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LUNOTRIQUETRAL COALITION, A NORMAL VARIANT THAT MAY RARELY CAUSE ULNAR SIDED WRIST PAIN

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Lunotriquetral coalition (LTC), the most frequent and often bilateral type of carpal coalition, is in general considered as asymptomatic. In rare cases – however – fibrocartilaginous LTC may be an uncommon cause of ulnar sided pain in the wrist due to the pseudarthrosis or a post-traumatic disruption of LTC. Two rare cases of symptomatic LTC are presented and the role of MRI is emphasized. MRI shows the pseudarthrosis and may additionally show bone marrow edema and subcortical cysts. In symptomatic cases surgical lunotriquetral fusion may be considered as treatment option.

Key-word: Wrist, abnormalities.

Carpal fusion may occur in two or more adjacent bones in almost any combination (lunotriquetral, capitate-hamate, trapezium-trapezoid, scapho-trapezium, scapho-lunate, capitate-lunate, pisiform-hamate, hamate-triquetrum, triquetral-pisiform and trapezoid-capitate) (Fig. 1). Those on the ulnar side are more commonly involved (1). The bone fusion may involve two or more carpals or even all carpals may appear as a single bony mass. However, most coalitions occur between carpals within the same carpal row (1). Coalitions between carpals from different rows are thought to be quite rare (2) (Fig. 2). Complicated carpal fusions (Fig. 2E and 2F) are likely to be associated with more widespread anomalies. Fusion of carpal bones is hereditary and the trait is transmitted as a dominant factor which is not sex linked (3).

The lunotriquetral coalition is caused by a failure of cavitation of the cartilaginous hand bud precursor (during the fourth to eighth week of gestation) or cartilaginous segmentation of a common cartilaginous carpal precursor of the lunate and triquetral bone (4). The resulting malsegmentation between two normally distinct carpals results in a carpal coalition. This coalition may be fibrous (syndesmosis), cartilaginous (synchondrosis), frequently a mixture of both or osseous. As their ossification centers occur between 6 to 15 years the fusion may become visible on plain film.

Burnett (5) proposed a very simple classification with only two forms of coalition, osseous and non osseous.

de Villiers Minnaar (6) classified the carpal coalitions into four types, also known as the Minnaar types, on plain film (Table I) (Fig. 3). The latter classification is more frequently used. Minnaar type 1 (about 2%) resembles a pseudarthrosis due to its incomplete fibrocartilaginous coalition. In type 2 (second most frequent, about 22%) there is an incomplete osseous fusion, whereas in type 3 (most frequent, about 75%) the osseous fusion is complete. If other carpal congenital abnormalities are associated with a complete osseous coalition it is considered as a type 4 (about 1%) (7).

Our purpose was to review the plain film findings in our series (n = 9 patients, 12 LTC), compare the data with the literature and define the (potential) role of MRI. The differential diagnosis will be discussed as well.

Materials and methods

We examined nine patients with a LTC (of whom four had a known bilateral LTC) and analyzed the age, gender, type, clinical manifestation and imaging findings of LTC. A standard MRI protocol was used on a 1,5 Tesla MR with a dedicated wrist coil. A Field of View varying from 100-140 mm and a matrix varying from 256 x 180 to 512 x 360 were used. Coronal SE-T1 weighted (TR 470 msec, TE 22 msec, Slice Thickness (ST) 2 mm), Coronal PD-SE T2 weighted (TR 3930 msec, TE 13 and 93 msec, ST 2 mm) and Coronal GRE TR (23,59 msec, TE 8,31 msec, ST 0,5 mm) images were obtained. The number of averages varied from 1 to 3.

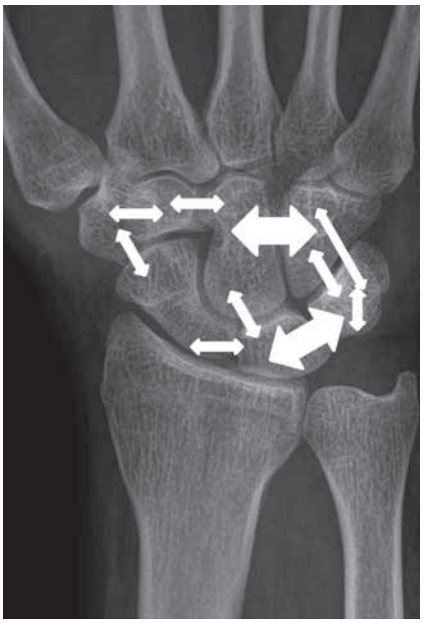

Fig. 1. — Carpal coalitions (arrows). Plain radiography. Thick arrows show the two most frequent coalitions (lunotriquetral and capitate-hamate).

Results

Our series includes 6 females and 3 males, all known with a LTC. Imaging findings and clinical manifestations are summarized in Table II. The age of our patients ranges between 11 and 56 years, with a mean of 30 years. The majority of the LTC were asymptomatic coincidental findings (Fig. 4). Two of them with type 1 LTC – of whom also the second youngest patient – had a symptomatic LTC (Fig. 5, 6). The other two with type 1 LTC were asymptomatic. Most of the LTC were of Minnaar type 3. In three patients LTC was bilateral. One of them (Fig. 7A) had a different Minnaar type on either side, the two other persons had the same type of LTC on both sides (Fig. 7B). On plain radiography one patient findings were in

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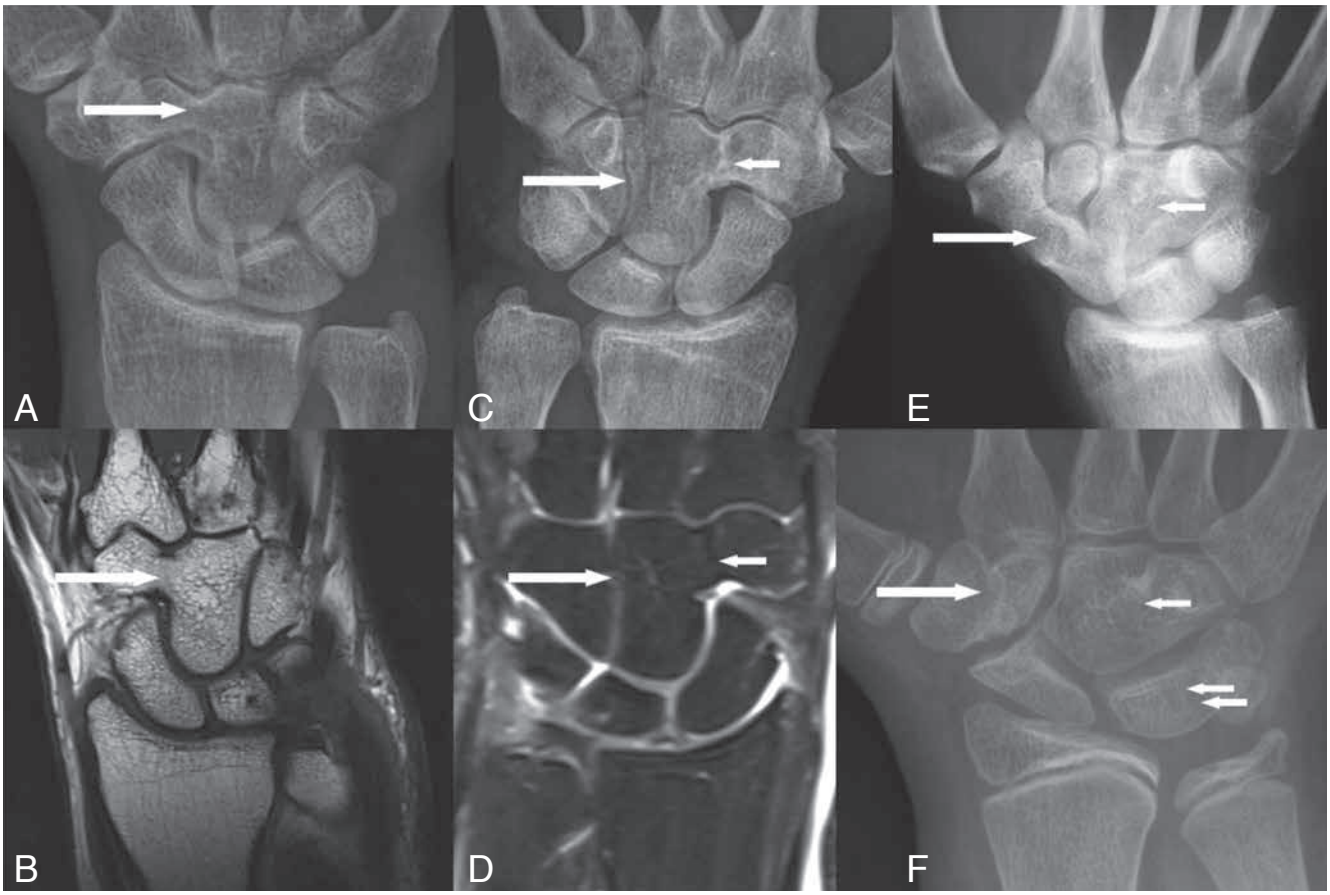

Fig. 2. — Isolated and combined coalitions. (A), (B), (C), (E) and (F) Plain radiography, (B) Coronal SE T1-WI and (D) Coronal SE T2-WI. A and B trapezoid-capitate coalition (arrows), C, and D capitate-hamate (long arrows) and trapezoid-capitate (short arrows). E. scapho-trapezium (long arrow) and capitate-hamate (short arrow). F. trapezo-trapezoideum (long arrow), capitate-hamate (short arrow) and LTC (double short arrow).

compliance with Minnaar type 3. Revaluation on MRI redefined this case as type 2 Minnaar (Fig. 8). Two symptomatic patients with a Minnaar type 1 LTC had ulnar sided pain. MRI showed subchondral cysts and a clear bone marrow edema adjacent the LTC (Fig. 5 B-D, 6 B-D). There were no associated soft tissue abnormalities. The surrounding joints were considered normal. These two symptomatic patients were successfully treated, one conservatively with medication and the second was surgically treated (Fig. 9).

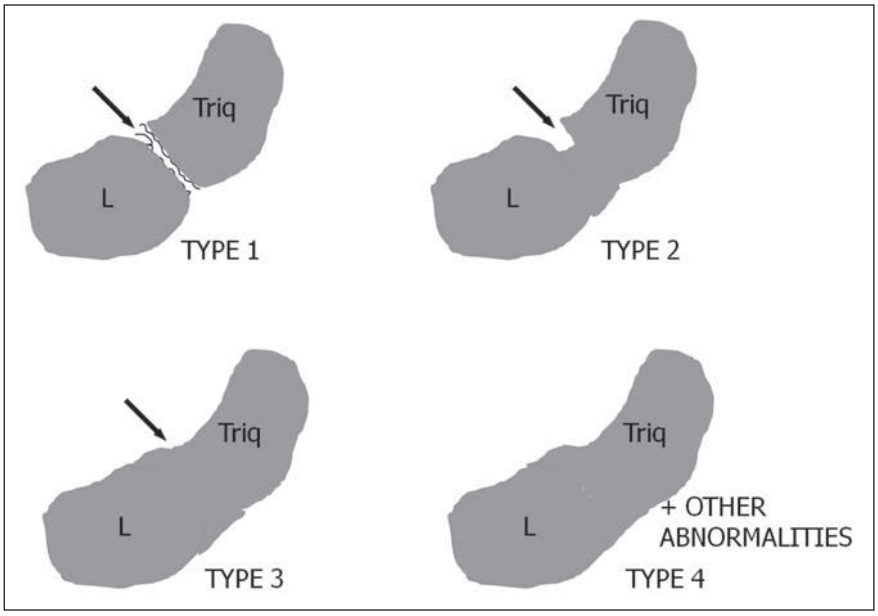

Fig. 3. — Minnaar types 1 to 4. Schematic view. Type 1: narrowed LTJ with irregular sclerotic margins (arrow). Type 2: incomplete osseous fusion with (small) mostly distal remnant of the joint space (arrow). Type 3: complete osseous fusion between the lunate and triquetral bone (arrow). Type 4: = Type 3 with other carpal congenital bony abnormalities.

Discussion

Lunotriquetral coalition (LTC) is the most frequent type of carpal coalition, representing 90% of all carpal fusions (8). The general prevalence is about 0,1% in Caucasian population and the congenital variant is commonly bilateral. We found a bilateral appearance in all of the three patients from whom the wrist was examined bilaterally. The congenital fusion of the lunate and the triquetral

Table I. — (de Villiers) Minnaar classification (plain film) with MR correlation, histopathology and clinical corrrelation.

Coalition	Plain film (de Villiers) Minnaar	MRI	Histopathology	Clinical correlation
Type 1	– narrowed LTJ – irregular sclerotic margins – possibly subcortical cysts	– narrowed LTJ – irregular sclerotic margins – possibly subcortical cysts – possibly bone marrow edema – possibly damage to the surrounding cartilage – possibly concomitant pathology	fibro-cartilaginous	(a) symptomatic
Type 2	– incomplete osseous fusion – (small) mostly distal remnant of the joint space	– incomplete osseous fusion – (small) mostly distal remnant of the joint space	incomplete osseous	asymptomatic
Type 3	– complete osseous fusion between the lunate and triquetral bone	– complete osseous fusion between the lunate and triquetral bone – dd. type 2 and 3	complete osseous	asymptomatic
Type 4	– complete osseous fusion between the lunate and triquetral bone – other carpal congenital bony abnormalities	– complete osseous fusion between the lunate and triquetral bone – other carpal congenital bony abnormalities – possibly anomalies of the soft tissues	complete osseous	other carpal congenital abnormalities

Table II. — Illustrative cases of LTC.

	Patient	Age (y)	Sex F/M	Minnaar type L-side	Minnaar type R-side	Surgery	Additional clinical information	Figure(s)
1	EJ	37	M	1	?	/	symptomatic	5
2	AM	46	F	3	1	/	asymptomatic (both sides)	7A, 7B, 8
3	DN	14	F	1	?	+	symptomatic	6, 9
4	KV	56	F	?	3	/	asymptomatic	4A, 4B
5	EM	24	F	1	?	/	asymptomatic	4C, 4D
6	VK	12	F	3	3	/	asymptomatic (both sides)	7C, 7D
7	VE	37	F	?	3	/	asymptomatic	/
8	BA	38	M	3	?	/	asymptomatic	/
9	VN	11	M	3	3	/	asymptomatic (both sides), complicated carpal fusion	2F
	Mean Range	30 11 -56	6F / 3M	7L (2?)	5R (4?)	1	2 symptomatic / 7 asymptomatic (4 on both sides)	

bone is more common in females which was in line with our series (Table II) (female to male ratio is 2:1, as in larger series), in African-Americans (1,6%) and up to 9% in West African natives (6). This coalition is mostly bilateral but – if unilaterally present – more common on the left side. This is probably the reason why we encountered more LTC on the left side.

It is usually considered as an asymptomatic normal variant. LTC can be associated with other hand-wrist abnormalities. Complicated carpal fusions are likely to be associated with more widespread anomalies.

In our series we only found Minnaar type 1 (33%) and 3 (67%) LTC based on plain film.

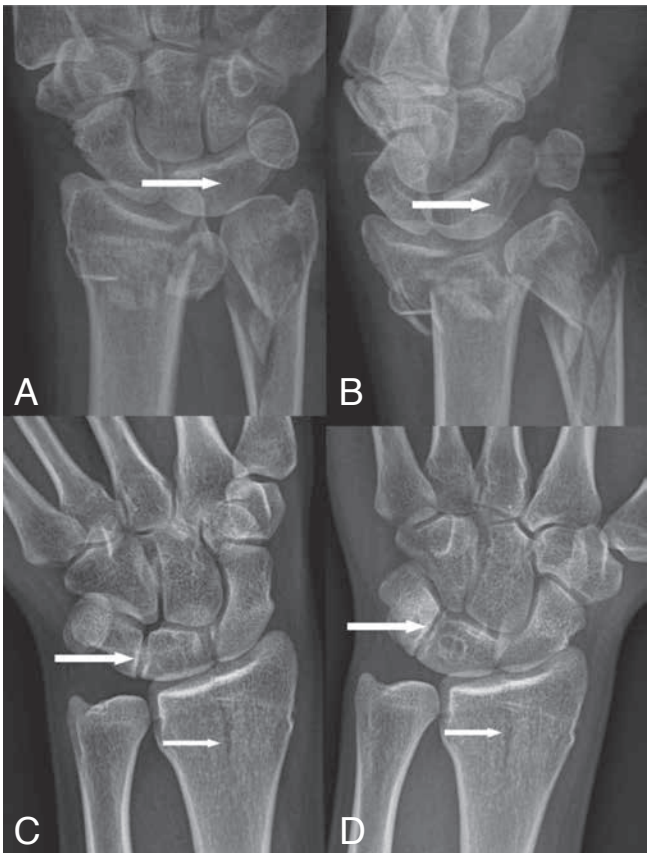

Fig. 4. — Asymptomatic variant. Plain radiography. A. and B. A LTC (arrows) type 3 was found during X-ray examination after major trauma (patient 4). C. and D. A LTC (long arrows) type 1 was found during X-ray examination after minor trauma (short arrows) (patient 5).

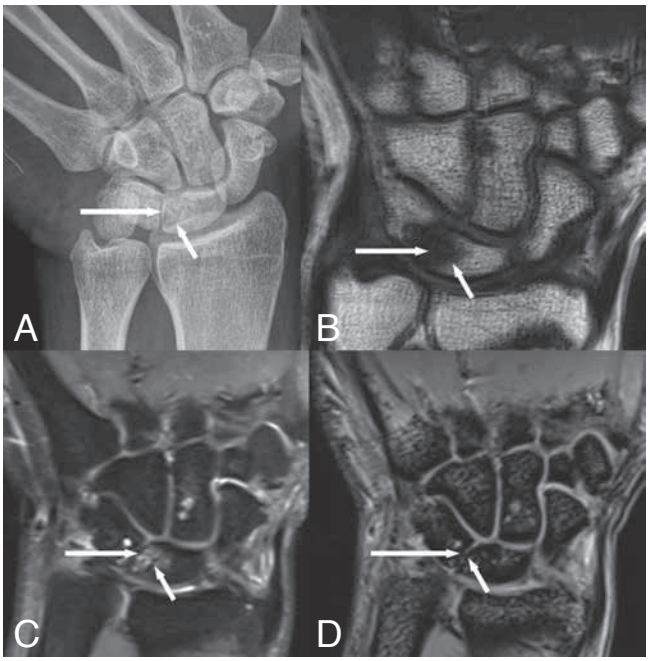

Fig. 5. — LTC type 1 (patient 1). A. Plain radiography, B. Coronal SE T1-WI, C. Coronal SE T2-WI and D. Coronal 3D-GRE. A. The LTJ is narrowed with irregular margins (long arrow) and subchondral cysts (short arrow). B, C and D: The LTJ is filled with fibrovascular tissue (long arrows). There is oedema (B, C,short arrows) surrounding a subchondral cyst (C) (short arrow) and the margins are irregular (D) (short arrow).

The type 1 coalition may become symptomatic due to the pseudarthrosis or – as for all structures – in case of fracture. The weaker fibrocartilaginous coalition appears to be more susceptible to stress or trauma. The deficient intra-articular cartilage formation at the lunotriquetral joint results in a clinical and anatomic condition similar to degenerative osteoarthritis (9). The cartilage of the surrounding joints may become damaged as well due to disturbed motion. Our two symptomatic patients had a type 1 Minnaar LTC. Although carpal fusion is mostly an asymptomatic condition, symptoms may appear in specific conditions such as after intense and repeated movements. A possible alteration of the normal biomechanics of the wrist may cause an abnormal stress on the contributing joints and the surrounding soft tissues.

In rare cases fibrocartilaginous type 1 LTC may be an uncommon cause of ulnar sided pain in the wrist due to the pseudarthrosis or a post-traumatic disruption of the fibrocartilagineous LTC (10). Two of our pa-

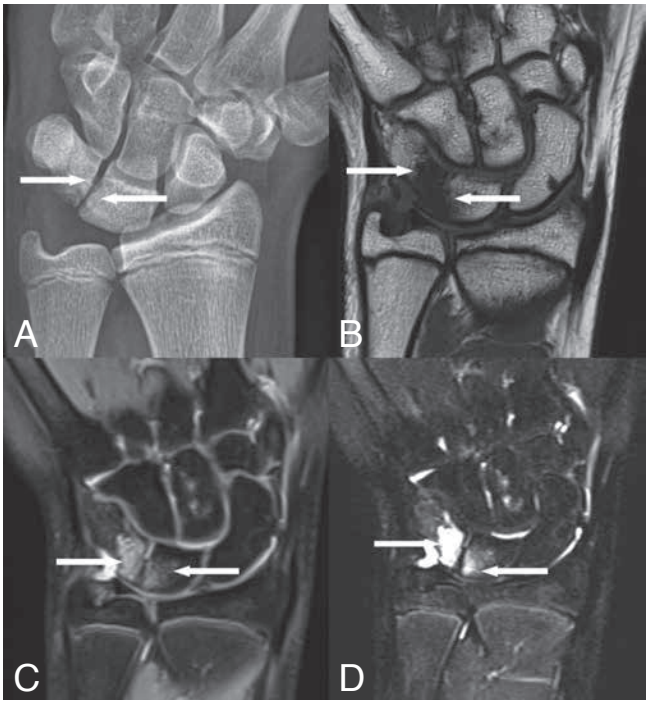

Fig. 6. — Symptomatic patient with LTC type 1 (patient 3). A: Plain radiography and B: Coronal SE T1-WI, C, SE proton density and D, SE T2-WI. Type 1 LTC with subchondral cysts (A) and surrounding edema (B-D) in a patient with ulnar sided wrist pain.

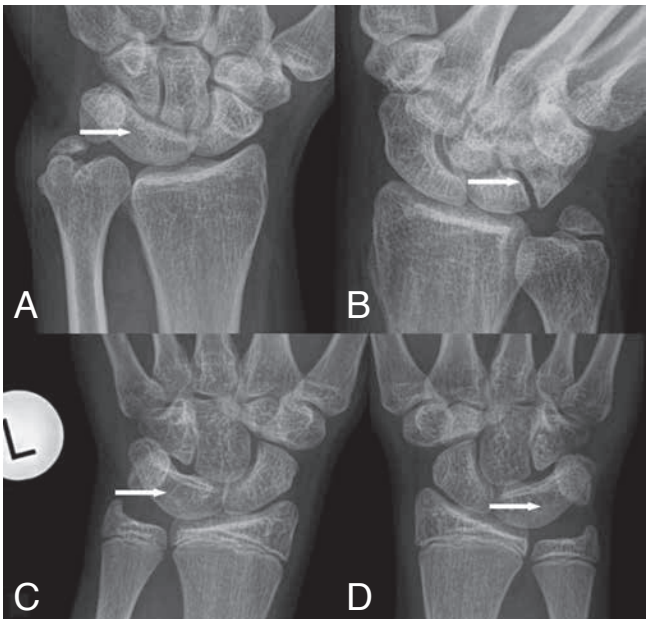

Fig. 7. — Bilateral LTC in the same patient. Plain radiography. A. Type 3 LTC on the left side and B and type 1 LTC on the right side (patient 2). C and D, LTC type 3 on both sides (patient 6).

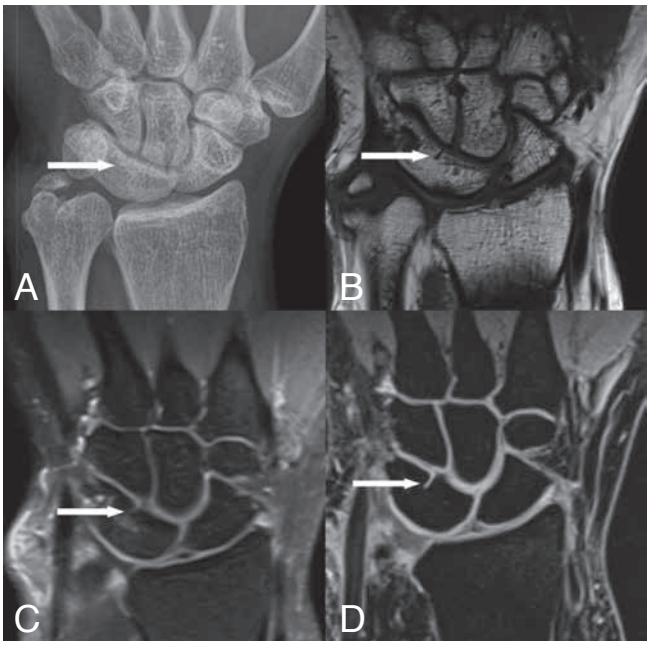

Fig. 8. — Reevaluation on MRI compared to plain radiography (patient 2). A. Plain radiography, B: Coronal SE T1-WI, C: Coronal SE T2-WI and D: coronal 3D-GRE. A. Based on plain film evaluation LTC seems complete, in compliance with Minnaar type 3. B, C and D: on MRI of the same patient, a (small) distal notch can be seen, thus redefining this case as type 2 Minnaar.

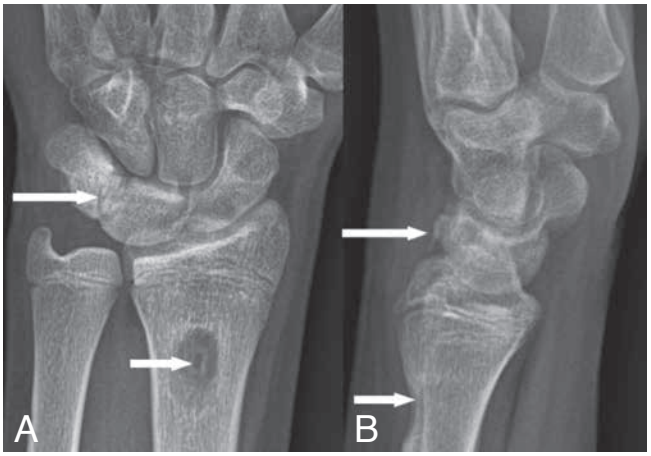

Fig. 9. — Surgical treatment of a symptomatic LTC (patient 3). Plain radiography. A corticocancellous wedge from the dorsal side of the distal radius (short arrows) was interposed between the lunate and triquetral bone (long arrows) after resection of the pseudarthrosis.

tients with type 1 LTC had ulnar sided pain. The other two with type 1 LTC were asymptomatic. Osseous LTC (type 2 and 3) of the lunate bone and the triquetral bone are in general considered as asymptomatic. However a case of painful wrist movement on the side of a complete bony fusion has been reported (8), without clear explanation of the possible pathogenetic mechanism. All of our six patients with type 3 LTC (of whom two bilateral) were asymptomatic. Although fractures of osseous coalitions also have been reported, some suggest that these might have been symptomatic fibrocartilaginous types (10).

Plain film findings

LTC type 1 resembles a pseudarthrosis with irregular sclerotic margins. There is a narrowed joint space (LTJ) between the lunate bone and triquetral bone, possibly with subcortical cysts. This non-osseous coalition may result in degenerative osteoarthritis due to abnormal joint mechanics and the thin cartilage between the affected carpals (11).

In type 2 there is an incomplete osseous fusion with trabeculae traversing the lunotriquetral joint space and a (small), mostly distal (but occasionally also proximally) remnant of the joint space, whereas in type 3 the osseous fusion between the lunate bone and the triquetral bone is complete and forms a so called os lunatotriquetrum. In type 4 other carpal congenital abnormalities are associated with the complete osseous LTC.

Remarkably LTC has been associated with a widening of the scapholunate joint space (12), which does not reflect a scapholunate ligament disruption. This differential diagnosis may be particularly important in a post-traumatic setting. This widening is namely caused by a compensatory thickening of the cartilage on the opposing surfaces of the scaphoid bone and the lunate bone.

Examination of the opposite wrist may be useful as LTC is often bilateral (6) (about 60%) but not always of the same type.

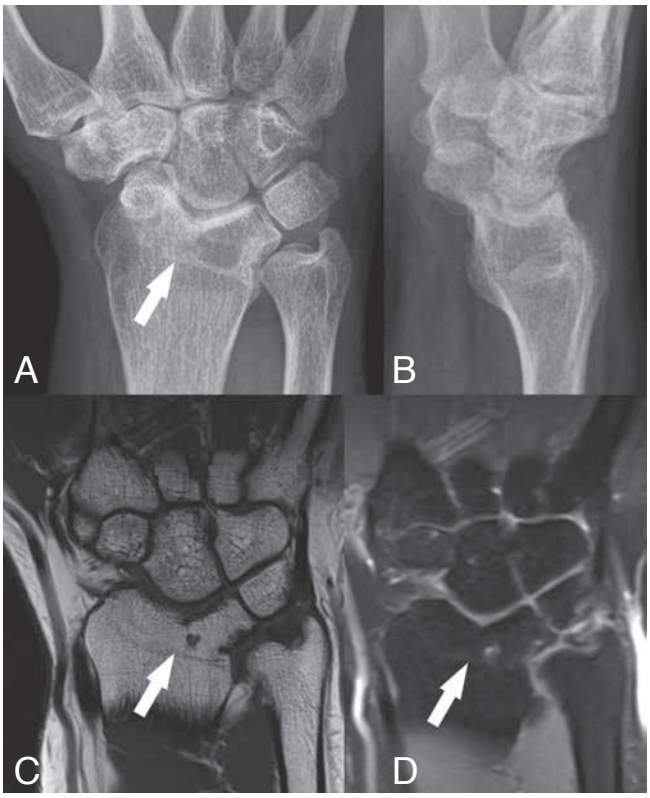

Fig. 10. — Secondary fusion due to arthritis. A and B: Plain radiography, C: Coronal SE T1-WI and D: Coronal SE T2-WI. There is a carpal "coalition" (here between the scaphoid and the lunate) but also an associated "coalition" with the radius (arrows). The scaphoid bone has lost a part of its volume and the proximal cortical delineation of the lunate bone is irregular. The fusion is secondary to a juvenile arthritis.

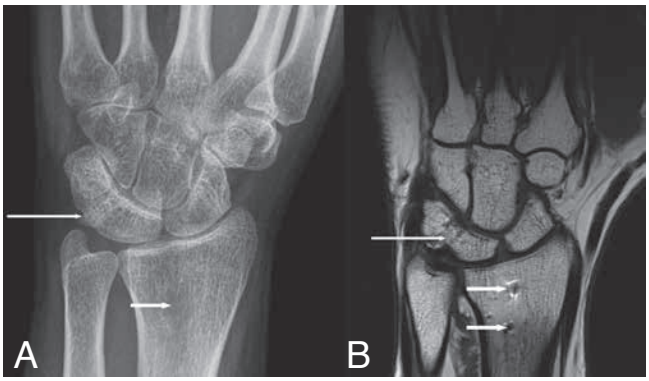

Fig. 11. — Secondary fusion due to surgery for a lunotriquetral ligament lesion. A: Plain radiography and B: Coronal SE T1-WI. There is a carpal "coalition" between the lunate bone and the triquetral bone (long arrows). Notice the bony defect after prelevation of a bone graft in the distal radius (A, short arrow) and the susceptibility artifacts after surgery (B, short arrows).

MRI findings

MRI in LTC type 1 shows the pseudarthrosis with irregular sclerotic margins a narrowed joint space filled with fibrocartilage between the lunate and triquetral bone, subchondral cysts and may additionally show bone marrow edema on fluid-sensitive sequences adjacent to lunatotriquetral joint in symptomatic cases. After contrast administration the edema and the fibrovascular tissue

Table III. — Carpal coalitions in association with other abnormalities. Differential diagnosis.

Disease	Abnormalities
Turner's syndrome	– dorsal and radial bowing of the radius (Madelung deformity) – short fourth metacarpal with a positive metacarpal sign (positive sign of Kosowicz) – carpal angle less than 117°
Ellis-van Creveld syndrome	– fusion of the capitate and hamate bone – extra carpal bones – malformed carpals – broad, short middle phalanx – polydactyly ("six-fingered dwarfism")
Holt-Oram syndrome	– polydactyly – hypoplastic or triphalangeal thumb – partial or complete absence of the radial bone – accessory carpal bones
arthrogryposis	– camptodactyly – ulnar deviation
diastrophic dysplasia	– dwarfism – narrow joint spaces – hitchhiker thumb
Nievergelt-Pearlman syndrome	– symphalangism
foetal alcohol syndrome	– radio-ulnar synostosis
hand-foot-uterus syndrome	– deformed scaphoid bone
oto-palatodigital syndrome	– anomalies of shape and position of carpal bones as comma shaped trapezoid and transverse position of the capitates bone
symphalangism	– partial or total absence of interphalangeal joints

in the synovium and the subcortical cysts will enhance (13), although this does not add any clear diagnostic information.

MRI may provide the necessary information about the condition of the surrounding articular cartilage and may also exclude concomitant pathology of the wrist, which is to be evaluated certainly if any operative treatment is considered.

In type 2 LTC there is an incomplete proximal osseous fusion and a (small) mostly distal notch filled with hyaline cartilage, whereas in type 3 the osseous fusion is complete. MRI will evaluate the LTJ more in detail. Due to the absence of osseous superposition, MRI allows a more accurate evaluation and classification than plain radiography. Type 3 coalitions will often be reclassified on MRI as a type 2 LTC. However this does not seem to have any clinical importance.

In type 4 possibly additional soft tissue anomalies are illustrated as well.

Differential diagnosis

Carpal coalitions may be associated with other hand-wrist abnormalities (Table III). LTC specifically is most frequently seen in Turner's syndrome, Ellis-van Creveld syndrome, Holt-Oram syndrome and arthrogryposis.

Anamnesis and clinical information should always exclude an acquired fusion secondary to arthritis (Fig. 10), trauma, surgery (Fig. 11), drug intake during pregnancy or a metaplastic conversion of intra-articular structures (fibrous tissue, ligaments or cartilage) (14).

Therapy

After resection of the pseudarthrosis, lunotriquetral surgical fusion (15) may be performed in symptomatic cases (i.e. type 1) using a Herbert screw (16) and/or a corticocancellous wedge from the dorsal side of the distal radius (Fig. 9) or the iliac crest.

Normally the symptoms should disappear completely and mostly mobility is also restored, although sometimes there may be a residual a minor loss of range of motion (9).

Conclusion

Lunotriquetral coalition (LTC) – the most frequent and often bilateral type of carpal coalition – is usually considered asymptomatic. In rare cases however fibrocartilaginous LTC type 1 may be an exceptional cause of ulnar sided pain in the wrist due to the pseudarthrosis or a post-traumatic disruption of the fibrocartilaginous LTC. MRI shows the pseudarthrosis more clearly and offers a more accurate classification than plain films. It directly evaluates the symptomatic variants that may benefit from (surgical) treatment by showing eventually present bone marrow edema and subcortical cysts. Associated bone and soft tissue abnormalities will be illustrated as well. Moreover, it offers a complete preoperative cartography of the surrounding joints. Symptomatic variants may be treated conservatively or by lunotriquetral surgical fusion which may result in pain relief and restored mobility.

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