White Paper

Study to Demonstrate Efficiency of Sharpness Recovery

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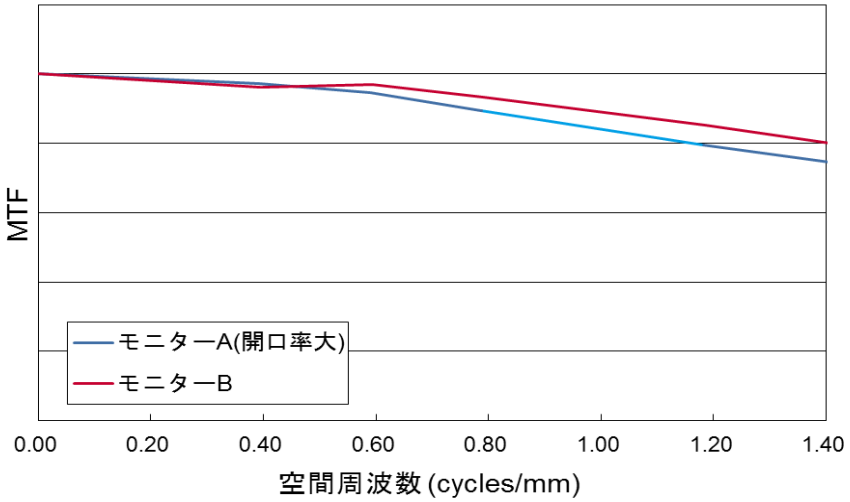
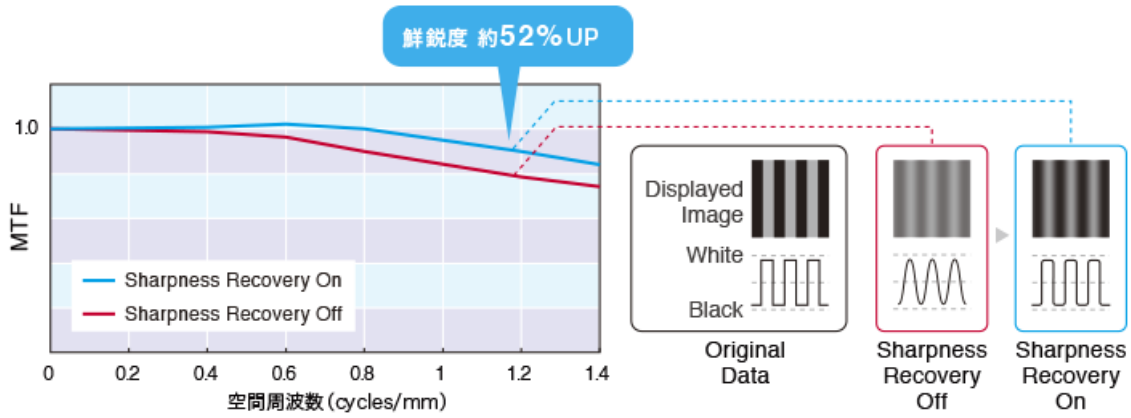
医用モニターには高輝度タイプの液晶パネルが広く使われているが、液晶パネルの開口率を大きくすることが高輝度を実現する手段の１つとして有効である。一方、開口率と鮮鋭度（MTF 値）には密接な関係があり、液晶パネルの開口率を大きくすると鮮鋭度が低下する関係にある。下記は開口率の大きいモニターA とモニターB の MTF を測定したグラフだが、モニターA の鮮鋭度がモニターB に比べて低下していることが分かる。



当社が 2015 年に発表した「RadiForce RX350」「RadiForce RX250」には、この問題を解決するため、「Sharpness Recovery 機能」を搭載した。Sharpness Recovery 機能は、低下した鮮鋭度を回復する。これにより、RX350、RX250 は先行機種と同等の鮮鋭度を保ちながら高輝度化を実現し、長期にわたり安定した性能を発揮する。



しかし画像を過度に補正すると、ノイズ成分が強調されて診断の精度、読影の効率に悪影響を及ぼす可能性がある。そこで当社は、Sharpness Recovery 機能のオン/オフでの診断の精度、読影の効率に与える影響について Dr. Elizabeth Krupinski (Emory University Department of Radiology & Imaging Sciences)に臨床評価を依頼した。

臨床評価の結果、Sharpness Recovery 機能のオン/オフでの診断の精度、読影の効率に有意差が無いことが明らかとなった。これはつまり、Sharpness Recovery 機能による診断の精度、読影の効率への悪影響が確認できなかったことを示している。詳細は次頁以降の Dr. Krupinski の研究論文(英文)を参照のこと。

注)全ての図は実測図ではなく模式図です。

Final Research Report for Eizo

Study to Demonstrate Efficiency of Sharpness Recovery

Elizabeth A. Krupinski, PhD

Emory University Department of Radiology & Imaging Sciences

Contact: ekrupin@emory.edu

1. PURPOSE

The goal of this study was to assess diagnostic accuracy and reader efficiency as a function of whether the sharpness recovery (SR) function for the display was on or off. There were two aspects of reader performance that were studied: diagnostic accuracy as measured by Receiver Operating Characteristic (ROC) analysis and reading time.

2. METHODS

The study was carried out using a single RadiForce RX350 display monitor set up by Eizo with appropriate white point, maximum/minimum luminance, and black level, and was calibrated to the DICOM GSDF. Whether the sharpness recovery function was on or off was the main parameter under consideration.

The study protocol was approved by Emory University's Human Subjects office for IRB approval prior to the start of the study. Six radiologists were recruited as observers – 3 Board-certified musculoskeletal (MSK) radiologists and Fellows, and three senior level (PGY5) residents interested in MSK Fellowships.

Each observer viewed a set of 50 bone cases, once with and once without sharpness recovery using a counterbalanced design in which half of the observers viewed the cases in one condition first and the other half viewed them on the alternative condition first. At least 3 weeks passed between sessions to promote forgetting of the cases. Twenty-five cases contained a single

fracture and 25 were fracture free. Fractures ranged from subtle to moderately subtle and were be located throughout the images which covered the range from foot, ankle, lower leg, upper leg, lower arm, upper arm and chest (rib and clavicle fractures). Truth was established in a prior study using an expert MSK radiologist to confirm fracture types and locations; plus this test set has been used in a number of observer performance studies so we know the difficulty of the cases. Figure 1 is an example of one of the fracture cases (arrow = radial head fracture).

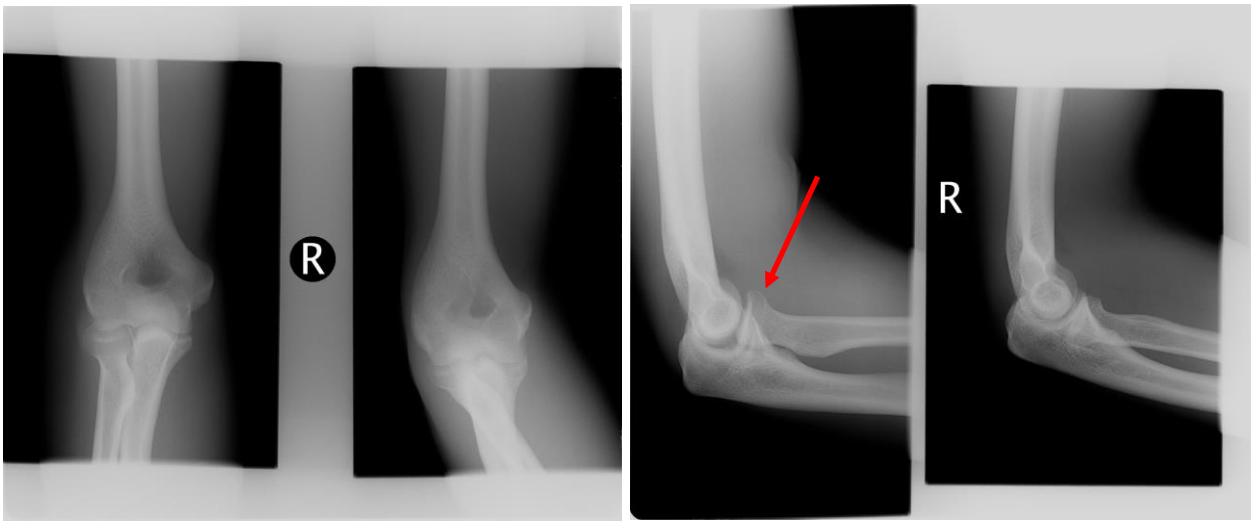


Figure 1. An example of one of the fracture cases (arrow = radial head fracture).

The images were displayed using specialized display software (ImprocRAD) for image presentation and recording of observer response data. Standard observer performance study protocols were observed, such as having the ambient room lights set to 40 lux and noise levels were minimized.

The task of the readers was to determine for each case if a fracture was present or absent. They then reported their confidence in that decision using a 6-point scale: lesion present definite; lesion present probable; lesion present possible; lesion absent possible; lesion absent probable; lesion absent definite. They indicated the location using the mouse and a cursor. Reading time (time from when the images first appear until a decision is rendered) was recorded.

The confidence data were analyzed for statistically significant differences in reader accuracy using the Multi-Reader Multi-Case (MRMC) Receiver Operating Characteristic (ROC) technique and software from the University of Iowa (http://perception.radiology.uiowa.edu/Software/ReceiverOperatingCharacteristicROC/MRMCAnalysis/tabid/116/Default.aspx). The timing data were analyzed using a repeated measures Analysis of Variance with time (sec) as the dependent variables and display condition as the independent variable.

3. RESULTS

Diagnostic Accuracy

The MRMC ROC analysis revealed no statistically significant difference in diagnostic performance between the two display conditions ($F = 0.02$, $p = 0.8854$). The average and individual area under the curve (Az) results are shown in Table 1.

Reader	No SR	SR
1	0.847	0.888
2	0.817	0.851
3	0.966	0.918
4	0.859	0.894
5	0.872	0.867
6	0.911	0.870
Mean	0.879	0.882

Table 1. ROC Az values for each of the readers in each condition with means for the conditions at the bottom.

Viewing Time

For viewing time, there was no significant difference ($F = 2.804$, $p = 0.0951$) between No SR and SR. On average, viewing time with SR on the no fracture images was 31.80 (sd = 15.53) sec and 27.98 (sd = 12.84) sec on the fracture images; and viewing time with No SR on the no fracture images was 34.12 (sd = 15.06) sec and 29.56 (sd = 14.11) sec on the fracture images.

Figure 2 shows the average viewing times for No SR vs SR for fracture and no fracture images. The difference in viewing time as a function of fracture vs no fracture was significant (F = 12.389, p = 0.0005), but this was expected as numerous studies have shown that normal cases tend to take longer to interpret than cases with abnormalities. The difference was similar for both SR and No SR conditions. Figure 3 shows the average viewing time for each reader in SR and No SR conditions.

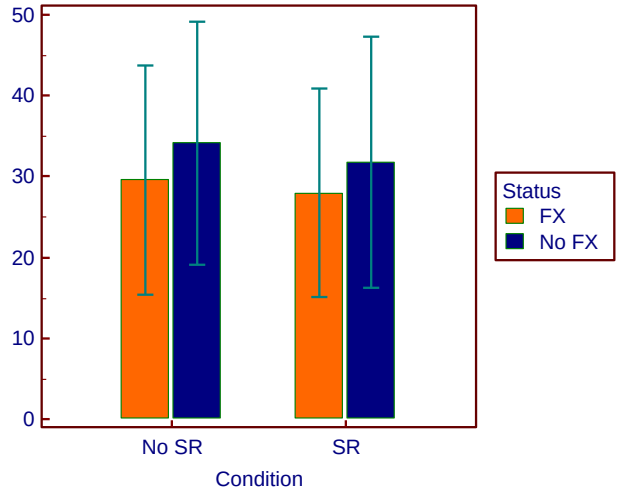


Figure 2. Average viewing times for No SR vs SR for fracture and no fracture images.

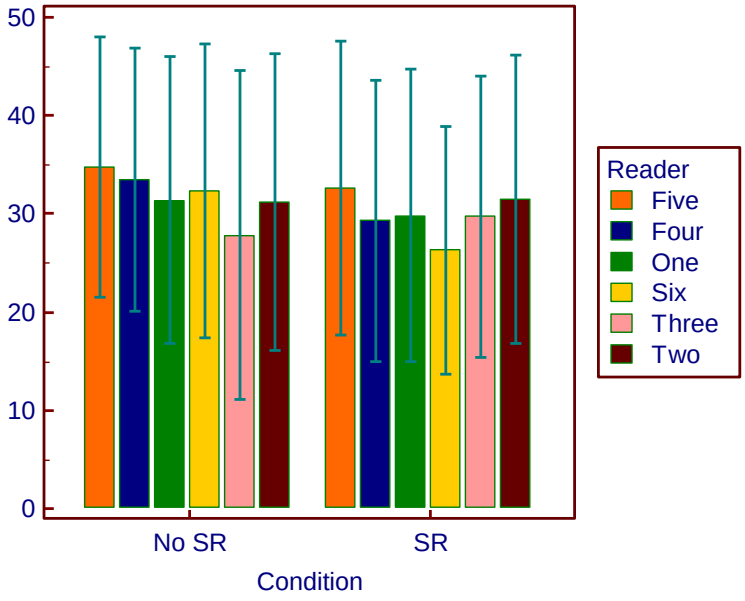


Figure 3. Average viewing time for each reader in SR and No SR conditions.

4. CONCLUSIONS

Overall there were no significant differences in diagnostic accuracy or reader efficiency (viewing time) as a function of whether SR was on or off. After the study was completed with each reader, they were shown (by toggling on and off) what the difference was between SR on and off. Although four of them could see subtle differences two of them could not. All of them agreed that the degree of sharpness was too subtle to have an impact on the visibility of the fractures or the speed with which they interpret images. A future study should be conducted with the sharpness level increased (although balanced against the likely increase in noise levels) either with the bone fracture images or perhaps chest with nodules or pneumothoraces.