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Comparison of X-ray Image Quality Between Multi-Function Device(MFD) and Weight Bearing Platforms(WBPs)

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ABSTRACT

The purpose of this study is to manufacture a multi-function device (MFD) which can be applied to various types of weight-bearing view of the lower leg, and to compare the results with the images from the existing weight-bearing platforms (WBPs), thereby suggesting a clinical utilization. The MFD was manufactured, by considering the minimum adjustable heights of the platform for weight-bearing foot/ankle, platform for hindfoot alignment view, and X-ray tube of the X-ray device. A foot/ankle phantom was used to take the images of weight-bearing lateral foot in MFD and WBPs to compare the resolutions of the X-ray images using a quick modulation transfer function (MTF) program. Between both the images taken from the MFD and WBPs, there was no statistically significant difference found in the mean cycles per pixel (C/P) and the lines per image height (LPH) of the 50%-Contrast Spatial Frequency (MTF50), and 10-90% of Maximum Energy Rise Distance (10-90%), where $p>0.05$. The MFD is suggested for its clinical trial as a useful positioning device that can secure the patient’s safety and manifoldly perform various inspections. Also, the recommendation of the positioning device as a policy can activate dedicated manufacturers, while also improving the quality of medical services.

Keywords: Hindfoot Alignment View, Multi-Function Device, Positioning Device, MTF, Weight Bearing Platform

I. INTRODUCTION

In an X-ray examination, the use of positioning device is the key to the success of the inspection, and can enhance the satisfaction of patients.

In the 1993 session of the International Society of Radiographers and Radiological Technologists (ISRRT), 7 roles of radiographers and radiological technologists were defined, and every member was recommended to begin practicing them. Among the roles, the patient positioning includes the utilization of positioning device for the patient to hold onto, the manufacture of a block that can prevent radiation exposure, and the manufacture of wedge and compensator for a uniform irradiation of the X-ray. Especially, the utilization of positioning device is being stressed for the patient to take the right pose.[1]

The positioning devices used in the X-ray examination are either purchased from a professional and dedicated manufacturers or self-developed. The type of positioning device varies, including caliper, sand bag, cassette hold, block for fixating head, arm and leg,[2] merchant view device for inspecting patella,[3-5] KT-2000 knee ligament arthrometer for inspecting knee or ankle joint, and some others manufactured for specific inspections like the Telos stress device.[6-8]

The positioning device used in the X-ray examination

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is majorly focused on a function to fixate the patient, in order to increase the efficiency of the inspection.[1] These position devices are made to aim only on the success of the examination by constraining the patient, and thus can bring about discomfort to the patient. Since the weight-bearing knee and foot view has limited range of adjustable height of the X-ray tube, the patient must step onto a step platform or an X-ray table to proceed with the inspection.[9-11] In this case, depending on the patient's condition, the absence of a supporting body for supporting the patient or fixating the patient's pose can deter the inspection. Also, the risk of falling arises. In an actual weight-bearing view, a radiological technologist has to literally help the patient up, if the patient cannot take the necessary pose by himself/herself. This requires 2 personnel for the examination, one for back up and one for radiographing. The radiological technologist who helps the patient is also involved in a radiation exposure as well.

Considering these circumstances, the value of the positioning device should be much higher. However, the step platform or the X-ray table are stripped of such traits.

While the positioning devices developed by Son SH & Kim SK (2010),[3] Seoung YH (2013),[5] Steven E. Rovvins and Adel M. Hanna (1987),[12] Moon IB et al. (2006)[13] provide improved safety and convenience for patients, they were based on only a single type of inspection or disease. The purpose of this study is to develop a multi-function device (MFD) which can be applied to various types of weight-bearing view of the lower leg, and to compare the results with the X-ray images taken from the weight-bearing platforms (WBPs), in order to suggest a clinical utilization of the same.

II. MATERIAL AND METHODS

1. Design and Manufacture of MFD

The design of MFD is shown in figure 1. The MFD's design and manufacture considered the platform for Weight Bearing foot/ankle,[10-12,14,15] platform for Hindfoot Alignment View[13,16-18], and the minimum adjustable height of the X-ray tube in X-ray device (SHIMADZU Model: UD150L-30E).[9]

The MFD was designed into a staircase shape attached with a supporting pole, so that a patient can easily step on to maintain a comfortable posture. The height of the upper end was 55cm as the minimum adjustable height of the X-ray tube, while the supporting pole was 175cm high. Amidst the supporting pole was installed 2 middle poles, so that patients with different heights could easily hold onto. Also, an image plate slot and an image plate slot support were installed to set the image plate (or detector). The image plate slot had the width of 3cm, and length of 40cm in order to set the image plate, of which size was 43cm X 35 cm, vertically. The image plate support is capable of setting the image plate vertically, as can be applied to the Weight Bearing foot/ankle, or tilted 20°, as can be applied to the hindfoot alignment view.

The MFD was made of steel. Only the part which meets the soles of the patient can occlude the inspection area, this part was made of reinforced acrylic material, a highly durable but capable of transmitting the X-ray.

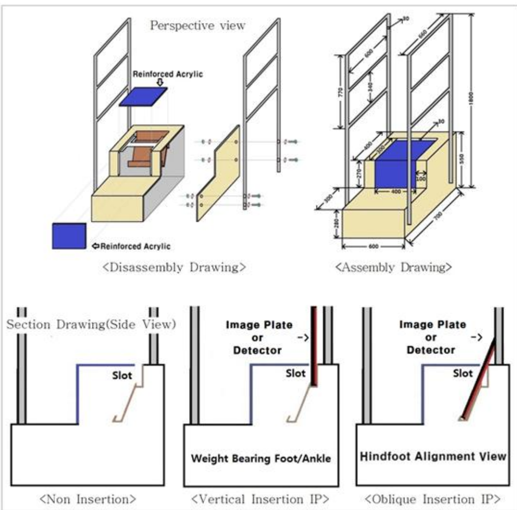

Fig. 1. Design of MFD.

2. Comparison of X-ray image quality between MFD and WBPs

The X-ray images of MFD and WBPs are shown in figure 2. The comparison of X-ray Image Quality between steel MFD and wooden WBPs was conducted by comparing the X-ray image qualities of weight-bearing lateral foot view and hindfoot alignment view, using the foot/ankle phantom (Model: RS-116T, Radiology Support Devices Inc.). The parameters for X-ray irradiation were 60kVp, 100mA, 0.1sec, and the distance from the phantom as 110cm. The resolutions of the respective X-ray image were compared, by setting 10 identical regions of interest (ROI) on the sole of the foot, using the Quick MTF (ver 2.10, Avanagate Inc.). The comparison of resolutions involved the mean C/P(Cycles Per Pixel) and mean LPH(Lines Per Image Height) of the 10 ROI of the two images, using Mann-Whitney U test. SAS Enterprise Guide software (ver 5.1; SAS Institute, Cary, NC, USA) was used to carry out the analysis.

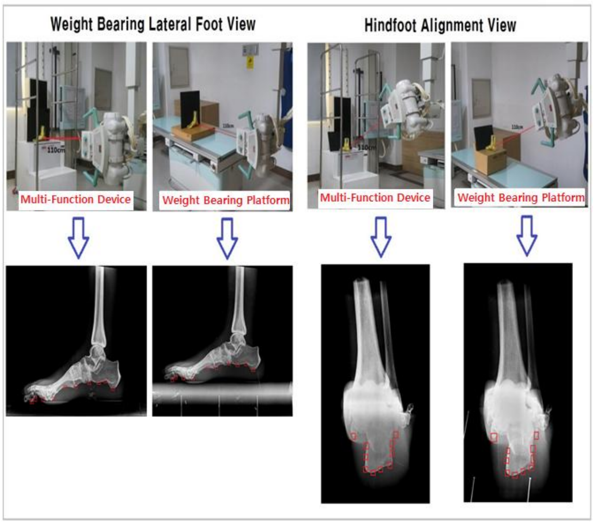

Fig. 2. X-ray images of MFD and WBPs.

III. RESULT

1. Comparison of resolutions of weight-bearing lateral foot images

The comparison of resolutions of weight-bearing lateral foot images are shown in table 1 & figure 3. The C/P of 50%-Contrast Spatial Frequency (MTF50) was 0.131±0.030 in MFD, while the figure in the platform for weight-bearing foot/ankle was 0.127±0.047, showing similar results (p=0.621). The LPH was 537.59±120.51 in MFD, while the figure in the platform for weight-bearing foot/ankle was 522.23±184.82, with no difference (p=0.623).

The C/P of 10-90% rise was 5.864±3.794 in MFD, and the figure in the platform for weight-bearing foot/ankle was 5.885±3.772, showing similar results (p=0.910). The LPH was 522.62±335.72 in MFD, while the figure in the platform for weight-bearing foot/ankle was 525.80±382.05, representing no difference as well (p=0.940).

Table 1. Comparison of resolutions of the weight-bearing lateral foot image.

Classification		Device		z	p*
		MFD (Mean±SD)	WBP (Mean±SD)		
MTF50§	C/P†	0.131±0.03	0.127±0.05	-0.495	0.621
	LPH‡	537.59±120.51	522.23±184.82	-0.492	0.623
10-90% Rise‖	C/P	5.864±3.79	5.885±3.77	-0.113	0.910
	LPH	522.62±335.72	525.80±382.05	-0.076	0.940

* p<0.05
† Cycles Per Pixel, ‡ Lines Per Image Height
§ 50% Contrast spatial frequency
‖ 10-90% of maximum energy rise distance

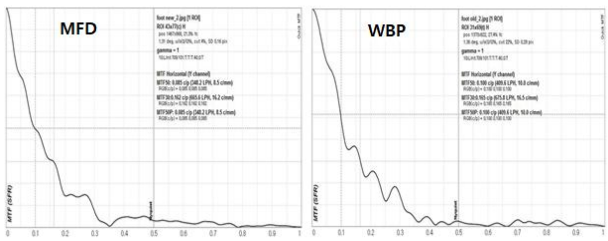

Fig. 3. MTF graph of 10th ROI of the weight-bearing lateral foot image.

2. Comparison of resolutions of hindfoot alignment view images

The comparison of resolutions of hindfoot alignment view images are shown in table 2 & figure 4. The C/P of MTF50 was 0.105±0.062 in MFD, and 0.104±0.054 in the platform for hindfoot alignment view, which are similar (p=0.849). The LPH was 323.41±200.77 in MFD, and 311.21±161.3 in the platform for hindfoot alignment view, showing no difference as well (p=0.791).

The C/P of 10-90% Rise was 7.060±5.573 in MFD, and 6.173±5.067 in the platform for hindfoot alignment view, showing similarity (p=0.910). The LPH was 350.26±244.40 in MFD, and 395.58±250.31 in the platform for hindfoot alignment view, showing no difference (p=0.677).

Table 2. Comparison of resolutions of the hindfoot alignment view image.

Classification		Device		z	p*
		MFD (Mean±SD)	WBP (Mean±SD)		
MTF50§	C/P†	0.105±0.06	0.104±0.05	-0.191	0.849
	LPH‡	323.41±200.77	311.21±161.30	-0.265	0.791
10-90% Rise‖	C/P	7.060±5.57	6.173±5.07	-0.378	0.705
	LPH	350.26±244.40	395.58±250.31	-0.416	0.677

* $p<0.05$
† Cycles Per Pixel, ‡ Lines Per Image Height
§ 50% Contrast spatial frequency
‖ 10-90% of maximum energy rise distance

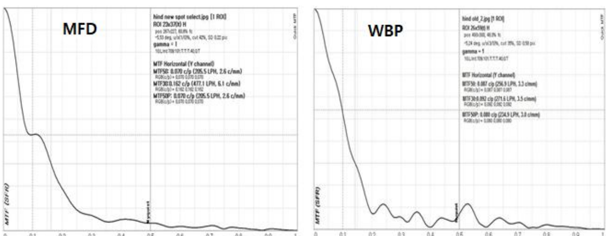

Fig. 4. MTF graph of 10th ROI of the hindfoot alignment view image.

IV. DISCUSSION

There are some poses that a common person has difficulties in taking. Children, seniors and those with handicaps have more difficulties in obtaining the images. Therefore, the utilization of appropriate positioning devices is an essential part of patient care. [1]

The MFD manufactured in this study not only considered these factors, but also reconsidered the existing WBPs and the range of adjustable height in X-ray tube, to integrate various types of positioning devices into a single one. As a result of the X-ray image comparison, since the X-ray image taken from wooden WBPs show no difference in its resolution, a clinical use is available. This can further stress the advantage of using the MFD. In other words, unlike the WBPs, which are applied to only a single type of examination or ailment, the MFD can be applied to multiple inspection cases, thereby increasing the efficiency of space. Moreover, the installation of step platform and supporting pole can guarantee the safety of patient.

The height of the step platform in the MFD manufactured in this study can be adjusted, depending on the height of the ceiling frame of the X-ray device camera. If the X-ray tube and detector (or wall-stand bucky) are installed to move lower enough to the floor of the room, at least the weight-bearing knee view is available without the help of step platform.[10,11,19,20]

However, since the normal installation case of an X-ray device makes the camera be adjusted to the predetermined ceiling height, it is normally impossible to perform even the weight-bearing knee without the step platform, if the ceiling of the room is high. Also, the weight-bearing foot/ankle view should be implemented with the help of a step platform, even if the ceiling frame of the X-ray device is lowered to the minimum. This is due to the inherent size of the X-ray tube, which disables the irradiation of X-ray onto the center of the foot and ankle, even if the X-ray tube is lowered to the floor height.

To carry out the weight-bearing view of the lower leg more stably and efficiently, the ceiling frame should be ordered to be installed as low as possible, during the initial installation of the X-ray device. In case of an X-ray device already installed, the manufacture of MFD is more favorable, due to the costs for re-installation.

Consequentially, the MFD manufactured in this study is a useful positioning device, which can perform multiple functions for various types of inspection, and guarantee the safety of patient. Therefore, the MFD is sufficiently functional to be suggested as a means of clinical use.

The limitation of the study lies within the method for evaluating the performance (resolution) of the device by using Quick MTF, since it is not a method for directly assessing the positioning device itself. However, Quick MTF was adopted, since the program can be of use to compare the image qualities between different positioning devices.

V. CONCLUSION

In an X-ray examination, a positioning device is an important factor which can increase the efficiency of the radiographing process, and many medical facilities (hospitals and clinics) use self-developed models to reduce costs. Since these self-developed or prefabricated positioning devices lack expert verifications, the efficiency is low, and the patient’s safety cannot be guaranteed as well. Also, since these models are prefabricated only for temporary use, their increasing quantity only takes up space.

Therefore, the manufacture of a self-developed positioning device should consider both efficiency and safety, while using the products made by professional manufacturers is one of the alternatives. However, there are not many dedicated manufacturers, due to limited demand in Korea. By recommending the use of professionally manufactured positioning devices through policies, such manufacturers will be activated, and the quality of medical service will also improve further.

Reference

[1] H. T. Kim, D. G. Kwon, M. Y. Jeong, S. H. Ahn. "A Study on the Usability Evaluation and Manufacture of Diagnostic X-ray Equipment Fixing Device," Shinheung College, Vol. 32, pp. 59-102, 2009.

[2] Research Committee of Korean Medical Imaging Technology, "*Textbook Of Radiographic Positioning And Clinical Diagnosis Volume 1-2*," Daihaks. 2009.

[3] S. H. Son, S. K. Kim. "The Evaluation of Usefulness New Assistant Device to Increase Patient Convenience and Processes Efficiency of Radiographic Procedures for Merchant View," Korean Journal of Digital Imaging in Medicine, Vol. 12, No. 1, pp. 43-50, 2010.

[4] S. Y. Seo, M. S. Han, M. C. Jeon, S. J. Yu, Y. K. Kim, "The Evaluation of Usefulness New Assistant Device to Observe Posterior Cruciate Ligament Rupture and Patellofemoral Joint Injury in Emergency Patient," Journal of Radiological Science and Technology, Vol. 28, No. 3, pp. 241-248, 2010.

[5] H. Y. Seoung, "Usefulness Evaluation of Merchant Auxiliary Equipment of Body Type Changing Suitable for X-ray Table Integral Type," Journal of the Korea Academia-Industrial cooperation Society, Vol. 14, No. 6, pp. 2773-2779, 2013.

[6] O. G. Sørensen, K. Larsen, B. W. Jakobsen, S. Kold, T. B. Hansen, M. Lind et al, "The combination of radiostereometric analysis and the telos stress device results in poor precision for knee laxity measurements after anterior cruciate ligament reconstruction," Knee Surgery, Sports Traumatology, Arthroscopy, Vol. 19, No. 3, pp. 355-362, 2011.

[7] J. C. Lim, D. K. Han, "A Study on the Standardization of the Test Method Upon Testing the Anterior Cruciate Ligament Damage Using TELOS," Journal of the Korean Society Radiology, Vol. 8, No. 2, pp. 57-63, 2014.

[8] J. H. Park, H. S. Kim, K. G. Jung, J. H. Yoo. "The benefit of KT-2000 knee ligament arthrometer in diagnosis of Anterior Cruciate Ligament injury," Journal of the Korean Arthroscopy Society, Vol. 8, No. 2, pp. 82-88, 2004.

[9] https://www.shimadzu.com/

[10] P. W. Ballinger, E. D. Frank, "*Merrill's Atlas of Radiographic Positions and Radiologic Procedures Tenth Edition*," Mosby, 2003.

[11] K. L. Bontrager, J. Lampignano, "*Textbook of Radiographic Positioning and Related Anatomy*," Elsevier Health Sciences, 2013.

[12] S. E. Robbins, A. M. Hanna, "Running-related injury prevention through barefoot adaptations," Medicine and Science in Sports and Exercise, Vol. 19, No. 2, pp. 148-156, 1987.

[13] I. B. Moon, J. S. Jeon, K. C. Yoon, N. K. Choi, S. K. Kim, "Introduction of hind foot coronal alignment view," Journal of the Korean Society of Radiological Technology, Vol. 29, No. 4, pp. 225-228, 2006.

[14] D. R. ADAMS, "The Weight Bearing X-ray in Shoe Fitting Problems," Orthopedic and Prosthetic Appliance Journal, Vol. 12. No. 2, pp. 75-78, 1958.

[15] Y. Tochigi, J. S. Suh, A. Amendola, D. R. Pedersen, C. L. Saltzman, "Ankle alignment on lateral radiographs. Part 1: sensitivity of measures to perturbations of ankle positioning," Foot & ankle international, Vol. 27, No. 2, pp. 82-87, 2006.

[16] K. Ikoma, M. Noguchi, K. Nagasawa, M. Maki, M. Kido, Y. Hara et al, "A new radiographic view of the hindfoot," Journal of foot and ankle research, Vol. 6, No. 48, pp. 1-5, 2013.

[17] W. Y. Han, H. S. Lee, W. K. Kim, J. Y. Ahn, "The New Radiographic Evaluation of Hindfoot Alignment," Journal of Korean Foot and Ankle Society, Vol. 16, No. 3, pp. 169-74, 2013.

[18] M. L. Reilingh, L. Beimers, G. J. Tuijthof, S. A. Stufkens, M. Maas, C. N. Van Dijk, "Measuring hindfoot alignment radiographically: the long axial view is more reliable than the hindfoot alignment view," Skeletal Radiology, Vol. 39. No. 11, pp. 1103-1108, 2010.

[19] J. Duddy, J. R. Kirwan, B. Szebenyi, S. Clarke, R. Granell, S. Volkov, "A comparison of the semiflexed (MTP) view with the standing extended view (SEV) in the radiographic assessment of knee osteoarthritis in a busy routine X-ray department," Rheumatology, Vol. 44, No. 3, pp. 349-351, 2005.

[20] R. P. E Albuquerque, C. Barbosa, D. Melquíades, H. Koch, J. M. Barretto, A. Albino et al, "Comparative analysis between radiographic views for knee osteoarthrosis(bipedal AP versus monopedal AP)," Revista Brasileira de Ortopedia(English Edition), Vol. 48, No. 4, pp. 330-335, 2013.

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다기능 보조기구와 체중부하검사 보조기구의 X선 화질 비교

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요 약

본 연구의 목적은 여러 가지 하지입식검사에 적용할 수 있는 Multi-Function Device(MFD)를 제작하여 기존에 사용하던 Weight Bearing Platforms(WBPs)들과 X 선 영상의 비교를 통해 임상 활용을 제안하고자 한다. MFD는 단상(보조기구)를 이용한 Weight Bearing Foot/Ankle, Hindfoot Alignment View 검사시 X선 장치의 X선 관구의 최하 조절 높이를 고려하여 제작하였다. 그리고 Foot/Ankle Phantom으로 MFD와 WBPs에서 Weight Bearing Lateral Foot과 Hindfoot Alignment View를 검사하여 X선 영상의 해상력을 Quick MTF(modulation transfer function)프로그램으로 비교하였다. 연구결과 MFD와 WBPs에서 검사한 두 가지 영상 모두 MTF 50(50% Contrast Spatial Frequency)과 10-90%(10-90% of Maximum Energy Rise Distance) Rise의 C/P(Cycles Per Pixel)평균과 LPH(Lines Per Image Height)평균 모두 유의한 차이는 없었다($p>0.05$). 연구에서 제작한 MFD는 환자의 안전과 여러 가지 검사를 복합적으로 수행 할 수 있는 유용한 보조기구로 임상 활용을 제안한다. 또한 정책적으로 보조기구의 활용을 권장한다면 전문 업체의 활성화를 돕는 길이며 의료의 질도 더욱 향상할 수 있을 것이다.

중심단어: 후족부정렬검사, 다기능 보조기구, 자세고정기구, 변조전달함수, 체중부하검사 보조기구

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