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REVIEW ARTICLE

Adult post-traumatic radioulnar synostosis

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Summary Post-traumatic radioulnar synostosis is a rare complication of forearm fracture. Resulting in loss of forearm axial rotation, it is functionally very disabling. The surgical indication, timing of operation, surgical technique, interest and type of adjuvant treatment are all issues with which physicians managing radioulnar synostosis must deal. No therapeutic consensus yet exists, but a wide variety of surgical techniques and adjuvant treatments are suggested. A literature review sought to identify risk factors for synostosis, with a view to prevention and determining a suitable therapeutic attitude in the light of existing data.

Introduction

Post-traumatic radioulnar synostosis in fracture of one or both forearm bones is a relatively rare complication, of potentially serious functional impact. It is defined as osseous or fibrous fusion of the two forearm bones, blocking pronosupination. There are numerous risk factors, prevention of some of which might prevent synostosis. Total pronosupination loss leads to severe functional impairment, not only in sports but in everyday life. Treatment is generally surgical, with variably foreseeable results according to lesion location and surgical technique. Some authors recommend adjuvant treatments to limit risk of recurrence, although their effectiveness is difficult to judge.

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Epidemiology

The incidence of post-traumatic radioulnar synostosis varies from series to series, at 0 to 9.4% of forearm fractures; the most reliable figure would seem to be that of Vince and Miller [1]: 2% (literature review of 2381 fractures). Incidence is elevated in case of neurological brain lesion; Garland et al. [2] reported an 18% rate of total radioulnar synostosis in 50 forearm fractures associated with severe cranial trauma; non-surgical management of the forearm fracture seemed to reduce the incidence of synostosis, but with poorer functional results (angular malunion or non-union). As a compromise, Garland et al. [2] recommended percutaneous intramedullary nailing, where feasible, to limit onset of severe angular malunion.

Botting described a case of post-traumatic synostosis without fracture, secondary to a knife-wound in the upper third of the forearm [3]. He suggested that synostosis may follow any wound involving the interosseous membrane.

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A particular case is that of postoperative iatrogenic synostosis following distal bicipital tendon reinsertion in the radial tuberosity, especially in dual anterior plus posterior approach techniques. These account for 2 to 5% of synostoses in adults.

Risk factors

Vince and Failla described various types of risk factor for onset of radioulnar synostosis in their series [1,4].

Trauma-related: monteggia fracture (Figs. 1 and 2), fracture of both forearm bones at the same level, open fracture, significant soft-tissue lesion, comminutive fracture, high-energy kinetic fracture, associated cranial trauma, or bone fragments on the interosseous membrane.

Treatment-related: excessive trauma-to-surgery interval, single (Boyd) approach for synthesis of both forearm bones, cortical screws too long (extending beyond the second cortex) (Fig. 3), primary bone graft, prolonged immobilization or delayed rehabilitation.

Clinical findings

Diagnosis is founded on total prono-supination blockage some months after forearm fracture. Clinical examination finds prono-supination totally lacking in both passive and active mobilization (although a few degrees of prono-supination may be found in the radiocarpal joint [5]). Except in case of associated humeroulnar or humeroradial synostosis, elbow ROM in flexion and extension is conserved.

In total synostosis, the patient is pain-free, with the forearm completely blocked. In incomplete synostosis, on the other hand, the clinical aspect is of limited painful prono-supination.

Figure 1 Right forearm Monteggia fracture at 6 months after ulnar plate osteosynthesis: radioulnar synostosis in Hastings areas 2 and 3.

Figure 2 Right forearm Monteggia fracture at 6 months: radioulnar synostosis in Hastings areas 2 and 3.

Figure 3 Left trans-olecranal elbow dislocation: too long screw extending beyond the 2nd cortex.

Complementary examinations

Imaging

Plain AP, lateral and three-quarter radiographs confirm diagnosis and locate the synostosis. Vince's classification distinguishes three location areas for therapeutic and prognostic purposes [1].

Area 1: distal intra-articular part of the radius and ulna; this is a rare location according to Vince, associated with 100% (4/4) failure in his series and therefore with poor prognosis.

Figure 4 Left trans-olecranal elbow dislocation, 7 months after removal of osteosynthesis material: radioulnar synostosis in Hastings area 3.

Area 2: mid-third and extra-articular part of the radius and ulna. This location is frequently associated with severe trauma; surgery provides better results here, with only three failures out of 10 cases in Vince's series.

Area 3: proximal third of the radius and ulna. Vince reported two failures out of three cases (Figs. 1—4).

This classification was subsequently modified by Hastings and Graham [6] (Fig. 5).

CT scan with reconstruction provides more precise determination of location and extension, indicating the most suitable surgical approach.

Bone-scan provides the initial diagnosis, before radiography or even clinical examination, and some authors recommend it to determine the maturation and activity of the synostosis [6].

Biology

Alkaline phosphate blood assay has no diagnostic contribution, and its usefulness in follow-up remains to be proven. Furman et al. [7] reported elevated values in paraplegic patients with heterotopic calcification. Diagnosis was based on such elevated values found at the time of radiographic examination; they persisted during bone formation, and fell once the new bone was mature. Does this, however, apply to synostosis? Alkaline phosphate assay is not used in routine practice.

Indications

Which patients?

Other than in patients with contra-indications to anesthesia or with synostosis that is so extensive that total resection appears unfeasible, surgery is strongly recommended when functional tolerance is unsatisfactory. Results are variable, but surgery is the sole means of restoring active prono-supination.

When?

There is a general consensus to operate neither too early, with risk of recurrence by operating on a metabolically inactive synostosis, nor too late, with risk of definitive peri-articular soft-tissue and bone retraction.

Muheim et al. [8] recommended performing a series of bone-scans in case of heterotopic ossification in paraplegic patients, then waiting for the phase of decreasing activity before operating. The question remains as to whether this applies in synostosis.

Recommended intervals to surgery range from 6—12 months [4] to 1—2 years [1]. Friedrich et al. [5], in a series of 13 patients, reported no significant difference in prono-supination between patients operated on before versus after 12 months (range, 5—132 months). Jupiter and Ring [9] came to the same conclusion in a series of 18 patients. Cullen et al. [10] reported a fall in recurrence

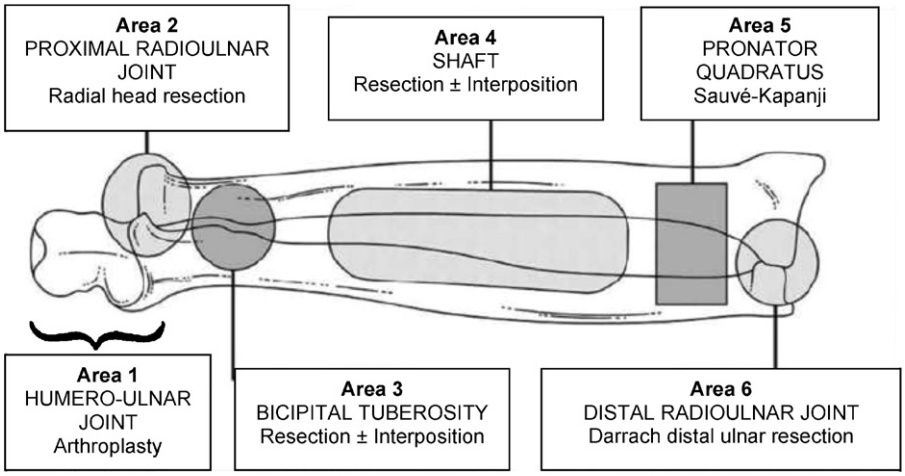

Figure 5 Hastings and Graham classification.

risk after early (a few months?) surgery with adjuvant postoperative radiation therapy; in this series, however, only one of the four patients was operated on before 6 months (at 14 weeks), and showed a good result. This is in agreement with McAuliffe and Wolfson's report [11] on elbow ossification in eight patients operated on at 3—10 months, with postoperative adjuvant radiation therapy, none of whom showed recurrence at a mean 46-months' follow-up. These series, however, were often heterogeneous; some patients underwent bone-scan, others not... At all events, bone-scan as a decision aid in scheduling surgery does not seem to be standard practice.

Surgical technique

Surgical technique depends on location. Hastings attempted a synthesis (Fig. 5).

Synostosis resection: interposition or not?

Numerous techniques have been described, none standing out as clearly optimal.

Jupiter and Ring [9] interposed a free fat flap after eight forearm synostosis resections, with no interposition in another 10 cases; no adjuvant therapy was prescribed. Results in both groups were functionally equivalent. One case of recurrence occurred, associated with initial cranial trauma; other complications comprised one fat flap migration, one ulna fracture and one fracture of a humeral pin in the dynamic external fixator used in certain cases.

Friedrich et al. [5] recently reported a series of 13 cases with fascia lata graft interposition (autograft in the first three cases, then allograft in the other 10 due to the observed risk of donor site morbidity) after synostosis resection; at a mean 30-months' follow-up, there were two moderate, two good and nine excellent results, with a single postoperative complication (scar dehiscence requiring surgical revision).

Bell and Benger [12] reported a series of three patients undergoing proximal synostosis resection with vascularized anconeus muscle interposition; there were no postoperative complications, and prono-supination ROM at 12 months was 100°, 110° and 150° respectively.

In Failla's et al. series [4], interposition was used in 12 (out of 20) patients: silicone gum leaf in eight cases, muscle in two, fat, fascia and polyethylene in one, and silicone block in one; results were excellent in four cases, good in three, moderate in four and poor in nine. Biologic interposition material was associated with exclusively moderate or poor results, but interposition of no particular material could be shown to be optimal or more beneficial than isolated resection.

Sugimoto et al. [13] reported a case of proximal radioulnar synostosis managed by resection and interposition of a vascularized fat flap taken from the distal third of the forearm, sparing the posterior interosseous artery; ROM at 1 year was 10° in pronation and 55° in supination. Likewise, Sonderegger et al. [14] interposed a vascularized adipofascial flap after radioulnar synostosis resection in seven patients; mean ROM was 70° in pronation and 70° in supination.

Hastings and Vince [1] recommended the Darrach procedure (resection of the distal part of the ulna) for distal synostosis; Vince, however, in a series of four patients, reported three poor results using this technique, the 4th having undergone resection with silicone interposition, with an equally poor result.

To sum up: there is at present no consensus regarding the benefit of interposition following synostosis resection or the material used (fat flap whether vascularized or not, muscle, fascia lata, cellophane, silicone, etc.), although fascia lata autograft seems to provide the best results.

Synostosis conservation

In proximal synostosis, Kelikian and Doumanian [15] in 1957 developed a swivel to be inserted in the radial shaft between the supinator and pronator teres muscle insertions, associating two procedures: muscle transfer (flexor carpi ulnaris or carpi radialis) to restore satisfactory supination, and ulnar styloid resection to achieve pain-free prono-supination. Only two results were reported (for four patients operated on): both seemed satisfactory, with prono-supination ROM of 75° and 85° respectively.

Kamineni et al. [16] recommended proximal radius resection in Vince-Miller type III synostosis, creating non-union. He considered the technique to have three indications in radioulnar synostosis:

- synostosis too extensive for safe resection;
- synostosis extending to the joint surface;
- associated anatomic deformity.

In a series of seven patients, with bone wax and Gelfoam plus, in one case, anconeus muscle interposed in the resection site, he reported encouraging results (one poor, one moderate, one good and four excellent) at a mean 80-months' follow-up; there was one case of ulnar nerve paresthesia.

In distal synostosis (Vince-Miller area 1 or Hastings areas 5 and 6), the Sauvé-Kapandji procedure may be applied (Figs. 6—8).

Adjuvant treatments

Bisphosphonates have failed to prove efficacy in preventing calcification secondary to total hip replacement (THR) [17]. Theoretically, they inhibit osteoid matrix calcification, but there would appear to be a rebound effect on cessation. To the best of our knowledge, there have been no studies of bisphosphonates in the prevention of recurrence after radioulnar synostosis resection, and they seem not to have been used in any of the relevant series.

Indomethacin proved effective in preventing heterotopic hip ossification after THR, at a dose of greater or equal to 75 mg per day [18], but no comparable study could be retrieved for the prevention of radioulnar synostosis recurrence.

Certain authors use low-dose radiation therapy. It proved effective in preventing heterotopic hip ossification after THR [19]. In radioulnar synostosis, Cullen et al. [10], reporting on a series of four patients, recommended a single dose of

Figure 6 Comminutive fracture of the inferior extremities of both left forearm bones; 6 month X-ray of plate reduction osteosynthesis: radioulnar synostosis in Hastings areas 2 and 3.

Figure 7 Radioulnar synostosis in Hastings areas 2 and 3 treated by Sauvé-Kapandji procedure.

800 cGy within 4 days of resection; there were no radiation-related complications or cases of recurrence. Other authors applied radiation therapy in all [20] or in only proximal synostosis [5,12], without radiation-related complications or recurrence. Kim et al. [21] found no sarcomas induced by doses of less or equal to 3000 rad at 3 weeks' follow-up. Finally, Jupiter and Ring [9] considers any adjuvant treatment unnecessary.

There is thus no present consensus as to the benefit or type of adjuvant, although the good results found in regard to hip calcification may promise similar effects in preventing

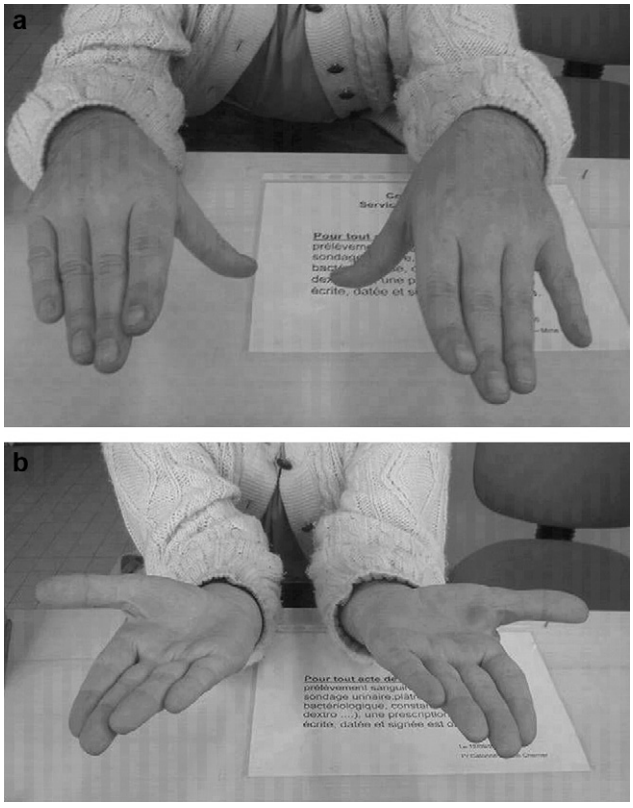

Figure 8 a: left radioulnar synostosis in Hastings areas 2 and 3: clinical result at 4 months after Sauvé-Kapandji procedure; pronation is maximal; b: left radioulnar synostosis in Hastings areas 2 and 3: clinical result at 4 months after Sauvé-Kapandji procedure; supination is maximal.

radioulnar synostosis: radiation therapy as used in the above four series seemed clearly effective in terms of recurrence and absence of complications, although the series were small.

Postoperative rehabilitation

There is unanimous agreement as to the importance of early and intensive rehabilitation but, as with adjuvants, no consensus as to its form. Splinting in maximum pronation and supination is often used between passive and active physiotherapy; some authors developed a dedicated thermoformed apparatus [12,22].

Recurrence rates

The only series in which recurrence was reported were those of Vince and Miller [1] (29%: 5/17, but with none in area 2) and Jupiter and Ring [9] (5.55%: 1/18, in a patient with initial cerebral trauma).

Conclusion

Radioulnar synostosis is a rare complication of forearm trauma. Prevention involves rigorous surgical management of fractures of both forearm bones.

Treatment is surgical. Procedure is now consensual, basically depending on synostosis site as categorized by Hastings. In contrast, interposition and adjuvant treatment to prevent recurrence remains to be demonstrated, given the low incidence of post-traumatic radioulnar synostosis itself. Postoperative rehabilitation is fundamental, and should be early and intensive in order to maintain postoperative ROM.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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