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GEOMETRIC CORRECTION OF RADIOGRAPHIC IMAGES USING GENERAL PURPOSE IMAGE PROCESSING PROGRAM

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CONTENT

I. INTRODUCTION
II. MATERIALS AND METHODS
III. RESULTS
IV. DISCUSSION
V. SUMMARY AND CONCLUSION
REFERENCES

I. INTRODUCTION

Digital Radiography(DR) is a technique in which analog signal such as radiation is converted to digital signal by analog/digital converter and digital image can be processed and reconstructed by computer. Its system has 4 major components; image detection, digitization, image processing and image display[1-3]. There are 4 types of DR, according to a radiation detector; Film-based digital imaging system, digital subtraction angiography(DSA), direct digital imaging system such as Radiovisiography(RVG), computed radiography(CR)[1]. Film-based digital imaging system utilizes a conventional film as a radiation detector[1,3-9]. DSA uses image intensifier as a radiation detector[1,2], RVG optic fiber and CCD sensor[10-12], CR imaging plate with phosphor[1].

At the film-based digital imaging system, conventional films are taken as a radiation detector. Film images are digitized by high resolution CCD camera with A/D converter or film scanner. And then images can be processed in many ways, for example, subtraction, contrast enhancement, reconstruction and so on[4,13,14]. Many papers regarding digital subtraction radiography, which is considered to be the best tool for diagnosing slow or small changes, were reported. Grondahl et al.[15] suggested digital subtraction technique for dental radiography for the first time. Ruttimann and Webber[16] mentioned volumetry of localized bone lesions by subtraction radiography. Two important aspects of subtracted radiography are contrast and geometric correction before subtraction of image pairs. For the contrast correction, Ruttimann et al.[17] reported a robust digital method and Ohki et al.[18] suggested another contrast-correction method. For the method of superimposition, Wenzel[19] compared the effect of manual method with reference point method on image quality in digital

subtraction radiography". Benn[20] also mentioned limitations of the digital image subtraction technique due to misalignment errors during image capture. Rudolph and White[21] reported about film holding instruments for intraoral subtraction radiography. They concluded that regisil registration material on Rinn XCP instrument was the most accurate one. Dunn et al.[22] compared two registration techniques for digital subtraction radiography and reported that mathmatical algorithm can be used to establish correspondence between pairs of clinical images taken at different projection angles and to produce reconstructed images comparable with images taken with occlusal stents.

However, it is not easy for dentists to develop their own new program. This study was performed in order to compare geometrically corrected, non-standardized image by general-purpose image processing program with standardized image by individualized custom fabricated alignment instrument for digital subtraction radiography.

Ⅱ. MATERIALS AND METHODS

Materials

Digital imaging system was composed of Macintosh II ci computer(Apple Computer,Inc., U.S.A.) with high resolution Sony XC 77 CCD camera (Sony Co, Japan) and QuickCapture frame grabber board (Data Translation Inc, U.S.A.). This frame grabber board showed spatial resolution of 640x480 pixels and 256 level gray scale (0-black, 255-white). "NIH Image" and "Adobe Photoshop" program was used for image capture and processing. For the contrast correction, a robust digital method suggested by Ruttimann et al.[17] was utilized on IBM compatible PC. For the conversion IBM data to Macintosh data "Apple file exchange" and "Photoshop" program were used.

Periapical films were taken at the lower right molar portion of 19 volunteers. Oramatic x-ray generator(Trophy, France), Dental Pony automatic processor(Fuji Medical., Japan), XCP film holder and customized XCP film holder with Optosil impression material on the bite-block were utilized.

Methods

Periapical films were taken at the right lower molar portion of each volunteers.First, two non-standardized periapical films were taken with XCP film holder only(Fig 1). And then two standardized periapical film were taken with customized XCP film holder with Optosil impression material on the bite-block(Fig 2). All image pairs were digitized via CCD camera and contrast-corrected with robust film contrast correction method suggested by Ruttimann et al. And then digital subtraction was performed using "NIH Image" program. We classified those three groups: freehand(F) group, corrected(C) group and standardized(S) group. Freehand group was subtracted image group between non-standardized image pairs.

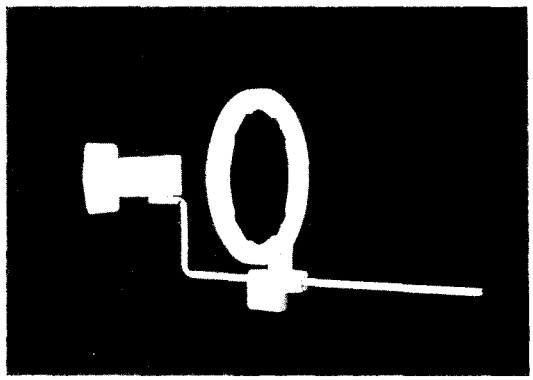

Figure 1. XCP film holder

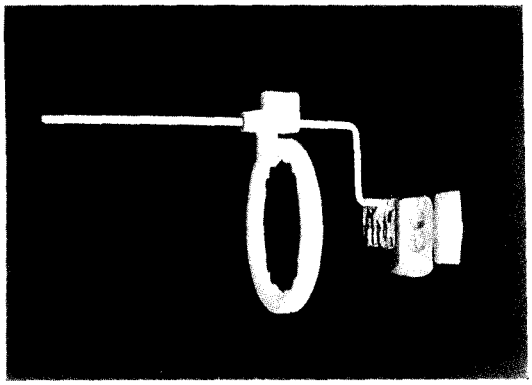

Figure 2. customized XCP film holder with Optosil impression material on the bite-block

Corrected group was subtracted image group between geometrically corrected image pairs, using "Adobe Photoshop" and "NIH Image" program. Specially, geometric correction was performed with arbitrary rotation function of "Adobe Photoshop" and translation with transparency function of "NIH Image". Standardized group was subtracted image group between standardized image pairs. To compare image similarity of each image pair, standard deviations of grey values of subtracted images in each group were used. Multiple comparison paired t-test was used for statistical analysis.

Ⅲ. RESULTS

Standard deviations of grey values of subtracted images in each group were as follows (Table1, Fig 3). Average standard deviation of grey values of subtracted images in freehand (F) group was 5.99, that in corrected(C) group was 4.24 and that in standardized(S) group was 4.10. There was a significant difference between F and C group($p<0.05$). Difference between F and S group was also statistically significant($p<0.05$). But, difference between C and S group was statistically insignificant ($p>0.05$)(Table 2). Fig 4 shows two image pairs and subtracted image in F group. Subtracted image in Fig 4 shows incomplete cancellation of image. Fig 5 shows two image pairs and subtracted image in C group. Subtracted image shows better cancellation of image than in F

Table I. Standard deviations of grey values of subtracted images of each group

	freehand group	corrected group	standardized group
1	5.1	4.78	4.75
2	8.24	5.91	5.59
3	4.07	3.91	3.86
4	4.08	4.08	3.82
5	5.12	4.16	3.49
6	5.45	3.63	5.17
7	4.52	4.52	4.14
8	6.75	6.25	7.35
9	6.19	4.92	4.75
10	2.42	2.42	3.22
11	4.57	3.35	6.14
12	6.78	6.41	4.92
13	3.76	3.01	3.26
14	4.93	3.78	2.62
15	3.1	3.1	2.54
16	15.6	4.31	2.72
17	12	5.23	4.06
18	4.92	3.26	3.42
19	6.24	3.47	2.04
mean	5.99	4.24	4.1

Table II. Results of multiple comparison paired t-test for the F,C and S groups

	paired t- value	significance
F group vs C group	2.739	P<0.05
F group vs S group	2.442	P<0.05
C group vs S group	0.544	P>0.05

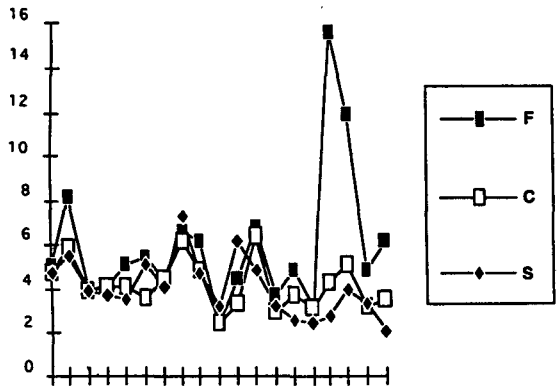

Figure 3. Graph of standard deviation of grey value of subtracted images in each group

group. Fig 6 shows two image pairs and subtracted image in S group. Subtracted image shows slightly better cancellation of image than in C group.

Ⅳ. DISCUSSION

Direct visual inspection of dental radiographs has several limitations, although it is an indispensable aid in the practice of dentistry. Generally, only gross bone changes can be identified. Digital subtraction radiography may be able to overcome some of these limitations. Digital subtraction radiography allows direct comparison of two images and detection of slow or small changes.[21,22] So it was reported that its application in dentistry is various.[12,16,23-27] To make digital subtraction radiography effective, two important aspects of subtracted radiography are contrast and geometric correction before subtraction of image pairs.

Digital subtraction radiography requires close matching of the contrast in the films to be subtracted. For the contrast correction, Ruttimann et al.[17] suggested a robust digital method permitting the retrospective correction of film contrast differences. This method is nonparametric and derives the required grey level transformation directly from the histograms associated with the radiographs. They reported that it performs significantly better in reducing the contrast mismatch measured by the standard deviations of the gray levels in the subtraction image. Ohki et al.[18] reported another contrast-correction method, which is a parametric technique. They converted grey levels of one image to be equal to that of the other image using the equation obtained from grey level relations of both images. Robust digital method suggested by Ruttimann et al.[17] was used in this study.

For the method of superimposition, Wenzel[19] reported the effect of manual compared with reference point superimposition on image quality in digital subtraction radiography. They compared a new subtraction program based on positioning of reference point(RP) in the two images with the classic manual(M) superimposition of the images during recording and concluded that the RP method is superior to the M method in clinical trials using subtraction radiography. Benn[20] mentioned limitations of the digital image subtraction technique due to misalignment errors during image capture. Rudolph and White[21] reported about film holding instruments for intraoral subtraction radiography. They concluded that regisil registration material on Rinn XCP instrument was the most useful one for digital subtraction in a clinical setting. Dunn SM et al.[22] compared two registration techniques for digital subtraction radiography. A new technique for registering digital images of radiographs based on the correspondence of 3D anatomical structures

was compared with a registration method using occlusal stents. They reported that mathmatical algorithm can be used to establish correspondence between the pairs of clinical images taken at different projection angles and to produce reconstructed images comparable with images taken with occlusal stents. However a limitation of this algorithm was that there will always be a single line passing through the image that cannot be registered. So, they introduced a new algorithm which is based upon an analytical projective geometry and reported that this algorithm successfully registers the entire images.[28] In this study, Rinn XCP film holder with silicon impression material suggested by Rudolph and White was utilized instead of occlusal stent. And general purpose image processing program was used for geometric correction. Because it is not easy for dentist to develop his own new program, so author performed this study using general-purpose image processing program. Although geometric corrected images by using general-purpose image processing program did not show better result than standardized images, they showed statistically insignificant differences. Dunn et al.[22] utilized mathmatical algorithm for three dimensional geometric correction, but author made use of algorithm for two dimensional geometric correction, i.e. arbitrary rotation and translation. Although geometric corrected images showed statistically insignificant differences with the standardized images, further studies to develop an algorithm to get the better results would be needed.

V. SUMMARY AND CONCLUSION

The present study was undertaken to compare geometric corrected image by general -purpose image processing program for the Apple Macintosh II computer(NIH Image, Adobe Photoshop) with standardized image by individualized custom fabricated alignment instrument.

Two non-standardized periapical films with XCP film holder only were taken at the lower molar portion of 19 volunteers. Two standardized periapical films with customized XCP film holder with impression material on the bite-block were taken for each person. Geometric correction was performed with Adobe Photoshop and NIH Image program. Specially, arbitrary image rotation function of "Adobe Photoshop" and subtraction with transparency function of "NIH Image" were utilized. The standard deviations of grey values of subtracted images were used to measure image similarity. Average standard deviation of grey values of subtracted images of standardized group was slightly lower than that of corrected group. However, the difference was found to be statistically insignificant($p>0.05$). It is considered that we can use "NIH Image" and "Adobe Photoshop" program for correction of nonstandardized film taken with XCP film holder at lower molar portion .

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-국문초록-

일반 영상처리 프로그램을 이용한 방사선사진의 기하학적 보정에 관한 연구

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본 연구는 비규격화시켜 촬영한 두장의 방사선 사진을 일반 영상처리 프로그램으로 기하학적 보정을 하여 디지탈 공제 촬영술을 시행한 결과를 개인별로 제작된 필름유지장치를 이용하여 규격화 시켜 촬영한 두장의 방사선사진을 디지탈 공제 촬영술을 시행한 결과와 비교하여 일반 영상처리 프로그램의 임상적 유용성을 평가해보고자 시행하였다.

19명의 자원자를 대상으로 하여, 각 환자에서 4매의 하악구치부 치근단 사진을 촬영하였다. 그중 2매는 XCP 필름 유지장치만으로 평행촬영법으로 촬영하였고, 나머지 2매는 교합제에 인상재를 부가하여 개인별로 제작된 XCP 필름 유지장치를 이용하여 표준화시켜 역시 평행촬영법으로 촬영하였다. 기하학적 보정은 "Adobe Photoshop"과 "NIH Image" 프로그램으로 시행하였다. 특히 "Adobe Photoshop"의 임의영상회전 기능과 "NIH Image"의 공제시술시 중첩된 사진을 투명하게 보여주는 기능, 병진기능을 활용하였다. 두 사진의 유사성을 측정하기 위해 공제된 사진의 계조도의 표준편차를 구하였다. 표준화군의 평균 표준편차가 기하학적 보정군의 평균 표준편차보다 약간 낮았으나, 통계적으로 유의성이 있는 차이를 보이지는 않았다. 위의 결과로 미루어보아, 하악구치부 에서 XCP 필름 유지장치로 평행촬영한 비표준화방사선사진을 "Adobe Photoshop"과 "NIH Image" 프로그램을 이용하여 기하학적 보정을 할수 있으리라 사료된다.

논문사진부도

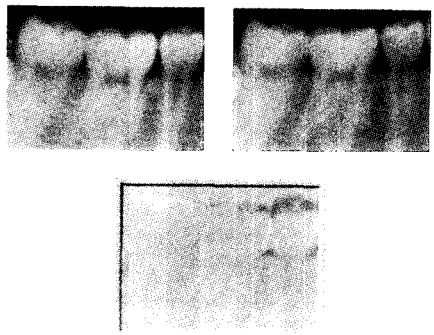

Figure 4. Image pairs(top left and right) and subtracted image(bottom) in Freehand group

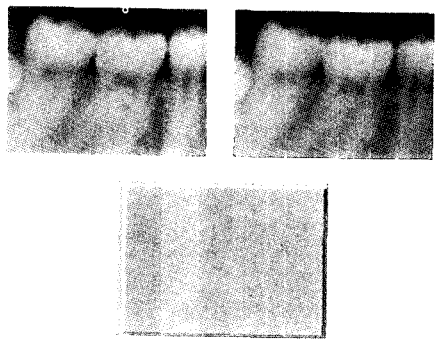

Figure 5. Image pairs(top left and right) and subtracted image(bottom) in Corrected group

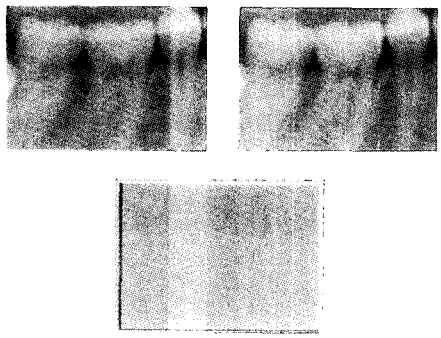

Figure 6. Image pairs(top left and right) and subtracted image(bottom) in Standardized group