Second Ray Syndrome (SRS): Multimodality Imaging for early assessment of the

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Purpose

The purpose of this study is to demonstrate the spectrum of radiological appearances encountered in the SRS and its mimics, using a multi-modality approach. The role of high resolution ultrasound (HR-US) in the early diagnosis will be highlighted.

Methods and Materials

The value of specifying a syndrome of the second ray belongs to Denis et al., who defined it in 1978 as a painful instability of the second toe between the intrinsic stabilisation system (capsule, interosseous and lumbrical muscles) and the long flexors and extensors of the toes (Fig. 2 on page 4, Fig. 3 on page and Fig. 4 on page 5).

Claustre et al. in 1986 linked the SRS to a more or less complete lesion of the plantar plate of the metatarso-phalangeal joint and not simply as Denis had thought a disharmony and instability.

Etiopathology

The weakening of the plantar plate can result from intrinsic and extrinsic factors.

INTRINSIC

a) Foot anatomy

- Excess length of the second metatarsal
- Normal length of the second metatarsal with a short first ray that increase the loading on the second metatarsal head (Fig. 5 on page 5).
- The inadequacy of the first metatarsal may be due to a true metatarsal shortening or due to excessive metatarsus varus.

EXTRINSIC

a) Traumatic and/or micro-traumatic factors:

- Repetitive trauma, causing a sudden overloading in the forefoot, can damage a weakened plantar plate
- Repetitive movements producing hyperpressure in work, or particularly sporting activities, can produce a biomechanical overload on the plantar plate and finally its rupture.
• Poor footwear on a foot anatomically predisposed to overloading of the second metatarsal head.

b) Iatrogenic factors:

• Injudicious infiltration of cortico-steroids in the joint can provoke rupture of the plantar plate

c) Hallux valgus

• The clinical history can clearly reveal a hallux valgus (Fig. 6 on page 6) predating (A) or following (B) the elevation and sub-dislocation of the second toe.

Clinical signs and diagnostic imaging

4 stages are recognized in the natural history of the SRS:

• **Stage 0**: aspecific symptoms without instability.
• **Stage I**: simple instability. Positive modified Lachman's test (manual subluxation of the MTPJ that creates pain)
• **Stage II**: phase of subluxation or reducible dislocation. Clawing of the second toe appears when the phalangeal base starts dislocating.
• **Stage III**: phase of fixed dislocation.

The evolution of these three stages is very variable and may be more or less rapid.

Aspecific symptoms (stage 0)

• Joint effusion (Fig. 7 on page 6)
• Plantar soft tissues edema (Fig. 8 on page 7)
• Tenosynovitis (Fig. 9 on page 8)

In this stage, sonography provides to clearly identify such soft tissues alterations.

Phase of simple instability (stage I)

• Due to the mechanical damage of the plantar plate (Fig. 10 on page 8, Fig. 11 on page 9)
• Moderate pain over the plantar aspect of the metatarsal head (Fig. 12 on page 9, Fig. 13 on page 10)
• No true joint space narrowing.
Phase of subluxation or reducible dislocation (stage II)

- Instability and progressive dorsal sliding of the flexor tendon and stabiliser system.
- There follows a subluxation and then a true dislocation of the base of the proximal phalanx on the metatarsal head, usually reducible (Fig. 14 on page 10, Fig. 15 on page 11).
- May constitute the inaugural stage of the SRS since there may have been no previous pain.

The stage of fixed dislocation (stage III)

- Corresponds to retraction of the ligamento-tendinous system.
- Fixed position of dislocation of the base of the proximal phalanx above the head of the second metatarsal (Fig. 16 on page 12, Fig. 17 on page 12).
- Pain is always present under the head of the second metatarsal.
- The toe clawing is fully developed and accompanied by hyperkeratosis on top of the proximal interphalangeal joint and even on the distal pulp.

Differential diagnosis

SRS or second MTPH Joint overloading syndrome has become a catch-all term for patients who complain of chronic pain involving the second MTPH Joint.

Symptoms from SRS can be confused with those produced by several entities:

- Degenerative joint disease (DJD) of MTPH joints (Fig. 18 on page 13)
- Morton's neuroma (Fig. 19 on page 14, Fig. 20 on page 15)
- Intermetatarsal or plantar bursitis (Fig. 21 on page 15, Fig. 22 on page 16)
- Crystal-induced arthropathies

Images for this section:
**Fig. 2:** Anatomical scheme of a metacarpal-phalangeal joint and its capsular-ligamentous complex

**Fig. 4:** US longitudinal scan of a MTPJ. Flexor tendon is seen on its long axis as a fibrillar hyperechoic structure (arrowheads), whereas the cortical bones of the metatarsal head (M) and of the proximal phalanx (P1) are visualized as regular, linear hyperechoic structures
Fig. 5: Anatomical variations of the foot can lead to different distributions of pressure on the plantar surface. Note the differences in the colored pressure map of a greek-shaped foot (characterized by a long second toe compared to the others) when compared to an egyptian-shaped one (characterized by a long first toe and the rest of the toes taper).

Fig. 6: A. Surface-rendered CT image showing degenerative changes and a valgism of the first MTPJ. This condition can lead to a subluxation of the second toe. B. Dorso-volar radiograph showing the subluxation of the second toe.
Fig. 7: US longitudinal scan showing a hypoechoic effusion of the second MTP joint
**Fig. 8:** Transverse US scan at the level of the MTP joints demonstrating the presence of plantar soft-tissues edema.

**Fig. 9:** Transverse US image on the second MTPJ showing a small tenosynovitis of the flexor tendon, seen as a hypoechoic fluid collection around the tendinous structure.
**Fig. 10:** Plantar plate rupture. Longitudinal US scan showing the loss of echogenicity of the plantar plate.

**Fig. 11:** T1-weighted sagittal MR image showing the presence of joint effusion with a partially teared plantar plate.
Fig. 12: Sagittal T2 Fat-Sat weighted image showing the presence of joint effusion with a partially teared plantar plate.

Fig. 13: Axial T2 Fat-Sat MR image demonstrating the presence of soft tissues edema and synovitis (arrows) at the level of the second MTP joint. Joint effusion is also present (arrowhead).
**Fig. 14:** The 3/4 oblique forefoot view best differentiates subluxation and true dislocation of the 2nd proximal phalangeal base.
**Fig. 15:** 3D surface-rendered CT reconstruction showing subluxation of the 2nd MTPJ

**Fig. 16:** Sagittal MR T2 Fat-Sat image showing the dislocation of the MTPJ and bone edema.
Fig. 17: 3/4 oblique forefoot radiograph demonstrating a clear overlapping of the base of the phalanx and the metatarsal head.
Fig. 18: Sagittal T2 Fat-Sat MR image showing the presence of a stress fracture of the 2nd metatarsal head with bone edema.
Fig. 19: Transverse US image demonstrating the presence of a little neuroma, showed as a hypoechoic structure (asterisk) arising from the 2nd intermetatarsal space. M= metatarsal bones.

Fig. 20: Axial T2 Fat-Sat MR image demonstrating a little intermetatarsal neuroma (arrowheads).
**Fig. 21:** Transverse US scan showing a thin effusion (asterisks) in the anterior plantar fat pad due to forefoot overload. M= metatarsal heads.

**Fig. 22:** Plantar bursitis: axial T2 Fat-Sat MR image showing a thin effusion (arrowheads) in the anterior plantar fat pad due to forefoot overload.
Results

The SRS consists of a painful instability of the second toe on its metatarsal head. Such instability leads, in later stages after rupture of the plantar plate, to initially reducible and then progressively fixed and irreducible dislocation. Medical treatment is effective at the beginning, while surgery is required at later stages (Fig. 23 on page 17, Fig. 24 on page 17).

Images for this section:

Fig. 23: Surgical FDL tendon transfer
Fig. 24: Surgical FDL tendon medial transposition
Conclusion

While it is important to differentiate this entity from the others, it is even more important for the practitioner to determine an accurate etiology or etiologies for the SRS, because only by understanding the cause of the problem can one develop an effective treatment plan in order to reduce unuseful invasive surgery.

Ultrasound, Magnetic Resonance Imaging and Radiography are extremely valuable tools in the evaluation of the early stages of SRS, thus giving the possibility of an early diagnosis and a better management of this condition.

References


Personal Information