and alveolar bone height over 6 months using CADIA. Lee et al[35]. reported that tooth mobility was gradually decreased from 4 weeks after modified Widman flap. Kerry et al[36]. reported that a significant decrease of tooth mobility was observed 1 month following initial periodontal therapy. But, they didn't measure the change of alveolar bone density. As above passage, we confirmed that enhancement of tooth stability resulted from reduction of inflammation and increase of alveolar bone density.

Eickholz et al[37, 38]. suggested that the ability to standardize radiographs may be more obtainable in the mandibular arch than the maxilla, but the present study showed no difference of alveolar bone density between maxilla and mandible.

In conclusion, with the passage of time, alveolar bone density could be increased by initial periodontal therapy.

V. Conclusion

The purpose of present study was to assess the changes of alveolar bone density after initial periodontal therapy using digital imaging with copper stepwedge. Clinically, the 40 interproximal sites in a premolar and molar area were confirmed by the presence of a pocket depth of at least 5mm with intrabony defect. Clinical parameters (plaque index, gingival index, probing depth, gingival recession, clinical attachment level) were measured baseline and 8 weeks after initial periodontal therapy. Standardized radiographs of the 40 sites were taken baseline, 2 weeks, 4 weeks, 6 weeks and 8 weeks after initial periodontal therapy using Rinn XCP device and copper stepwedge. The image analysis was operated by NIH image program(U.S.A.). The following results were obtained.

1. Alveolar bone densities showed a tendency to decrease at 2 weeks after treatment but to increase gradually from 4 weeks after initial periodontal therapy.
2. Alveolar bone densities were significantly increased from 6 weeks after initial periodontal therapy($P<0.01$).
3. Alveolar bone density between maxilla and mandible was not significantly different ($P>0.05$).

This results showed that alveolar bone density could be increased by initial periodontal therapy.

VI. REFERENCES

1. Mick, R.K.. "A clinical evaluation of hand and ultrasonic instruments on subgingival debridement. part I." *Int J Perio Res Dent 12*:311-323, 1992
2. Lavanchy, D.L., Bickel, M., Baehni, P.C.. "The effect of plaque control after scaling and root planing on the subgingival microflora in human periodontitis." *J Clin Periodontol 14*:295-299, 1987
3. Edhar, F., Richard, L., Walter, J., "Effect of periodontal therapy on alveolar bone as measured by subtraction radiography." *J Periodontol 59*:633-638, 1987
4. Lang, N.P., Hill, R.W.. "Radiographs in periodontics." *J Clin Periodontol 4*:16-28, 1977
5. Bender, I.B.. "Factors influencing the radiographic appearance of bony lesions." *J Endodontics 8*:161-170, 1982
6. Pitts, N.B.. "Film holding, beam aiming and collimating devices as an aid to standardization intraoral radiography." *J Dentistry 12*:36-46, 1984
7. Lavstedt, S.. "Quantitative evaluation of periodontal diseases by physical measurement techniques." *J Dent Res 58*:547-551, 1979
8. Brägger, D., Pasquali, L., Rylander, H., Carnes, D., Kornman, K.S.. "Computer-assisted densitometric image analysis in periodontal radiography." *J Clin Periodontol 15*:29-39, 1988
9. Brägger, U.. "Digital imaging in periodontal radiography." *J Clin Periodontol 15*:551-557, 1988
10. Christagu, M., Wenzel, A., Hiller, K.A., Schmalz, G.. "Quantitative digital subtraction radiography for assessment of bone density changes following periodontal guided tissue regeneration." *Dentomaxillofac Radiol 25*:25-33, 1996

11. Gröndahl, H.G., Gröndahl, K., Webber, R.L.. "A digital subtraction technique for dental radiography." *Oral Surg 55*:96-102, 1988
12. Gröndahl, K., Gröndahl, H.G., Webber, R.L.. "Influence of variations in projection geometry on the detectability of periodontal bone loss." *J Clin Periodontol 11*:411-420, 1984
13. Hildebolt, C.F., Vanier, M.W., Gravier, M.J., Shrout, M.K., Knapp, R.H., Walkup, R.K.. "Technical report digital dental image processing of alveolar bone." *Dentomaxillofac Radiol 21*:162-169, 1992
14. Hildebolt, C.F., Vanier, M.W., Pilgram, T.K., Shrout, M.K.. "Quantitative evaluation of digital dental radiograph imaging systems." *Oral Surg Oral Med Oral Pathol 70*:661-668, 1990
15. Nummikoski, P.V., Martinez, T.S., Matteson, S.R., McDavid, W.D., Dove, S.B.. "Digital subtraction radiography in artificial recurrent caries detection." *Dentomaxillofac Radiol 21*:59-64, 1992
16. Ohki, M., Okano, T., Yamada, N.. "A contrast-correction method for digital subtraction radiography." *J Periodont Res 23*:277-280, 1988
17. Payot, P., Haroutunian, B., Pochon, Y., Herr, P., Bickel, P., Cimasoni, G.. "Densitometric analysis of lower molar interradicular areas in superposable radiographs." *J Clin Periodontol 14*:1-7, 1987
18. Eickholz, P., Hausmann, E.. "Evidence for healing of interproximal intrabony defects after conventional and regenerative therapy: digital radiography and clinical measurements." *J Periodont Res 33*:156-165, 1998
19. Badersten, A., Nilveus, R., Egelberg, J.. "Effect of nonsurgical periodontal therapy." *J Clin Periodontol 8*:57-72, 1981
20. Hill, R.W., Ramfjord, S.P., Morrison, E.C.. "Four types of periodontal treatment compared over two years." *J Periodontol 52*:655-662, 1981
21. Lindhe, J., Westfelt, E., Nyman, S., Socransky, S.S., Haffajee, A.D.. "Long-term effect of surgical/non-surgical treatment of periodontal disease." *J Clin Periodontol 11*:448-458,1984
22. Pihlstrom, B.L., McHugh, R.B., Oliphant, T.H., Ortiz-Campos, C.. "Comparison of surgical and non-surgical treatment of periodontal disease." *J Clin Periodontol 10*:524-541, 1983
23. Garrett, S.. "Peiodontal regeneration around natural teeth." *Ann Periodontol 53*:8-14, 1982
24. Benn, D.. "A computer-assisted method for making linear radiographic measurements using stored regions of interest." *J Clin Periodontol 19*:441-448, 1992
25. Guilemin, M., Mellonig, J., Brunsvold, M., Steffensen, B.. "Healing in periodontal defects treated by decalcified freeze-dried bone allografts in combination with e-PTFE membranes." *J Clin Periodontol 20*:520-527, 1993
26. Masters, L., Mellonig, J., Brunsvold, M., Nummikoski, P.. "A clinical evaluation of demineralized freeze-dried bone allograft in combination with tetracycline in the treatment of periodontal osseous defect." *J Periodotol 67*:770-781, 1996
27. Duckworth, J.E., Judy, J.M., Socransky, S.S.. "A method for the geometric and densitometric standardization of intraoral radiographs." *J Periodontol 54*:435-440, 1983
28. Hodge, H.C., Van Huysen, G., Warren, S.L.. "Factors influencing the quantitative measurement of the roentgen-ray absorption of tooth slabs." *Am J Roentgenol 34*:817-823, 1935
29. 김재덕. "구리당량 영상작성에 의한 골밀도계측 방법의 평가" 대한구강악안면방사선학회지 *30*:101-108, 2000
30. Badersten, A., Nilveus, R., Egelberg, J. "Effect on nonsurgical periodontal therapy." *J Clin Periodontol 11*:114-124, 1984

31. Badersten, A., Nilveus, R., Egelberg, J.. "Reproducibility of probing attachment level measurements." *J Clin Periodontol 11*:475-485, 1984
32. Okano, T., Mera, T., Ohki, M., Ishikawa, I., Yamada, N. "Digital subtraction of radiograph in evaluating alveolar bone changes after initial periodontal therapy." *Oral Surg Oral Med Oral Pathol 69*:258-262, 1990
33. Wilderman, M.N., Pennel, B.M., King, K., Barron, J.M. "Histogenesis of repair following osseous surgery" *J Periodontol 41*:551-565, 1970
34. Fourmousis, I., Tonetti, M.S., Mombelli, A., Lehmann, B., Lang, N.P., Brägger, U.. "Evaluation of tetracycline fiber therapy with digital image analysis." *J Clin Periodontol 25*:737-745, 1998
35. 이규호 · 한경윤. "외과적 치주치료에 따른 치은열구액의 삼출량과 치아동요도의 변화에 관한 연구" 대한치주과학회지 *21*:345-354, 1991
36. Kerry, G.J., Morrison, E.C., Ramfjord, S.P., Hill, R.W., Caffesse, R.G., Nissle, R.R., Appleberry, E.A.. "Effect of periodontal treatment on tooth mobility" *J Periodontol 53*:635-638, 1982
37. Eickholz, P., Hausmann, E.. "Evidence for healing of Class II and III furcation after GTR therapy." *J Periodontol 68*:636-644, 1997
38. Graf, J.M., Mounir, A., Payot, P., Cimasoni, G.. "A simple paralleling instrument for superimposing radiographs of the molar regions." *Oral Surg Oral Med Oral Pathol 66*:502-506, 1988

-국문초록-

디지털영상을 이용한 초기 치주처치후 치조골 밀도변화의 정량적 평가

안경현 · 김재덕 · 김병옥

조선대학교 치과대학 치주과학교실

치주질환이 진행되는 동안이나 치주처치후 치유되는 과정에서 치조골의 변화가 야기되는데 방사선 사진은 치조골 변화를 감지하는 유일한 비외과적인 방법이다. 미묘한 치조골 변화의 진단은 치료시나 유지관리기 환자의 평가시 중요한 바, 최근에는 규격화시킨 디지털 영상을 이용하여 정량적인 골변화 측정이 가능하게 되었다.

본 연구의 목적은 중등도의 치주질환을 지닌 환자에서 국소마취하에 초기 치주처치를 시행한후 참조체와 함께 구내 방사선 사진을 촬영하고 디지털화 한 다음 참조체 당량치를 이용하여 치조골의 밀도변화를 평가하기 위한 것이다.

이 연구를 위하여 치주질환에 이환된 환자 5명(남자 3명, 여자 2명 : 평균 47.4세)에서 탐침깊이가 5mm 이상이고 골내낭이 있는 제 1 · 2 소구치, 제 1 · 2 대구치 40개(상악 24개, 하악 16개)를 대상으로 구강위생교육과 치석제거술, 치근면활택술을 시행하였다. 임상지수는 술전과 술후 8주째에 측정하였고, 방사선 사진은 술전, 술후 2주, 4주, 6주, 8주째에 촬영하였고, 구리 스텝웨지를 사용하여 규격화 하였다. 촬영된 영상은 NIH image program(U.S.A.)에 의해 분석되어졌고 이들 자료를 통해 다음과 같은 결과를 얻었다.

1. 치조골의 밀도는 초기치료후 2주째 까지는 감소된 양상을 보이다가 4주 이후로는 점차적으로 증가하는 양상을 보였다.
2. 치조골의 밀도는 초기치료전과 비교시 초기치료후 6주째와 8주째에서 유의한 차이를 보였다.($P < 0.01$)
3. 상하악 간의 치조골 밀도는 유의한 차이를 보이지 않았다($P > 0.05$).

이상과 같은 결과를 통하여 볼때 초기 치주처치만으로도 치조골의 밀도가 증가됨을 확인할 수 있었다.