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Dynamic Radiography in RADspeed Pro - Focused on Orthopedic Wrist Radiography -

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1. Hospital Overview

Fujieda Municipal General Hospital, located in the central region of Shizuoka Prefecture, aims to excel in cancer treatment and emergency care. It is designated as the only Regional Cancer Treatment Cooperation Hospital in the Shida-Haibara secondary medical area that offers cancer care. For emergency care, it established the first advanced emergency medical center in the Shida-Haibara secondary medical area, operating on a 24-hour basis for tertiary emergency care. The hospital boasts 35 medical departments and 564 beds, making it a medium-sized hospital with 27 radiological technologists on staff (Fig. 1).

Fig.1 Exterior view of Fujieda Municipal General Hospital

2. Radiography Room Configuration and System Features

To conduct dynamic radiography, our hospital introduced the "RADspeed Pro" digital radiography system from Shimadzu and the "AeroDR fine" DR system from Konica Minolta in March 2022. One of our five general radiography rooms, including the emergency radiography room, is equipped with a dynamic radiography system (available only for the standing position), which is also used for normal radiography of the chest, abdomen, and limb joints (Fig. 2).

Notably, this system is highly attractive due to its copper filter, which has demonstrated utility for chest radiography. For film radiography, the narrow dynamic range necessitated the use of high voltage radiography above 120 kV to mitigate the density of the mediastinum and overlapping ribs on the lung field. The DR system, with its wide dynamic range, enables density adjustment through improved digital image processing, prompting discussions on the necessity of high voltage radiography. Currently, studies have reported that X-ray quality with added copper filters at 90 kV or 100 kV provides better image quality than high voltage radiography, given the excellent X-ray absorption efficiency of CsI in the FPD composition. In our dynamic radiography practice, imaging is performed at 100 kV with a 0.2 mm copper filter.

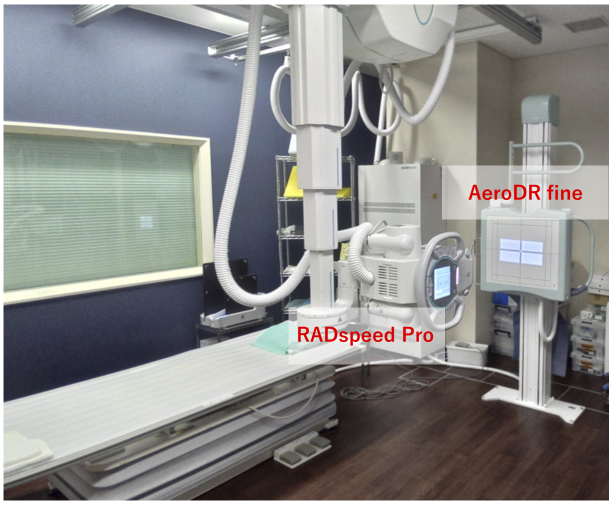
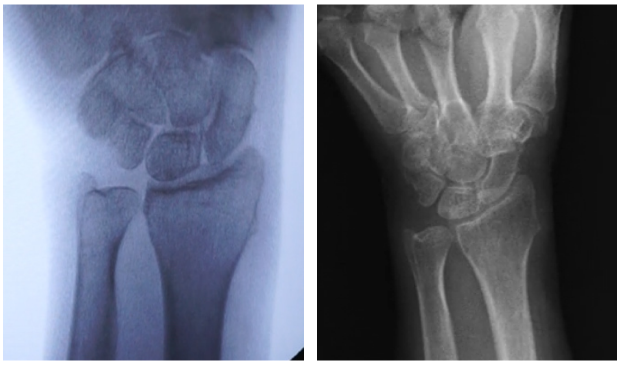


Fig.2 General Radiography Room Equipped for Dynamic Radiography

3. System Features

Typically, fluoroscopy systems are capable of continuous X-ray irradiation (fluoroscopy), sequential X-ray pulse irradiation, and X-ray

Fig.3 Grid Removal The grid can be easily removed with a single button press.



Fluoroscopic Image

Sequential Ray Pulse Image (dynamic radiography)

Fig.4 Comparison of Fluoroscopic and Sequential X-Ray Pulse Images

Dynamic Radiography Conditions for Wrist Imaging at Our Hospital:

Tube voltage	50 kV
Tube current	80 mA
Time	1.6 ms
Distance	120 cm
Frame rate	6 fps
Average imaging time	13 sec
Exposure dose	Approx. 0.2 mGy

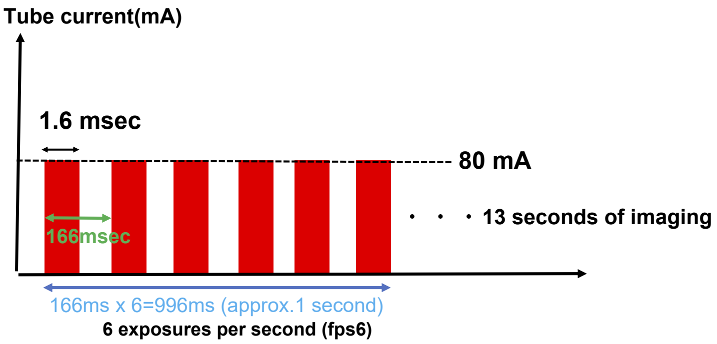


Fig.5 Dynamic Radiography of the Wrist Using Sequential X-Ray Pulses.

radiography. They are configured with an integrated system comprising an X-ray generator, detector, and table. In contrast, systems designed for dynamic radiography allow for sequential X-ray pulse irradiation and radiography, with separate components for the X-ray generator, detector, and Bucky stand/table, all working in synchronization. This separation allows users to arbitrarily set the imaging distance and tube angle, unlike in fluoroscopy systems. The removal of the grid is also simplified, which has the advantage of facilitating smooth removal of the grid for imaging at extremity joints. (Fig. 3).

Since dynamic radiography is performed using sequential X-ray pulse irradiation, it records video images with better quality compared to fluoroscopic images (Fig. 4 and 5). For limb joints, as mentioned earlier, the grid can be conveniently removed, allowing for more appropriate imaging conditions for dynamic radiography. The images are acquired using an FPD with a pixel size of 400 μm x 400 μm, a density resolution of 16 bits, and an image area of 17 inches x 17 inches. The sequential pulse X-ray irradiation time can be set arbitrarily up to 20 seconds. For chest dynamic radiography, the imaging is done at a distance of 180 cm and 15 frames per second (fps), while for limb joint dynamic radiography, it is performed at 120 cm and 6 fps.

At our hospital, dynamic radiography of the chest and wrist is mainly performed upon request from the departments of thoracic surgery, respiratory medicine, and orthopedics. For chest dynamic radiography, we conduct unique breath-hold imaging and forced breathing or deep breathing imaging. In addition, we provide images processed in FE-mode, PL-mode, and LM-mode using the “KINOSIS” Dynamic Digital Radiography Analysis Workstation from Konica Minolta.

4. Dynamic Wrist Radiography Procedure at Our Hospital

Unlike general radiography examinations, it is necessary to inform patients that dynamic radiography involves capturing movement. For wrist dynamic radiography, we explain that the patient should perform ulnar and radial deviation movements while, moving the wrist slowly with a clenched fist. We also demonstrate the movements to the patients (Fig. 6). At our hospital, dynamic

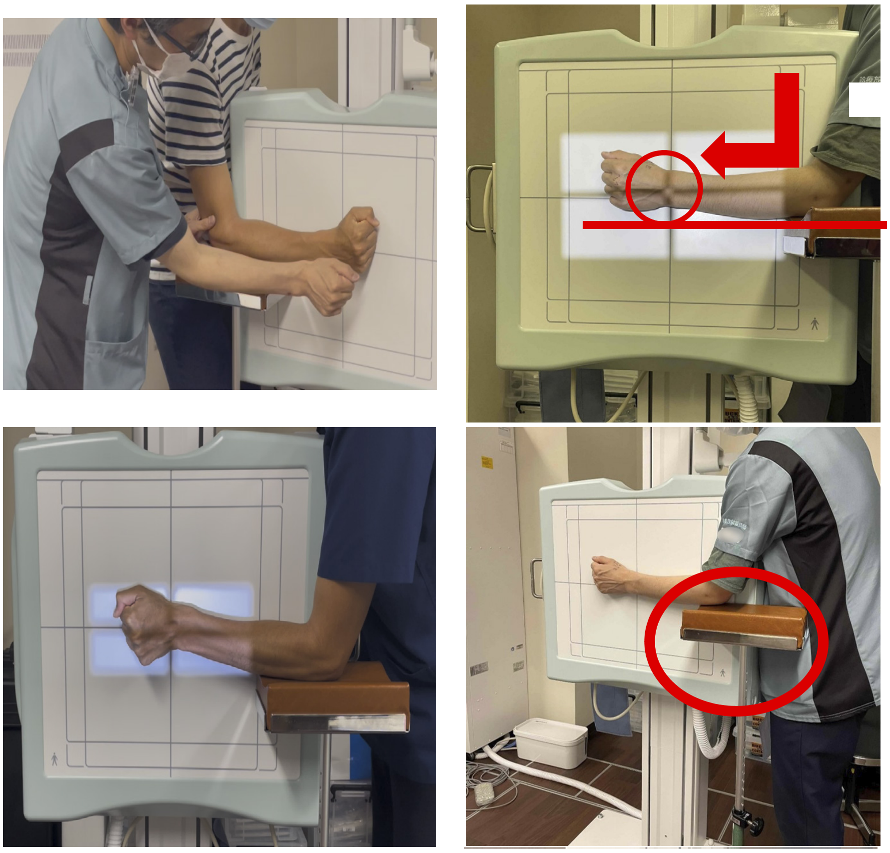


Fig.6 Positioning for Wrist Dynamic Radiography. Only dynamic radiography with Bucky stand is possible at our hospital. The hand is held in a clenched position. The elbow and forearm are horizontal and parallel to the FPD. The elbow joint is fixed at 90° flexion. During ulnar and radial deviation, care is taken to prevent hand rotation. Initially, positioning followed the protocol for general wrist radiography with 90° shoulder abduction and 90° elbow flexion, but the hand often rotated without forearm stabilization. The current protocol uses a support under the forearm.

※Pre-Imaging Preparation:

1. Practice the movements before the imaging.
2. Ask the patient about symptoms:
   - Which side has pain?
   - Which part of the wrist hurts?
   - What movements cause pain?

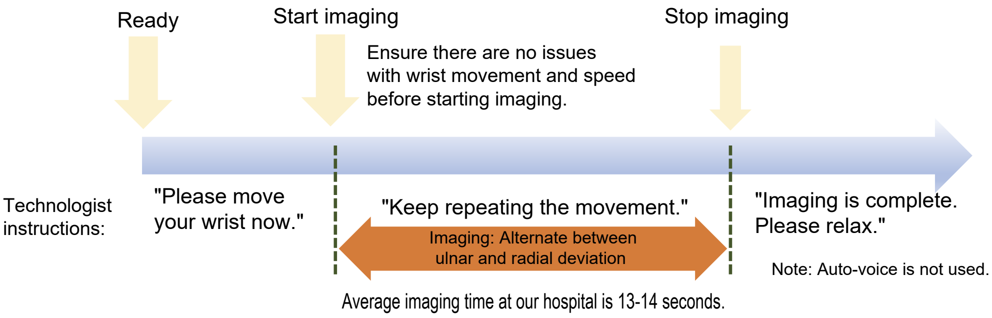


Fig.7 Timing for Wrist Dynamic Radiography

radiography is only available with the Bucky stand. For positioning, the elbow and forearm should be horizontal and parallel to the FPD. The elbow should be flexed at 90° and placed on a support to avoid rotation of the hand during ulnar and radial deviation. Proper positioning is crucial to accurately evaluating joint movement, as incorrect positioning or X-ray centering can lead to inaccurate assessments **(Fig.6)**.

Additionally, because we use the same tube voltage of 50 kV for wrist radiography as for general wrist imaging, images can become noisy if the grid is not removed, so attention must be paid to not forgetting to remove the grid. The imaging procedure is illustrated in **Fig. 7**. We confirm the patient's symptoms in detail before positioning, set the tube distance to 120 cm, align the irradiation field after confirming the center point, explain the ulnar and radial deviation movements, and have the patient practice to ensure there are no issues. Then imaging is started with verbal instructions rather than using an auto-voice system.

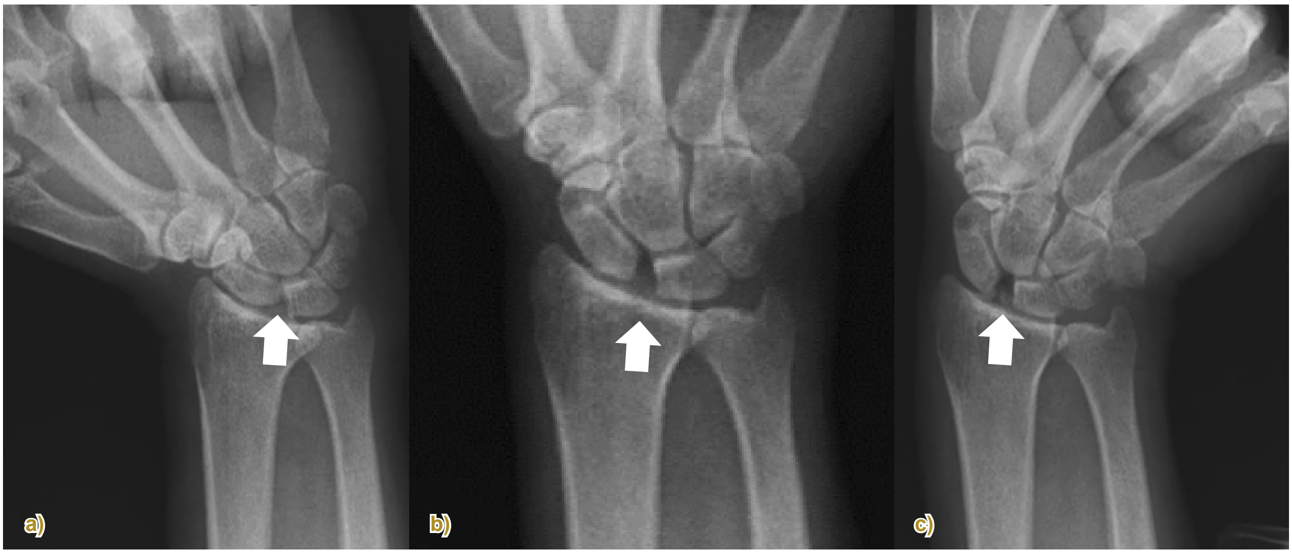
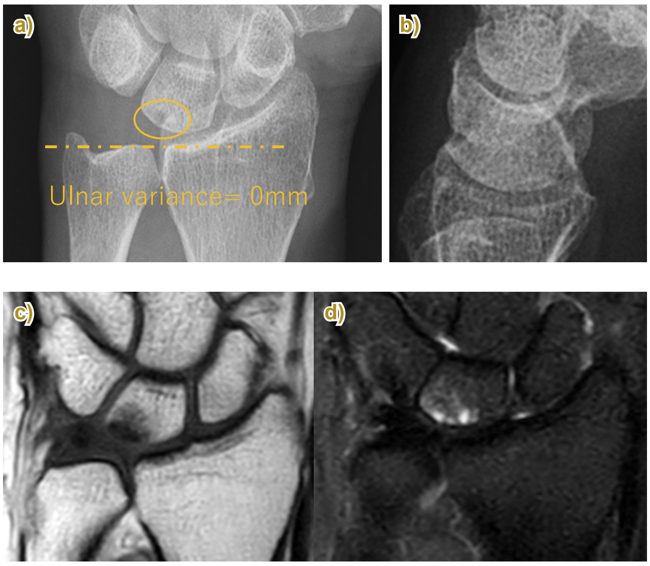


Fig. 8 Scapholunate Dissociation
a) Dynamic radiography (radial deviation) **b)** Dynamic radiography (frontal) **c)** Dynamic radiography (ulnar deviation)



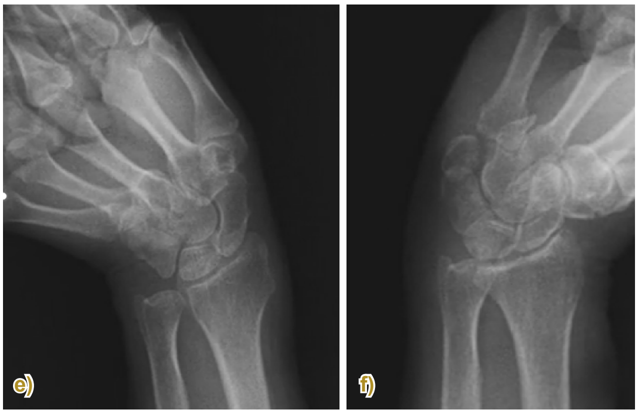


Fig. 9 Dynamic Ulnar Impaction Syndrome
a) Frontal wrist view: Radiolucent area in the lunate
b) Lateral wrist view: No collapse of the lunate
c) MRI T1-weighted image
d) MRI STIR image
e) Dynamic radiography (ulnar deviation)
f) Dynamic radiography (radial deviation): Approaching the ulna during radial deviation

5. Cases of Wrist Dynamic Radiography

• Scapholunate Dissociation (Fig. 8)

Scapholunate dissociation is one type of carpal instability and is said to be the most common. It occurs due to the laxity or rupture of the dorsal scapholunate ligament and the radioscapholunate ligament, often resulting from hyperextension injuries of the wrist or in conjunction with distal radius fractures. This condition is suspected when the gap between the scaphoid and lunate (scapholunate gap) exceeds 3 mm in a frontal wrist image. When the frontal wrist image is not clear, imaging in the ulnar deviation position is considered important[2].
In this case, wrist dynamic radiography revealed a separation between the scaphoid and lunate, leading to a diagnosis of scapholunate dissociation.

• Dynamic Ulnar Impaction Syndrome. (Fig. 9)

This shows a case diagnosed as dynamic ulnar impaction syndrome using wrist dynamic wrist radiography.
Dynamic ulnar impaction syndrome, reported by Nakamura, is generally caused by ulnar plus variance, diagnosed when the ulna is more than 2 mm longer than the radius. However, Nakamura reported that even in neutral variance cases, the ulna shows about 2 mm positive variance in pronation and about 1-2 mm negative variance in supination. This indicates that ulnar variance can cause impaction of the TFCC and ulnocarpal bones during pronation and supination[3]. In this case, although the patient had neutral variance in the frontal wrist view, a radiolucent area was observed in the lunate. No collapse of the lunate was seen in

the lateral view. in MRI images, the lunate showed low signal intensity in T1-weighted images and high signal intensity in STIR images, extending to the center of the lunate, which is atypical for impaction syndrome, raising the suspicion of Kienbock's disease. Therefore, wrist dynamic radiography with radial and ulnar deviation movements was performed, confirming that the ulna impinged on the lunate during radial deviation, leading to a diagnosis of dynamic ulnar impaction syndrome.

6. Conclusion

While the dynamic behavior of joints is observed using fluoroscopy on a daily basis in limb joint examinations, the reality is that it is not yet common practice to immediately use fluoroscopy to check joint dynamics when encountering diagnostically challenging cases. The greatest advantage of a system capable of dynamic radiography is that the ordering physician can request examinations with the same ease as general radiography, and the radiographers can conduct them with the same familiarity. Adding dynamic imaging information to conventional static radiography increases the amount of information available and may aid in diagnosis. Moreover, unlike stress imaging, automatic movement-based imaging may provide new insights. We expect that dynamic imaging for bones and joints will become more widely used in the future.

References

1) Oda, N. "Optimal X-ray Quality for DR Chest Radiography Recommended Worldwide: 90kV, Cu Filter - Contrast and CNR Verified by Monte Carlo Method." Innervision 38(5), 2023
2) Nakamura, T. "Injuries of the Intercarpal Ligaments, Carpal Instabilities, and Their Treatment." MB Orthop. 32(4): 79-84, 2019
3) Nakamura, T. "Treatment of Ulnar Impaction Syndrome." MB Orthop. 27(4): 33-39, 2014