VolumeRAD imaging in the evaluation of fractures of the foot

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My disclosure is in the Final AOFAS Program Book. I have no potential conflicts with this presentation.
Foot Fractures

- Stress or non-displaced fractures, can easily be missed on plain radiographs
- 80% of all foot and ankle injuries get an x-ray, fewer than 15% have a significant fracture
- Inadequate treatment → Painful non union, mal union and arthritis exacerbated by:
  - Weight bearing
  - Ambulation

- Imaging techniques:
  - **Radiography**: Basic imaging tool, less sensitivity and accuracy, stress or non-displaced fractures, are commonly missed in plain radiographs
  - **CT-scan**: Efficient, more expensive than X-ray, may miss trabecular fractures, radiation exposure >> X-ray
  - **MRI**: Most powerful technique, hard to differentiate occult fracture from simple bone bruising, less available and more expensive than X-ray, recommended for cases in which X-ray or CT are inconclusive.
  - **Bone Scan**: Sensitive but not specific, false positive in tumors, infections and inflammations, less available and more expensive than x-ray
Volume-Rad Imaging

- This recently invented application provides multiple high resolution slice images using an X-ray system.
- Low-dose projection images are taken during a single sweep of the X-ray tube over a limited angle.
- A computer then assembles the information to provide up to 60 high-resolution slice images with a selectable thickness ranging from 1 to 10 mm.
- This technique has been used in mammography for several years. It has recently become available for musculoskeletal radiography.
- It has lower cost and less radiation than a CT-scan.

Imaging Techniques:
- Images obtained with GE Definium 8000 M3 digital x-ray machine (GE healthcare, USA) with 0.1 mm pixel spacing
- Radiography:
  - Foot: AP, Lat, Oblique views
- Volume Rad:
  - Foot: Lateral/Frontal
- 24 low-dose projections, 4mm thickness
- the detector was stationary, whereas the x-ray tube performed a horizontal continuous movement from -26° to +26°
Material and Methods

- 134 patients with foot injuries between July 2009 and June 2012
- All patients had clinical symptoms of fracture: pain, swelling, Ecchymosis and impaired function
- Initial plain X-ray:
  - Foot AP, oblique, lateral views
- Follow up Imaging by Volume-Rad in single plane (AP/ Lateral)
- Control by CT, MRI or Bone Scan
- 37 Patients (19 male, 18 female) included in this study
  - Mean age: 31 years (Range 15-78)
  - Median age: 23 years
  - Inclusion criteria: Acute foot trauma and pain
  - Exclusion criteria: Old known fractures, severe arthritis, diabetic and charcot foot

- Radiographic studies reviewed on PACS by 4 reviewers: One senior Musculoskeletal Radiologist, one musculoskeletal radiology fellow, two orthopaedics surgeons.
  - Each observer reviewed x-ray, volume-rad, x-ray plus volume-rad and finally CT, MRI or Bone scan as a control.
  - Each study reviewed separately with the observers blinded to the other examinations.
  - Images were analyzed for presence or absence of foot and ankle fractures
Results

**X-ray vs. Volume-Rad**

- Sensitivity: X-ray 0.53, Volume-Rad 0.87
- Accuracy: X-ray 0.65, Volume-Rad 0.85
- Specificity: X-ray 0.93, Volume-Rad 0.83
- Precision: X-ray 0.95, Volume-Rad 0.91

**X-ray after Volume-Rad**

- Sensitivity: X-ray 0.53, X-ray+Volume-Rad 0.64
- Accuracy: X-ray 0.65, X-ray+Volume-Rad 0.72
- Specificity: X-ray 0.93, X-ray+Volume-Rad 0.91
- Precision: X-ray 0.95, X-ray+Volume-Rad 0.94

**Inter-observer Agreement**

- Overall: X-ray 0.75, Volume-Rad 0.83
- Fixed: X-ray 0.48, Volume-Rad 0.63
- Free: X-ray 0.51, Volume-Rad 0.66
Navicular fracture
Liffranc Fracture
Talus Post. Process Fracture
Volume-Rad imaging proved to be more sensitive, specific and accurate for evaluation of fractures of the foot as compared to plain x-rays.

Inter-observer agreement value analysis shows a high level unanimity between observers in Volume-Rad compared to X-ray.

In 62% of cases Volume-Rad Imaging reveals additional information compared to X-ray.

CT scan and MRI may help in the diagnosis of foot fractures but Volume-Rad imaging may provide some information with less radiation and lower cost.
Conclusion

- Volume Rad is associated with less cost, radiation, and time with more potential availability in outpatient clinics than CT and MRI.

- We have demonstrated the value of Volume-Rad imaging to identify fractures of the foot.

- Volume-Rad imaging allows creation of sectional images with less overlapping anatomy. This provides clinicians a higher degree of confidence in diagnosis compared to x-ray.
References


