



Original Article

Ligamentous reconstruction of the interosseous membrane of the forearm in the treatment of instability of the distal radioulnar joint[☆]



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ABSTRACT

Objectives: To measure the quality of life and clinical outcomes of patients treated with interosseous membrane (IOM) ligament reconstruction of the forearm, using the brachioradialis (BR), and describe a new surgical technique for the treatment of joint instability of the distal radioulnar joint (DRUJ).

Methods: From January 2013 to September 2016, 24 patients with longitudinal injury of the distal radioulnar joint DRUJ were submitted to surgical treatment with a reconstruction procedure of the distal portion of the interosseous membrane or distal oblique band (DOB). The clinical-functional and radiographic parameters were analyzed and complications and time of return to work were described.

Results: The follow-up time was 20 months (6–36). The ROM averaged 167.92° (93.29% of the normal side). VAS was 2/10 (1–6). DASH was 5.63/100 (1–18). The time to return to work was 7.37 months (3–12). As to complications, one patient had an unstable DRUJ, and was submitted to a new reconstruction by the Brian-Adams technique months. Currently, he has evolved with improved function, and has returned to his professional activities. Three other patients developed problems around the transverse K-wire and were treated with its removal, all of whom are doing well.

Conclusion: The new approach presented in this study is safe and effective in the treatment of longitudinal instability of the DRUJ, since it has low rate of complications, as well as satisfactory radiographic, clinical, and functional results. It allows return to social and professional activities, and increases the quality of life of these patients.

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Reconstrução da membrana interóssea do antebraço no tratamento da instabilidade da articulação da radioulnar distal

R E S U M O

Palavras-chave:

Traumatismos do antebraço/cirurgia
Amplitude de movimento articular
Instabilidade articular
Membranas/lesões
Ligamentos articulares

Objetivos: Mensurar a qualidade de vida e os resultados clínico-funcionais dos pacientes submetidos à reconstrução ligamentar de membrana interóssea (MIO) do antebraço com o uso do braquioestilorrádial (BR) e descrever uma nova técnica cirúrgica.

Método: De janeiro de 2013 a setembro de 2016, 24 pacientes com lesão longitudinal da articulação radioulnar distal (ARUD) foram submetidos ao tratamento cirúrgico de reconstrução da porção distal da membrana interóssea ou *distal oblique band* (DOB). Foram analisados os parâmetros clínico-funcionais e radiográficos e descritos as complicações e o tempo de retorno ao trabalho.

Resultados: O tempo de seguimento foi de 20 meses [6-36]. A ADM foi em média 167,92° (93,29% do lado normal). A VAS foi 2/10 [1-6]. O DASH foi de 5,63/100 [1-18]. O tempo de retorno ao trabalho foi de 7,37 meses [3-12]. Quanto às complicações, um paciente evoluiu com instabilidade da ARUD e foi submetido a nova reconstrução pela técnica de Brian-Adams. Evoluiu com melhoria funcional e retornou às atividades profissionais. Outros três pacientes evoluíram com problemas ao redor do fio de Kirschner transversal à ARUD e foram tratados com a remoção desse, todos evoluíram bem.

Conclusão: A nova abordagem apresentada neste estudo demonstrou-se segura e eficaz no tratamento da instabilidade longitudinal da ARUD, já que apresentou baixa taxa de complicações, bem como resultados radiográficos, clínicos e funcionais satisfatórios, o que melhorou a qualidade de vida desses pacientes.

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Introduction

Forearm, wrist and elbow fractures can occur separately or associated, and account for one-sixth of the cases in orthopedic emergency rooms. They may be associated with injury to the interosseous membrane (IOM) of the forearm and, when not adequately treated, alter the anatomy, stability, and load transmission through the wrist, forearm, and elbow, resulting in pain, and decreased range of motion and palmar grip strength that may lead to the inability to perform activities of daily life (ADL).¹

The IOM is a fibrous tissue that runs obliquely through the radius and the ulna.² It is a complex of ligaments and membranes that stabilize the distal radioulnar joint (DRUJ) during pronation and supination movements. Its main region is the central band, in its oblique portion.^{3,4} The distal oblique band (DOB) is located in the distal portion of the IOM around the DRUJ, which originates in the distal third of the ulna and is inserted into the lower edge of the sigmoid notch of the radius (Fig. 1). Moreover, DOB appears to present a continuity with the dorsal and palmar radioulnar ligaments of the triangular fibrocartilage complex. In their biomechanical study, Watanabe et al.⁵ affirmed the importance of the distal membranous portion of the IOM in the volar and dorsal stability of the radius in the DRUJ, in all rotational positions of the forearm. Kihara et al.⁶ described a “cooperation” between the DOB and the triangular fibrocartilage complex (TFCC), as the DOB forms a ligament within the distal membranous portion. However, further biomechanical research is needed to confirm this hypothesis.

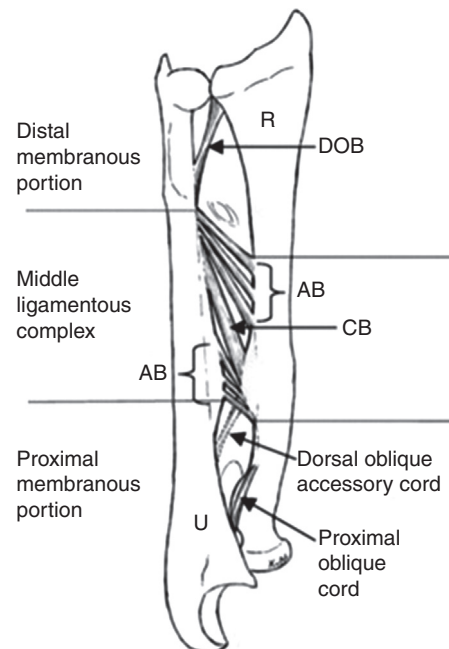


Fig. 1 – Schematic illustration of the IOM⁸; featuring the distal portion (DOB).

High-energy trauma can damage the IOM and lead to longitudinal instability of the radioulnar joint (Fig. 2). It can also be associated with radius head or diaphyseal fractures



Fig. 2 – Lateral and anteroposterior view radiographs of the wrist demonstrating the instability of the DRUJ.

and DRUJ dislocations (Essex-Lopresti and Galleazzi fracture-dislocations, respectively).

Some authors have attempted to biomechanically reproduce trauma energy dissipation in the structures of the forearm, and have described the Essex-Lopresti lesion. Miyake et al.⁷ determined that this lesion originates in the head of the radius, while Wegmann et al.⁸ stated that it occurs in the central portion of the IOM and dissipates in two directions: proximal, leading to radial head fracture; and distal, leading to DRUJ instability.

The diagnosis of these associated ligament lesions is difficult; the DRUJ should be checked through physical examination, with the ulnar drawer test in supination, pronation, and neutral positions, and should be compared with the non-affected side. In order to elucidate this diagnosis, an ultrasound exam or magnetic resonance imaging of the forearm is performed.⁹ The authors believe that the radiographic lateral view of the forearm associated with the ulnar drawer test, both with the forearm in a neutral position, establishes the diagnosis of DRUJ instability.

The traditional treatment method for acute longitudinal instability of the forearm consists of stabilizing the radius fracture and reducing DRUJ, whether or not associated through fixation with Kirschner wires or plaster cast immobilization. After 12 weeks, the radius fracture consolidates, but IOM healing does not always occur, especially in cases of anterior compartment muscle herniation. Thus, the diagnosis is late, and patients present chronic insufficiency of this joint and pain in the ulnar region of the wrist.⁹

The methods for ligament reconstruction in IOM lesions consist of the use of pronator quadratus, flexor carpi radialis, semitendinosus, patellar, and palmaris longus tendon grafts. However, the execution of these techniques is challenging and the results are unsatisfactory, with limited functional results.⁹

In the search for new treatments to correct DRUJ instability, the authors believe that DOB reconstruction restores the joint congruence between the ulnar head and the sigmoid fossa of the radius. The authors searched for methods that are reproducible and easy to perform; therefore, it was decided to use the brachioradialis (BR) muscle tendon, which is located in the

mid-third of the forearm and inserts into the radial styloid, near the DOB. Its resection does not lead to functional loss of the limb.

Moreover, as an advantage, the DRUJ is not directly approached, the technique is easy to execute, and the BR insertion is preserved; this is a natural and anatomical point to support the deforming forces that lead to DRUJ instability.

This study is aimed at measuring the quality of life and the clinical-functional results of patients who underwent ligament reconstruction of the forearm IOM using the BR muscle tendon and to describe a new surgical technique in the treatment of DRUJ instability.

Methods

The study was approved by the Ethics Committee of the institution under the CAAE number: 50917315.9.0000.5484.

From January 2013 to September 2016, patients with longitudinal DRUJ instability were assessed at the outpatient hand surgery clinic of this institution and underwent surgical treatment, with the procedure of reconstruction of the oblique distal portion of the IOM, with the new technique proposed in this study.

Inclusion criteria: patients with clinical (positive drawer test) and imaging (lateral view radiograph showing dorsal deviation of the ulna in relation to the radius) diagnosis of longitudinal DRUJ instability. Both exams (clinical and radiographic) were performed with the forearm in neutral position (0° of pronation, 0° of supination). Exclusion criteria: patients who did not complete the stages of the study (abandoned the rehabilitation program or outpatient follow-up consultations).

The mean age was 36 years (11–60). Fifteen right and nine left forearms were operated on. Regarding the professional occupation, two patients were students, three housemaids; one veterinarian; one athlete; one computer technician; ten factory workers; three motorcycle couriers; one saleswoman; one nurse; and one businessman. Seven patients had a fracture of the distal extremity of the associated radius; seven, Essex-Lopresti lesions; two, Galleazzi fracture-dislocations; one, rheumatoid arthritis (Vaugh-Jackson syndrome); six, complete TFCC lesion; and one, Basel-Hagen deformity. All patients presented pain in the ulnar region of the wrist, especially at the extremes of range of motion and on exertion; they also reported a sensation of instability, with painful clicking. Physical examination revealed pain at DRUJ palpation, and the ulnar drawer test was positive in all patients (Table 1). Subsequently, the patients were evaluated by the occupational therapy sector at regular intervals in the postoperative period; they followed a pre-established program (activities for analgesia and proprioception, passive and active gain of forearm pronation and supination; palmar grip strength gain, and training for ADL and work activities). Outpatient follow-up consultations were held on the second and sixth weeks, sixth months, and one year after the surgical procedure.

The analyzed parameters were:

- Range of motion (ROM) – goniometry of the range of motion, measured in degrees;

Table 1 – Epidemiological aspects of the patients included in this study.

Identification	Age	Follow-up	Side	ROM 1 year	DASH 1 year	VAS 1 year	Return to work	Complications	Profession	Reason
I	29	34	R	180	1	1	Before 3 months	N	Motorcycle courier	Essex-Lopresti
II	25	32	L	130	10	3	Before 12 months	Y – instability	Factory worker	Wrist fracture – TFC
III	25	36	R	180	1	1	Before 6 months	N	Computer technician	Essex-Lopresti
IV	32	35	L	180	9	2	Before 6 months	N	Saleswoman	Rheumatoid arthritis – MUH
V	25	29	R	150	10	3	Before 12 months	N	Motorcycle courier	Essex-Lopresti
VI	38	29	R	170	5	2	Before 12 months	N	Factory worker	Wrist fracture – TFC
VII	50	26	L	150	5	4	Before 12 months	N	Factory worker	Wrist fracture – TFC
VIII	28	25	R	125	18	3	Before 12 months	N	Factory worker	Complex TFCC
IX	43	24	R	155	1	2	Before 3 months	N	Nurse	Wrist fracture – TFC
X	50	20	R	180	2	6	Before 12 months	N	Housemaid	Complex TFCC
XI	45	20	L	180	1	1	Before 12 months	N	Factory worker	Wrist fracture – TFC
XII	39	17	R	180	1	1	Before 6 months	N	Athlete	Essex-Lopresti
XIII	57	19	R	180	1	2	Before 12 months	N	Housemaid	Essex-Lopresti
XIV	32	14	R	180	1	2	Before 3 months	N	Veterinarian	Complex TFCC
XV	28	14	L	180	1	2	Before 6 months	N	Factory worker	Complex TFCC
XVI	19	16	L	180	1	1	Before 3 months	N	Motorcycle courier	Galeazzi
XVII	35	20	R	180	1	1	Before 12 months	Y – Loose screw	Factory worker	Complex TFCC
XVIII	11	13	R	180	6	1	Before 6 months	N	Student	Bassel-Hagen
XIX	38	11	L	180	12	2	Before 6 months	N	Factory worker	Complex TFCC
XX	36	10	L	160	12	2	Before 6 months	N	Factory worker	Essex-Lopresti
XXI	32	10	R	155	12	2	Before 6 months	Y – broken K-wire	Factory worker	Galeazzi
XXII	60	6	R	150	12	1	Before 3 months	Y – K-wire secretion	Businessman	Wrist fracture – TFC
XXIII	15	6	L	180	6	1	Before 3 months	N	Student	Wrist fracture – TFC
XXIV	57	6	R	165	6	2	Before 3 months	N	Housemaid	Essex-Lopresti

Source: Medical Statistical File Service.

DASH, Disability Arm, Shoulder and Hand Questionnaire; TFC, triangular fibrocartilage; N, no; Y, yes; TFCC, triangular fibrocartilage complex; VAS, visual analogue scale.

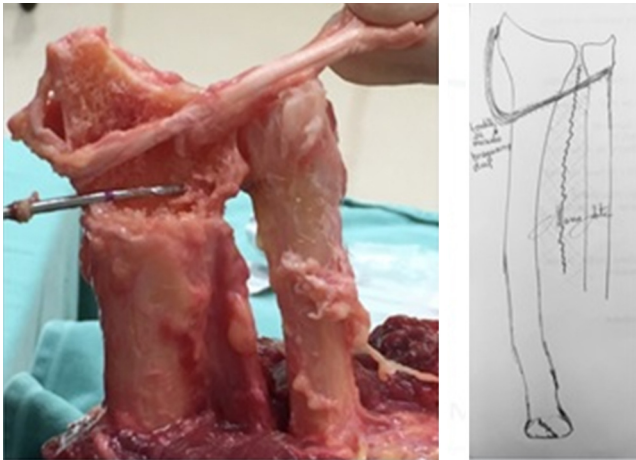


Fig. 3 – Photograph of a cadaveric specimen and illustrative drawing demonstrating the technique of DOB reconstruction with BR.

- DASH (Disabilities of the Arm, Shoulder, and Hand Questionnaire) – quality of life;
- VAS (visual analogue scale) – subjective pain assessment;
- Radiographic assessment to visualize reduction of dorsal ulna dislocation on a lateral view, with the forearm in the neutral position;
- Description of the complications that arose after surgical treatment;
- Time of return to work.

Description of the surgical technique (Figs. 3 and 4)

1. Longitudinal dorsal-radial incision of 10 cm in the affected forearm.
2. Fine dissection in layers of the subcutaneous tissue, radial artery, and radial nerve (sensory branches), with the aid of a microsurgical magnifying glass.
3. Direct visualization and dissection of the BR muscle tendon from its insertion in the radial styloid until its proximal myotendinous transition in the forearm. It must not be detached from the styloid of the radius and must be used entirely in the myotendinous region; section the tendon of

the muscle to form the stump to be transferred. Preparation of the graft stump with Krackow suture using a specific fiberwire (FiberLoop™, Arthrex Inc., FL, USA).

4. A radial and ulnar tunnel is made, oblique, proximally in the radius and distally in the ulna, with a specific drill, under indirect vision and with the aid of radioscopy.
5. Passage of the tendon through the radial and ulnar tunnel with the aid of a specific guidewire.
6. Fixation of the graft with two specific mini-interference or bio-tenodesis screws (Bio-Tenodesis™ screw, Arthrex Inc., FL, USA), one in each tunnel, to tension the system in order to stabilize the DRUJ. Perform the ulnar drawer test to ensure the stability of this joint. Fixation of the forearm in the neutral position, with a transverse Kirschner wire, passing through the radius and ulna, blocking pronosupination for six weeks.
7. Hemostasis, cleansing, and suture by layers of the surgical access to the radius and ulna with radiographic imaging in posteroanterior (PA) and lateral (L) views of the wrist to check the position of the DRUJ and implants (K-wire and screws).
8. Occlusive dressing and immobilization with a plaster cast.
9. After the procedure, an orthosis should be maintained for six weeks. Subsequently, a rehabilitation program should be conducted in the occupational therapy sector of the institution, with the previously established specific protocol (Figs. 3 and 4).

Results

The mean follow-up time was 20 months (6–36). The mean range of motion (pronation + supination) was 167.92° (93.29% of the normal side). The mean VAS was 2/10 (range: 1–6). Regarding quality of life, the DASH score was 5.63/100 (range: 1–18).

The mean time of return to work was 7.37 months (range: 3–12). As for complications, one patient developed DRUJ instability and underwent reconstruction using the Brian-Adams technique, six months after the procedure described in this present study; the patient progressed with pain improvement, had a functional wrist range of motion, and returned to professional activities.

Two other patients evolved with Kirschner wire rupture; a surgical procedure was required for its successful removal.

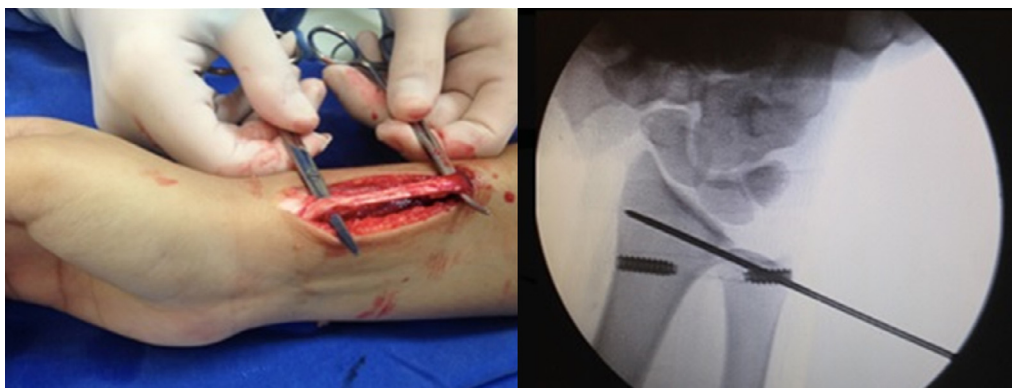


Fig. 4 – Intraoperative clinical and radiographic aspects demonstrating BR tendon grafting.

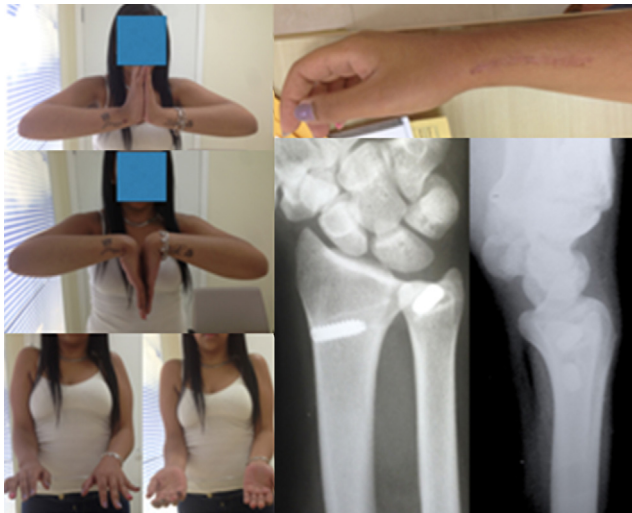


Fig. 5 – Postoperative clinical and radiographic aspects after reconstruction.

One patient developed secretion in the path of the Kirschner wire, which improved after its removal. Lastly, a patient presented loosening of the ulnar screw, successfully removed in a surgical procedure. DRUJ stability, assessed by postoperative examination (ulnar drawer test) and wrist lateral view, radiographs was observed in 23/24 patients (95.83%; Fig. 5).

Three patients had partial supination limitation, probably due to excessive graft tension during the surgical procedure. No cases of infection or neurological and vascular complications were observed in this present study.

Statistical results

The significance level was set at 5% (0.050) for the statistical tests.

MS-Excel spreadsheet, in its MS-Office 2013 version, was used to organize the data. The statistical package SPSS (Statistical Package for Social Sciences), version 23.0, was used to calculate the results.

The Wilcoxon signed-rank test was used to verify possible differences between the two moments studied (Table 2) for the variables of interest.

Discussion

The idea of IOM reconstruction is not new. The central portion is the most cited and studied in the literature. Clinical and cadaveric studies have demonstrated its biomechanical resistance. The literature describes IOM reconstruction with the use of a palmaris longus tendon graft, radial flexor carpi, Achilles tendon, pronator teres, and synthetic and patellar (bone-ligament-bone) materials in chronic lesions.⁹⁻¹⁵ Acute instabilities have been treated with DRUJ transverse fixation with Kirschner wire, with limited results.

The present series aimed to treat chronic and acute lesions in order to avoid instability and the complications resulting from it, such as radiocapitellar osteoarthritis, ulnocarpal impact, and the reduction in the functional capacity of these limbs.⁹

The results of this present study demonstrated an improvement in the mobility of the elbow, forearm, and wrist, with 93.29% recovery when compared to the contralateral ROM (pronation + supination), thus higher than the study by Adams et al.,⁹ in which IOM reconstruction was also performed, with 86.11% ROM recovery.

Recently, an intraoperative “radio joystick test” was described and tested on cadavers to improve the diagnosis of IOM injuries.¹⁶ Lateral traction is applied to the neck of the proximal radius while the forearm is completely pronated. The examiner visualizes the lateral displacement of the proximal radius, thus indicating an IOM lesion. This essay was 100% sensitive for the detection of this lesion and the positive predictive value was 90%. A study of this test *in vivo* has not yet been done.¹⁷ The authors believe that the ulnar drawer test also has an accuracy of close to 100%, and that the combination of these two tests would probably increase the certainty of the diagnosis.

The distal portion of the IOM is the DOB, which helps in transferring longitudinal loads between the radius and the ulna. When the ulnar variant is neutral, the radiocarpal joint absorbs 80% of the axial load transmitted through the wrist, the remaining 20% being transmitted to the ulna. The IOM continues to transfer loads from the radius to the ulna through the forearm (central portion) so that, at the elbow, the radiocarpal joint is subjected to 60% of the original axial load and the ulnar joint receives the remaining 40% (proximal oblique band).¹⁷ The authors suggest that the DOB is of fundamental

Table 2 – Clinical-functional results: patients included in this study.

Variables	n	Mean	Standard deviation	Minimum	Maximum	25th percentile	50th percentile (median)	75th percentile	Significance (p)
Normal ROM	24	180.00	0.00	180.00	180.00	180.00	180.00	180.00	0.005
Final ROM	24	167.92	17.06	125.00	180.00	155.00	180.00	180.00	
Normal DASH	24	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.001
Final DASH	24	5.63	5.08	1.00	18.00	1.00	5.00	10.00	
Normal VAS	24	1.00	0.00	1.00	1.00	1.00	1.00	1.00	<0.001
Final VAS	24	2.00	1.18	1.00	6.00	1.00	2.00	2.00	

Source: Medical Statistical File Service.

ROM, range of motion; DASH, Disability Arm, Shoulder and Hand Questionnaire; VAS, visual analogue scale.



Fig. 6 – Pre and postoperative radiographic aspects of the patient (ulnar lengthening).



Fig. 7 – Post-operative clinical and radiographic aspects of IOM reconstruction and radial head reduction.

importance in stabilizing longitudinal instabilities of the DRUJ, as described by Watanabe et al.⁵ and Kihara et al.⁶

The choice of the BR muscle tendon graft in the present study is unprecedented and offers some advantages:

- The diameter of the bone tunnels can be minimal, avoiding complications such as iatrogenic fractures of the radius and ulna;
- It preserve the insertion, which the authors believe helps during the surgical act to tension the graft;

- The location is adjacent to the DRUJ, which avoids approaching another surgical site, such as the knee (for removal of bone-ligament-bone);
- Its removal does not affect the function of the donor forearm.

DRUJ longitudinal instability recurrence is often cited in the literature¹⁷; the present results demonstrated a maintenance of this reduction in 23/24 patients (95.83%).

Replacing a ligament through a tendon cannot actually reproduce the original anatomy of the SL complex. However, the authors believe in the "ligamentization" of these grafts, since the environment in which they are found may favor this mechanism, similarly to what is observed in patients who undergo anterior cruciate ligament (ACL) reconstruction.¹⁸

In the following lesions, DOB reconstruction should be associated, since they present instability of the DRUJ, with indication of IOM reconstruction, and better treatment efficacy:

- Radial head osteosynthesis (Essex-Lopresti);
- Radial head arthroplasty (Essex-Lopresti);
- Osteosynthesis of the radial diaphysis (Galleazzi);
- Osteosynthesis of the distal end of the radius (complete TFCC lesions).

Many cadaver studies support the reconstruction of the central portion of the IOM. Pfaeffle et al.¹⁴ stated that the double band of the flexor carpi radialis (FCR) for IOM reconstruction showed the longitudinal and transverse resistance of an intact IOM. Other clinical studies have shown promising results, associating ulnar shortening osteotomy with IOM reconstruction.¹¹ The authors have been able to demonstrate satisfactory results in reconstructions isolated or associated to radial osteotomies, osteosynthesis, and arthroplasties in this present study.

This study presented the case of a patient diagnosed with Basel-Hagen disease (hereditary multiple exostosis), associated with elbow stiffness, dislocation of the radius head, and longitudinal DRUJ instability. The authors performed ulnar lengthening with a uniplanar external fixation device, resection of the distal ulna osteochondroma, DOB reconstruction with the graft described in the present study, and, finally, radial reduction, achieving adequate length of the ulna, DRUJ stabilization, and functional gains in the elbow, forearm, and wrist (Figs. 6 and 7).

Conclusion

The new approach presented in this study has shown to be safe and effective in the treatment of longitudinal DRUJ instability, since it presented a low rate of complications and satisfactory radiographic, clinical, and functional results, improving the quality of life of these patients.

Conflicts of interest

The authors declare no conflicts of interest.

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