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ORIGINAL PAPER

Radial tunnel syndrome: results of surgical decompression by a postero-lateral approach

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Abstract
Purpose Our purpose is to describe the results obtained in surgical treatment of a series of patients with symptoms of radial tunnel syndrome.
Methods We performed a prospective study on 42 patients (43 limbs) operated for radial tunnel syndrome between 1996 and 2010, using a posterior-external approach.
Results Using the Roles and Maudsley criteria, 21 patients had excellent results (48.8%), 16 good (37.2%) and six fair results (13.9%). Most patients were satisfied with the surgery, reporting symptom relief and improved functionality.
Conclusions Radial tunnel syndrome consists of intermittent compression of the posterior interosseous nerve in the forearm, with pain and functional disability of the forearm, without motor or sensory electromyogram alterations. Because it is often confused with enthesitis of the epicondyle muscle insertions (an entity often occurring simultaneously), differential diagnosis is necessary with treatment-resistant epicondylitis. The most effective treatment is surgical, releasing all possible nerve compression sites.

Keywords Radial tunnel syndrome · Distal neurolysis of the arcade of Frohse · Resistant epicondylitis

Introduction

Radial tunnel syndrome (RTS) is a painful syndrome in the proximal forearm area caused by compression of the posterior interosseous nerve (PIN), the motor branch of the radial nerve, at forearm level [1–8]. It is sometimes called resistant epicondylitis because it has been confused on multiple occasions with epicondylitis resistant to medical and surgical treatment and because of the interrelation between both pathologies [3, 6, 7, 9].

The syndrome was characterised for the first time by Roles and Maudsley in 1972. However, some authors indicate that the first to describe this pathology were Michele and Krueger in 1956, who called it radial pronator syndrome [3, 6, 7, 10]. In 1966 Sharrard published the first series of patients with RTS treated surgically [8].

It is characterised by a dynamic compression of the PIN brought about by repetitive pronation-supination forearm movements [11, 12]. The most frequent causes [3, 4, 6, 7, 13–16] are: fibrous bands located above the radial head; recurrent radial vessels jumping over the nerve in the area most proximal to the lateral epicondyle, which increase blood flow to the extensor, supinator and brachialis muscles during exercise, compressing the PIN; proximal aponeurotic insertion of the second radial; and the arcade of Frohse, formed by the two muscle bellies of the supinator, which surround the nerve and can also produce compression inside the supinator or at its distal border (Fig. 1).

The most normal clinical presentation of this entity is the presence of pain in the proximal radial area of the forearm at the level of the radial tunnel, in the external and posterior side of the forearm, at some 5 cm distal to the epicondyle region following the lateral epicondyle-radial styloid process; the pain increases with pressure in this area and with other provoking manoeuvres: (1) pain upon supination against resistance with the elbow in extension, to avoid the supinator force of the brachial biceps and the wrist in dorsiflexion, which provokes the contraction of the supinator muscle, and (2) pain upon extension against resistance of the third finger with the elbow extended and the wrist in neutral position, because it produces the contraction of the extensor carpi radialis brevis (ECRB) (second radial) that inserts in the base of the third metacarpal [3–7, 13–15, 17, 18].

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The neurophysiological study, static electromyogram (EMG), is negative because there is no involvement of nerve conduction [3, 9, 14, 15]. This makes diagnosing the condition more difficult [5, 10, 14, 17]. A decrease in the speed of motor conduction has been shown in patients with RTS during contraction against resistance of the supinator [5]. A reliable test is infiltration of a local nerve anaesthetic at the level of the radial tunnel, which makes the symptoms disappear [4–6, 8, 15].

Differential diagnosis is necessary with multiple entities. The most important of these are lateral epicondylitis (enthesitis of the insertion of the epicondyle muscles) and PIN syndrome, characterised by painless motor alterations, normally provoked by the compression of the nerve by masses and including EMG alterations [19]; multiple authors describe the relation with other nerve compression syndromes such as carpal tunnel syndrome or cubital tunnel syndrome [18].

The treatment of choice is surgery. There are two main approaches: anterior and posterior or transmuscular, freeing all the possible sites of PIN compression [3–5, 8]. Postoperative results are satisfactory in the majority of the cases, although there are certain differences among authors [3, 5, 6, 8, 9, 13].

The objective of this article was the study of a cohort of 42 consecutive patients treated for radial tunnel syndrome in the Hospital Clínico Universitario in Valladolid (HCUV) (Spain).

Material and methods

From 1996 to 2010, 42 patients (43 upper limbs) were treated surgically for RTS. We performed a prospective study of the patients, with the next criteria for inclusion being pain in the proximal posterior-external area of the forearm (arcade of Frohse) without presence of any masses or sensory or motor alterations of the radial nerve on electroneuromyography.

For each patient we gathered the following information for variables studied (Tables 1 and 2): personal patient data (age, gender, occupation, etc.), prior antecedents, relation with resistant epicondylitis and previous treatments, clinical symptoms and results of physical and complementary examinations, surgical technique used, and postoperative follow-ups.

Results were assessed using the criteria of Roles and Maudsley and the degree and patient satisfaction.

Roles and Maudsley criteria:

- Excellent: no pain, complete mobility and full range of activity.
- Good: occasional symptoms of discomfort, complete mobility and full range of activity.
- Fair: some symptoms after prolonged activity.
- Poor: pain that limits activity.

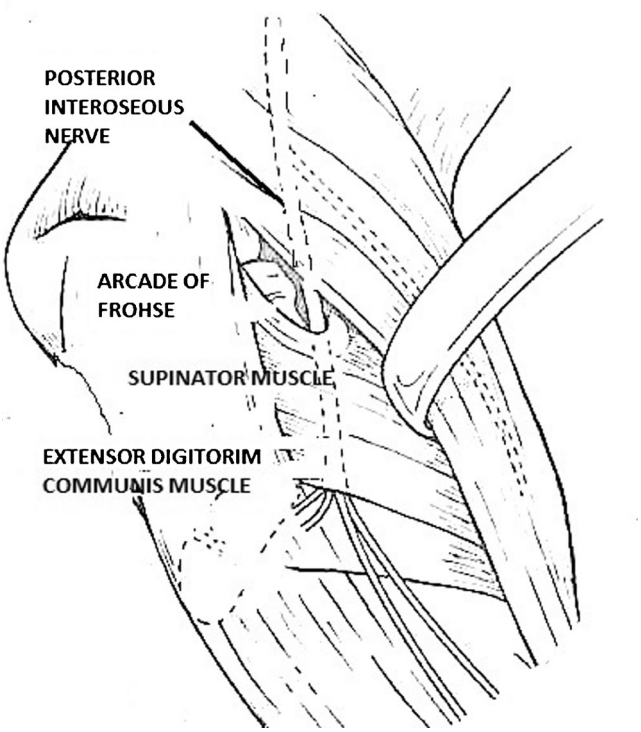

Fig. 1 Anatomy arcade of Frohse by postero-lateral surgical approach

The same surgeon, using the same surgical technique, carried out all the surgical procedures. This surgical technique involved a posterior-external incision at the line that joins the lateral epicondyle with the radial styloid, 2–3 cm distal to the epicondyle and 8–9 cm in length. Dissection was between the second radial and the common extensor of the fingers after opening the fascia (Fig. 2). Release of the nerve was at the level of the insertion of the second radial. There was section of the superficial part of the proximal edge of the supinator muscle (Fig. 3) and of all the muscle belly until the distal border of the supinator (Fig. 4). There was visualisation of all possible areas of compression of the PIN and complete release of the nerve (Fig. 5). Closure of the fascia with transversal incisions as used to decrease the strength of the epicondyle muscles. A plaster splint was placed for two weeks.

Results

Clinical characteristics

Thirty-one patients (32 procedures) were female (74.4 %) and 11 (25.6 %) were male, with ages ranging from 19 to 59 years (mean age of 42 years) at the time of intervention. Most of the patients had jobs involving repetitive manual work (housewife, hairdresser, mechanic, nursing assistant, etc.).

In 32 patients the affected was the dominant limb (76.2 %), in nine patients the non-dominant limb (21.4 %) and in one patient, both limbs (2.4 %). Five patients (11.9 %) had

Table 1 Patient data

Upper limb (UL)	Age (years)	Sex	Occupation	Limb operated	Prior traumatism	Symptom duration (months)	Previous treatments		
							Drugs	Infiltration	RH
1	47	F	Housewife	RD	No	24	Yes	2	Yes
2	46	F	Assistant	RD	No	5	No	No	No
3	39	F	Assistant	RD	No	24	No	No	Yes
4	42	F	Housewife	RD	No	18	No	No	Yes
5	43	F	Housewife	LND	No	6	No	No	No
6	55	F	Housewife	LND	Yes	4	Yes	No	No
7	19	F	Student	RD	Yes	24	No	1	Yes
8	49	F	Cleaning staff	RD	No	9	No	3	Yes
9	33	F	Housewife	LND	No	19	No	4	No
10	53	F	Greengrocer	RD	No	6	Yes	No	No
11	50	M	Retired	LND	No	16	No	8	No
12	51	F	Physician	LND	No	36	No	2	No
13	39	F	Physician	RD	No	6	No	No	No
14	27	F	Office worker	RD	No	12	No	No	No
15	35	F	Secretary	RD	No	7	No	No	No
16	56	M	Mechanic	RD	No	15	Yes	3	Yes
17	37	F	Housewife	RD	No	10	No	No	No
18	42	F	Nurse	RD	No	3	No	No	No
19	51	M	Carpenter	RD	No	7	No	1	No
20	28	F	Hairdresser	RD	No	5	No	No	No
21	31	F	Secretary	LND	No	11	Yes	No	No
22	43	F	Cleaning staff	RD	No	22	No	3	No
23	45	M	IT technician	LND	Yes	4	Yes	No	No
24	54	M	Conductor	RD	No	5	No	No	No
25	29	F	Clerk	RD	No	8	No	2	No
26	28	F	Hairdresser	RD	No	9	No	1	Yes
27	49	F	Housewife	RD	No	18	Yes	1	Yes
28	52	F	Porter	RD	No	7	Yes	No	Yes
29	59	M	Construction	RD	No	12	No	No	Yes
30	48	F	Housewife	RD	No	10	Yes	No	Yes
31	29	M	Construction	RD	Yes	20	No	1	Yes
32	46	F	Cleaning staff	RD	No	10	Yes	1	Yes
33	33	F	Housewife	LND	No	12	Yes	No	Yes
34	52	M	Upholsterer	LND	No	6	Yes	2	Yes
35	47	F	Office worker	RD	No	8	No	No	Yes
36	36	F	Secretary	RD	No	7	Yes	No	No
37	51	M	Mechanic	RD	No	24	Yes	2	No
38	40	F	Assistant	RD	No	10	No	No	Yes
39	45	F	Nurse	RD	No	3	No	No	Yes
40	51	M	Assembly line	RD	No	9	No	1	Yes
41	38	F	Hairdresser	RD	No	12	No	No	Yes
42	31	F	Administrative	LND	No	11	Yes	No	No
43	51	M	Construction	RD	No	18	Yes	1	Yes

F female, *LND* left extremity non-dominant, *M* male, *RD* right extremity dominant, *RH* rehabilitation

Table 2 Patient data

Upper limb (UL)	EMG	Sensory symptoms	Signs				Mobility	Other compressions	Roles & Maudsley results	Comments
			RT	SU	MR	F				
1	Good	No	Yes	Yes	Yes	No	Good	Cubital tunnel syndrome	Excellent	Bosworth
2	Good	No	Yes	Yes	Yes	No	Good	No	Excellent	
3	No	No	Yes	Yes	Yes	No	Good	CTS	Good	
4	Good	No	Yes	Yes	Yes	No	Good	CTS	Good	
5	Good	No	Yes	Yes	Yes	No	Good	De Quervain's	Good	
6	No	No	Yes	Yes	No	No	Good	Trigger finger	Excellent	Bosworth
7	No	No	Yes	No	No	No	Good	No	Excellent	Bosworth
8	Good	No	Yes	Yes	No	No	Good	CTS, trigger finger	Regular	Polyarthralgia, work-related disability
9	Good	No	Yes	Yes	No	No	Good	CTS	Good	
10	No	No	Yes	Yes	Yes	No	Good	No	Good	Bosworth, job change
11	No	No	Yes	Yes	Yes	Yes	Good	No	Excellent	Bosworth
12	No	No	Yes	No	No	No	Good	No	Excellent	Bosworth
13	Good	No	Yes	Yes	Yes	No	Good	No	Regular	Extensor paresis, partial recovery
14	No	No	Yes	Yes	Yes	No	Good	CTS	Good	
15	No	No	Yes	Yes	Yes	No	Good	No	Regular	Extensor paresis, complete recovery
16	No	No	Yes	No	No	Yes	Good	No	Excellent	Bosworth
17	No	No	Yes	Yes	Yes	No	Good	CTS	Excellent	
18	Good	No	Yes	Yes	Yes	No	Good	No	Good	
19	No	No	Yes	Yes	No	Yes	Good	No	Good	Bosworth
20	Good	No	Yes	Yes	Yes	No	Good	De Quervain's	Regular	Extensor paresis, complete recovery
21	Good	No	Yes	Yes	Yes	No	Good	No	Excellent	
22	No	No	Yes	Yes	No	Yes	Good	No	Regular	Bosworth
23	No	No	Yes	Yes	Yes	No	Good	No	Excellent	
24	No	No	Yes	Yes	Yes	No	Good	No	Excellent	
25	No	No	Yes	Yes	Yes	No	Good	Trigger finger	Excellent	
26	No	No	Yes	Yes	Yes	No	Good	CTS	Good	
27	Good	No	Yes	Yes	Yes	No	Good	No	Excellent	Bosworth
28	Good	No	Yes	Yes	Yes	No	Good	No	Excellent	
29	No	No	Yes	Yes	Yes	No	Good	No	Good	
30	Good	No	Yes	Yes	Yes	No	Good	CTS	Good	
31	No	No	Yes	No	No	No	Good	No	Excellent	
32	Good	No	Yes	Yes	No	No	Good	CTS	Regular	Polyarthralgia
33	Good	No	Yes	Yes	No	No	Good	No	Excellent	
34	No	No	Yes	Yes	Yes	Yes	Good	No	Excellent	
35	No	No	Yes	Yes	Yes	No	Good	No	Good	
36	No	No	Yes	Yes	Yes	No	Good	No	Good	
37	No	No	Yes	Yes	Yes	No	Good	No	Excellent	
38	No	No	Yes	Yes	Yes	No	Good	No	Excellent	
39	Good	No	Yes	Yes	Yes	No	Good	No	Good	
40	No	No	Yes	Yes	No	Yes	Good	No	Good	
41	Good	No	Yes	Yes	Yes	No	Good	No	Excellent	
42	No	No	Yes	Yes	No	Yes	Good	No	Excellent	
43	No	No	Yes	Yes	Yes	No	Good	No	Good	

CTS carpal tunnel syndrome, *EMG* electromyogram, *F* force, *MR* resisted middle finger extension, *RT* pain radial tunnel, *SU* resisted supination

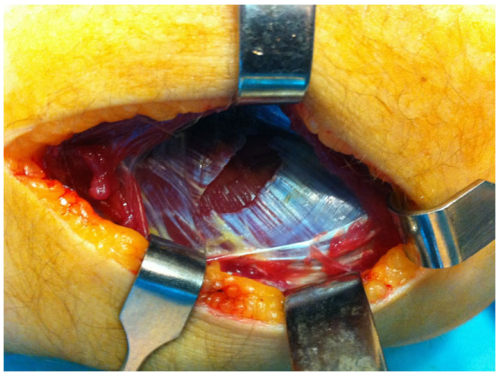

Fig. 2 Dissection between the second radial and the common extensor of the fingers and section of the supinator muscle

suffered a prior traumatism. The duration of the symptoms ranged from three months to 36 months (mean of 13.9 months).

Before the surgical procedure, multiple conservative treatments were carried out (Table 1). One patient (2.3 %) was previously operated on for lateral epicondylitis, without improving the symptoms.

The test of supination against resistance was positive in 40 procedures (93 %) and the middle finger extension resistance test was positive in 30 (69.7 %). A loss of wrist force due to pain was observed in eight procedures (18.6 %).

No patient presented paresthesias or dysesthesias in the radial innervation area. In eight procedures there were CTS (18.6 %), and one patient cubital tunnel syndrome (2.3 %) associated to RTS. Elbow mobility was complete in all the arcs of motion in all the patients studied (100 %).

Eleven patients also presented selective pain at the level of the lateral epicondyle, related with enthesitis of the epicondyle muscles at their insertion, associated with a radial tunnel (25.6 %).

Elbow X-rays were taken in 18 patients; the results were normal in 17 patients, while one patient presented sclerosis of the lateral epicondyle secondary to the multiple infiltrations carried out. In ten patients (23.2 %) a NMR was performed;

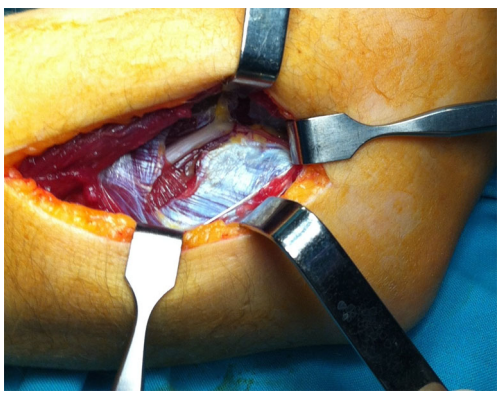

Fig. 3 Section of the superficial part of the proximal border of the supinator muscle

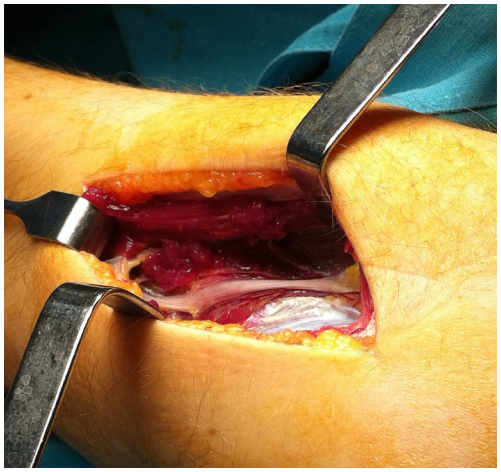

Fig. 4 PIN decompression in the distal border of the supinator

normal results were reported for six patients (13.9 %) and four patients (9.3 %) showed non-specific inflammatory changes (Table 2).

An EMG study was carried out on 17 patients, with the nerve conduction velocity for the PIN being normal in all of them (39.5 %).

Surgical findings

The approach described previously was used in all patients, releasing the nerve from all the possible compression sites. No masses or anatomical alterations were observed in any patients. In the majority of the patients, signs of possible PIN thinning were found.

All of them presented greater nerve compression at the level of the proximal border of the supinator in the intraoperative provocation procedures. Likewise, such compression was also observed at the level of the distal border of that nerve in nine patients (20.9 %).

The presence of varicosity was seen in the vasa nervorum of the PIN at the level of the radial tunnel in 23 patients

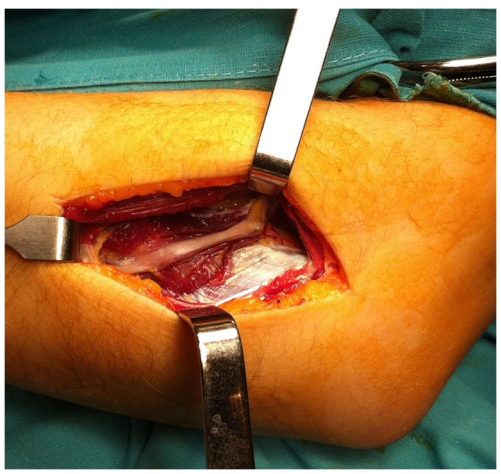

Fig. 5 Visualisation of compression of the PIN

(53.4 %). There were fibrous adhesions of the superficial bundle of the supinator muscle in ten patients (23.2 %). In seven patients that had received multiple infiltrations (16.2 %), great fibrosis was observed under the lateral epicondyle in the extensor muscle insertion. We performed a simultaneous modified Bosworth technique in 11 patients (25.6 %), as they presented symptoms of lateral epicondylitis in addition to RTS.

Mean follow-up time for the patients was 22 months (minimum, four months; maximum, six years and four months).

At present, 21 patients (48.8 %) present no symptoms, 16 patients (37.2 %) present occasional symptoms and six patients (13.95 %), symptoms with repetitive activities. Elbow mobility is complete in all patients, while all of the patients except one (2.3 %) recovered wrist force.

As for complications associated with the intervention, we observed a paresis of the common extensor of the fingers (lack of complete extension of the middle and ring fingers) in three patients (6.9 %). Two of them recovered complete extension in less than three months; one patient recovered only partial extension, with a lack of 15° in the metacarpophalangeal (MCP) joints of the middle and ring fingers (although the later EMG study did not show any nerve conduction abnormalities).

All of the patients reported that they had improved after the intervention, although one patient would not choose to be operated again knowing the results if the same thing should happen once more.

Using the criteria of Roles and Maudsley, the results were excellent in 48.8 % of the patients, good in 37.2 % and fair in 13.9 % of the patients. One patient with polyarthritis who achieved only a fair result requested work-related disability and two patients asked for a change in their job positions due to the impossibility of performing strong repetitive movements (7.14 %).

Discussion

Radial tunnel syndrome is a nerve compression syndrome with special characteristics, given that in spite of compressing a motor nerve (the PIN), it does not produce motor or nerve alterations [3, 4, 7, 8, 10, 14, 15].

Roles and Maudsley described this syndrome in 1972, with excellent results following surgical treatment of radial tunnel decompression; however, since that time, many authors have published results that are also good, but not as successful as those published by Roles and Maudsley [3, 6, 7, 13].

The diagnosis of RTS is chiefly clinical, with the most characteristic symptoms being pain at the level of the radial tunnel that increases with pressure, as well as weakness and heaviness in the forearm, especially after exertion. None of our patients presented motor anomalies, but an elevated percentage of them positive results in the provocation manoeuvres, supination against resistance and the middle finger test [4, 6, 7, 9, 14, 15, 18].

The appearance of paresthesias and limitations in elbow and hand mobility are infrequent [13, 14]. A significant number of patients complain of loss of wrist force, probably due to the pain that picking up weight causes them from the contraction of the extensor muscles. There are no alterations in the normal static neurophysiological state with a normal nerve conduction velocity [3, 5, 6, 9, 10, 13–15]. This is all due to the fact that the PIN is compressed intermittently by the muscles that form the radial tunnel, causing pain [6, 11, 12, 14].

In general, RTS is a mainly dynamic nerve compression syndrome. This was demonstrated in several studies in which a decrease in nerve conduction velocity was observed in the EMG during supination against resistance [3, 5, 8, 14, 17]. It is often mistaken for enthesitis of the insertion of the epicondyle muscles, which is why some authors call this syndrome treatment-resistant epicondylitis [4, 13, 18, 19]. These two pathologies are sometimes difficult to differentiate. In addition, they can even be associated occasionally; if so, both processes should be handled at the same time.

In our series there was a relationship with other nerve compression syndromes, such as carpal tunnel syndrome, cubital syndrome and repeated tendonitis, as other authors have indicated previously [3, 7, 9, 13, 18].

In all cases we used a posterior-external approach, following the radial epicondyle-styloid line because it made it possible for us to visualise the entire PIN, even in the border distal to the supinator [14]. The anterior approach allows us to see the proximal area more easily, but not the distal area of the arcade of Frohse and it has a greater risk of injuring the radial superficial sensory branch [7, 14, 18].

It is important to consider the variability of the pattern of radial nerve innervation at the distal level, as we have been able to observe in our study [1, 11, 12]. This explains the three pareses of the common finger extensors seen in our patients caused by excessive distal dissections. We did not observe the presence of tumours or anatomical abnormalities, which are characteristics that are more typical of the PIN syndrome [4, 6, 7, 10, 14].

The site in the surgical field where we suspected that PIN compression could exist was the proximal entry of the radial tunnel, although compression at the level of the distal border was observed in nine patients; for that reason, we believe that the posterior approach is better [3, 7, 9, 14]. In a few patients we found fibrosis between the second radial and the supinator, while fibrosis was present in the superficial bundle of the supinator in others.

After follow-up, all of our patients generally presented clinical improvement in comparison with their condition before the surgery, with satisfactory results in the majority of the

patients; most patients returned to daily activities in two or three months [3, 7, 8, 13, 14].

Conflict of interest There is no conflict of interest and the paper has not been submitted elsewhere.

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