Usefulness of intraoperative arthrogram in the treatment of pediatric fractures

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Abstract

Introduction: The aim of this study was to assess indications and complications in a consecutive series of children with fractures who underwent intraoperative arthrogram.

Materials and Methods: We evaluated retrospectively pediatric patients with elbow or ankle fractures who underwent intraoperative arthrogram from January 2009 to July 2014. We analyzed demographic data, post-operative medical results (Mayo Clinic criteria and AOFAS score), X-ray results and complications consecutive to the use of intra-articular contrast fluid.

Results: We evaluated 25 patients (16 boys, 9 girls) who averaged 7.6 years of age (4-15 range). Average follow-up was 30.1 months. Fifteen patients had elbow fracture and, 10, ankle fracture. According to the Mayo Clinic score, 14 patients had excellent results and one, good results (99 on average; 85-100 range). The 10 patients with ankle fracture had excellent results as outlined by the AOFAS score (98.5 on average; 95-100 range). There were neither infections nor adverse reactions associated with the use of the contrast fluid. Three patients suffered complications unassociated with the use of the contrast fluid.

Conclusion: Arthrography is a simple and affordable procedure that takes little surgical time and allows the surgeon to assess intraoperative structures better for intraoperative decision-making. It is a useful tool that should be taken into account at the time of treating some pediatric fractures.

Key words: Arthrography; trauma; elbow; ankle; children.
Level of evidence: IV

Utilidad de la artrografía intraoperatoria para el tratamiento de fracturas en niños

Resumen

Introducción: El objetivo de este estudio fue evaluar las indicaciones y las complicaciones de una serie consecutiva de niños con fracturas a quienes se les realizó artrografía intraoperatoria.

Materiales y Métodos: Se evaluó retrospectivamente a pacientes pediátricos con fracturas de codo o tobillo sometidos a una artrografía intraoperatoria, entre enero de 2009 y julio de 2014. Se analizaron los datos demográficos, la evolución clínica posoperatoria (criterios de la Clínica Mayo y puntaje de la AOFAS), la evolución radiográfica y las complicaciones derivadas del uso de material de contraste intrarticular.

Resultados: Se evaluaron 25 pacientes (16 niños, 9 niñas) con una edad promedio de 7.6 años (rango 4-15). El seguimiento promedio fue de 30.1 meses. Quince tenían fracturas de codo y 10, de tobillo. Según el puntaje de la Clínica Mayo, 14

Conflict of interests: The authors have reported none.

pacientes tuvieron resultados excelentes y uno fue bueno (promedio 99; rango 85-100). Los 10 pacientes con fracturas de tobillo obtuvieron resultados excelentes según el puntaje de la AOFAS (promedio 98,5; rango 95-100). No ocurrieron infecciones ni reacciones adversas relacionadas con el uso del medio de contraste. Tres pacientes tuvieron complicaciones no relacionadas con el uso del medio de contraste.
Conclusión: La artrografía es un procedimiento simple, de bajo costo, que agrega poco tiempo quirúrgico y permite una mejor evaluación de estructuras intrarticulares para la toma de decisiones intraoperatorias. Es una herramienta útil que debe ser tenida en cuenta en el tratamiento de algunas fracturas en pediatría.

Palabras clave: Artrografía; trauma; codo; tobillo; niños.
Nivel de Evidencia: IV

Introduction

Arthrography is an imaging method based on intra-articular contrast fluid that is aimed at improving visualization of intra-articular structures. The first arthrogram was carried out in the knee joint by Robinson and Werndorff in 1905.[1] After the 70's, with new diagnosis methods such as CT scan and MRI available, arthrography indications decreased dramatically. As of the 80's and nowadays, indications came back with the use of arthrography plus CT scan and MRI (arthro-tomography and arthro-resonance images respectively) for better diagnostic assessment of intra-articular conditions.[2]

In children, arthrography makes it possible to visualize cartilaginous structures that cannot be identified with routine X-ray. This technique allows the surgeon to establish diagnosis and the injury pattern so as to determine the appropriate treatment.[3] Although this method plays a clear role in intraoperative decision-making in patients with hip developmental dysplasia and Perthes disease,[4,5] its use in pediatric trauma has been scarcely reported.[6-9]

The aim of this study was to evaluate indications, immediate complications and functional results in a group of children with elbow and ankle fracture who underwent intraoperative arthrography.

Materials and Methods

We analyzed retrospectively patients with elbow or ankle fracture who underwent intraoperative arthrography between January 2008 and January 2014. All surgeries were carried out at two referential centers by the same surgical team made up of three surgeons specialized in Pediatric Orthopedics. We indicated arthrogram in patients with fracture or fracture-dislocation in elbow or ankle when we suspected joint surface involvement or displacement which could not be evaluated due to the patient's skeletal maturity degree. We excluded patients with congenital malformations, previous fracture in the same joint and <12 months follow-up.

Technique

Elbow arthrogram

The patient is under general anesthesia in supine position with his or her elbow flexed as near 90° as possible. The olecranon process tip is identified by palpation. An intramuscular needle is introduced in the joint through a posterior trans-tricipital approach.[10, 11] The needle is introduced normally to the arm axis in a posterior-anterior direction proximally to the olecranon process tip (Figure 1). The patient is then injected 1-3 ml of iothalamate meglumine (Telebrix 30®, Guerbet, Roissy, France) dissolved in1-3 ml of saline solution in his or her elbow joint. Then elbow flexion-extension is carried out for the contrast fluid to spread within the joint and allow the surgeon to evaluate it under fluoroscopy.

Ankle arthrogram

The patient is under general anesthesia in supine position on the operating table. An intramuscular needle is introduced through the frontal aspect of the ankle in anterior-posterior direction between the extensor hallucis tendon and the anterior tibial tendon (Figure 2). Needle sucking is then carried out until the hematoma that confirms that the needle is within the joint and, afterwards, the patient is injected 1-3 ml of contrast fluid dissolved in 1-3 ml of saline solution in his or her joint.

Patients assessment

The information assessed included demographic data (age, sex, side), type of fracture, surgical treatment, type of fixation, and post-operative complications (adverse reactions, infection, etc.). Functional results in elbow fractures were assessed using the Mayo Clinic criteria.[12] This system evaluates pain, ROM (extension and flexion), stability and function. Results can be excellent (90-100 marks), good (89-75), moderate (74-60), and poor (less than 60). Results in ankle fractures were assessed using the AOFAS (*American Orthopedic Foot & Ankle Society*) score.[13] It consists of a 100-mark objective and subjective classification that assess pain, function, alignment and joint ROM. Results can be excellent (90-100), good (80-

Figure 1. Four-year old girl with pain and limitation in elbow pronosupination after fall from her own height with extended arm. **A.** AP Elbow X-ray that shows radial neck fracture grade IV. **B.** Intraoperative arthrogram. It shows >2mm displacement. **C.** Reduction with combination of Böhler and Metaizeau methods. **D.** Reduction and definite fixation with titanium elastic nail.

Figure 2. Fourteen-year old patient who suffers right ankle fracture MacFarland type while playing football. **A.** Intraoperative image that shows intra-articular unevenness and the flow of the contrast fluid from the joint to the fracture line. **B.** Following closed reduction and percutaneous fixation with cannulated screw, joint congruence is obvious.

90), moderate (70-80) and poor (<70). Although neither system is validated in children, we believe that they are the most appropriate to assess results in heterogeneous populations such as this one.

Statystical analysis

We used descriptive statistics to report categorical and quantitative data.

Results

We evaluated 25 patients (16 boys and 9 girls) who averaged 7.56 years of age (ranging from 4 to 15). Fifteen patients had upper limb fracture (4 Monteggia fractures, 2 supra-intercondylar fractures, 3 external condylar fractures and 6 radial head fractures) and 10, ankle fracture (4 MacFarland fractures, 4 Tillaux fractures and 2 triplanar fractures) (Tables 1 and 2). Average follow-up was 30.1 months (23.09 months [ranging from 10 to 35] in the first group and 34.8 months [ranging from 12 to 60] in the second one.

According to the Mayo Clinic scale, 14 patients had excellent results and one of them had a good result. The average score was of 99 (ranging from 85 to 100). The 10 patients with ankle fracture had excellent results as outlined by the AOFAS score (average 98.5 ranging from 95 to 100). There were neither infections nor adverse reactions related to the contrast fluid. Two patients showed contrast fluid extravasation during the procedure. Both did favorably and the contrast fluid was reabsorbed immediately after the surgery. Three patients suffered complications nonrelated to the contrast fluid. All of them showed early physeal closure after the ankle fracture (2 MacFarland fractures, 1 triplanar fracture). One patient required physeal bar resection, whereas the other one received epiphyseal fixation in the remaining physis. The other patient did not require treatment because of near bone maturation.

Discussion

Interpreting X-rays in pediatric fractures comes as a great diagnosis challenge. Due to age variety in the maturity of the ossification centers, some injuries might not be appropriately diagnosed or interpreted during the surgery.[14,15] In medical bibliography there are just few reports on the use of intraoperative arthrogram in pediatric trauma.

In this series, we used intraoperative arthrogram in patients with elbow fracture (lateral condylar fracture in distal humerus, radial head fracture, supra-intercondylar fracture, distal humerus epiphysiolysis and Monteggia

Table 1. Demographic data from patients with elbow fracture

N	Age	Sex	Injury	Classification	Associated injuries	Treatment	Follow-up (months)	Complications
1	3	M	Radial head fracture	O'Brien III	No	Percutaneous reduction (spin)	27	No
2	8	M	Radial head fracture	O'Brien III	No	Metaizeau	32	No
3	5	M	Radial head fracture	O'Brien III	No	Percutaneous reduction (spin)	25	No
4	4	F	Radial head fracture	O'Brien IV	No	Böhler/Metaizeau	27	No
5	5	F	Radial head fracture	O'Brien IV	No	Percutaneous reduction (spin)	19	No
6	6	M	Radial head fracture	O'Brien II	No	Manual fracture reduction	21	No
7	5	M	Supra-intercondylar fracture	No	No	CRPF	28	No
8	4	M	Monteggia	Bado III	No	IMN	30	No
9	5	M	Monteggia	Bado I	No	CRC	12	No
10	3	F	Monteggia	Bado I	No	CRC	12	No
11	5	M	Supra-intercondylar fracture	No	No	CRPN	35	No
12	5	M	Lateral condylar fracture	II	No	CRPN	25	No
13	4	M	Lateral condylar fracture	II	No	CRPN	27	No
14	7	F	Lateral condylar fracture	III	No	ORN	20	No
15	6	F	Monteggia	Bado II	No	CRC	19	Extravasation

M = male, F = female, CRPF = closed reduction and percutaneous fixation, IMN = intramedullary nailing, CRC = closed reduction and cast, CRPN = closed reduction and percutaneous nailing, ORN = open reduction and nailing.

fracture) and intra-articular ankle fractures (McFarland fracture, Tillaux fracture and triplanar fracture). In those patients with elbow fracture in who the involved physis is unossified, angulation degrees and displacement are not easy to assess, something that affects the decision-making process. Arthrography helps by showing where the epiphysis is at the time of reduction or fixating the fracture. In lateral condylar fractures, the use of intra-articular contrast fluid is particularly useful. Since the lateral condyle has a great cartilaginous surface, X-ray assessment is modest. Arthrography allows the surgeon to determine if it is necessary to carry out open fracture reduction. In a series of 16 cases, Marzo et al.[3] show how the use of arthrogram helps in diagnosis and treatment. In patients with Monteggia fracture or radial head fracture in who the radial head is still unossified (<5 years old), it is very difficult to assess intraoperative fracture reduction. Some authors suggest using MRI to assess initial displacement.[16] Although MRI could show the fracture displacement, it cannot be used during the surgery to determine if fracture reduction has been appropriate. Only few case reports put forward the use of intra-articular contrast fluid to improve

Tabla 2. Demographic data from patients with ankle fracture

N	Age	Sex	Mecha-nism	Type of fracture	Salter-Harris		Diastasis (mm)		Unevenness (mm)		Fixation	Follow-up (months)	Com-plica-tions
					Tibia	Fibula	Pre-op	Post-op	Pre-op	Post-op			
1	14	F	Fall from height	MacFarland	IV	I	1,5	0	4	0	1 tibial epiphyseal screw	29	No
2	20	M	Fall from height	Tillaux	III	No	2	0	1,5	0	1 tibial epiphyseal screw	49	No
3	19	M	Fall from height	Tillaux	III	No	2	1	2	0	1 tibial epiphyseal screw	51	No
4	17	M	Fall from height	Triplanar	IV	No	2	0	0	0	1 epiphyseal screw + 2 tibial metaphyseal screws	31	No
5	12	F	Football	MacFarland	III	I	3	0	2	0	1 tibial epiphyseal screw	36	Physeal bar
6	7	F	Fall from height	MacFarland	III	I	4	0	0	0	1 tibial epiphyseal screw	42	No
7	14	M	Fall from height	Tillaux	III	No	2	0	1	0	1 tibial epiphyseal screw	13	No
8	14	M	Football	Triplanar	IV	No	3	0	3	0	1 epiphyseal screw + 1 tibial metaphyseal screw	23	No
9	12	F	Fall from height	MacFarland	III	I	9	0	7	0	1 tibial epiphyseal screw + 2 fibular pins	12	Extra-vasa-tion
10	16	M	Fall from height	Tillaux	III	No	2	0	1,5	0	1 tibial epiphyseal screw	47	No

visualization during radial head and Monteggia fractures reduction (Figure 1).[9,10,17] Although in Monteggia fractures many surgeons use the radiocapitellar line (RCL) in lateral X-rays as diagnosis method and means of verifying intraoperative fracture reduction, its reliability has been put into question. Kunkel et al.[18] have reported that the patient's age and the rotation degree of the forearm affect the RCL. In a recent study in the Children Hospital of Los Angeles, they found that the RCL is more reliable in elder patients and that it shows considerable variability in children <5 years old. According to Fader et al.,[20] humeral condyle eccentric ossification may explain variability in little children. The RCL does not cross reliably the central third of the ossified humeral condyle before the 10 years of age in girls and the 11 years of age in boys. The same authors consider that the RCL should be used taking these limits into account in children with immature skeleton and combining advanced images if need be.

In ankle fractures, arthrography was used to define diastasis between fragments or intra-articular uneven surfaces, to assess the quality of joint reduction, and to avoid open fracture reduction (Figure 2). Duran et al.[8] used arthrography to change open surgical techniques into percutaneous techniques in patients with MacFarland fracture. In no case was it necessary to move to open surgery, and they report that X-ray exposure might be lower tanks to better intraoperative visualization.

There are few reports on complications associated with the use of intra-articular contrast fluid. The most frequent adverse reaction is immediate hypersensitivity. Ninety-six percent of serious and lethal adverse reactions occur within the first 20 minutes following the injection.[6] Although the use of high doses of contrast fluid is nephrotoxic, the risk of adverse reactions in arthrography is minimal due to the low doses that are required. There are some reports on local complications, such as urticaria and thrombophlebitis due to fluid extravasation.[6] There are also reports on more serious complications, such as gas embolism during hip and knee arthrogram.[21-23] However, in general this complication follows a defective technique which introduces air within the joint to confirm needle location. In small children, a small volume of intravascular gas can be catastrophic. Therefore, it is not advisable to carry out this maneuver during the procedure. In our series, there were only five mild complications, three of them unassociated with the contrast fluid (physeal bars) and two cases of contrast fluid extravasation with reabsorption immediately after the surgery and no irritation.

This study presents the limitations that are characteristic in retrospective works with series of cases relatively small. The size of the sample is not sufficiently large so as to determine safety while introducing intra-articular contrast fluid in a patient with immature skeleton. However, if we compare it with other authors' findings,[5,8,24] we can verify its safety. Other limitation is that the scales we used for functional assessment are not validated in children, although they have been previously used by other authors.[25,26] The lack of assessment tools specifically designed for pediatric patients is one of the main difficulties at the time of carrying out clinical studies in this age group. Finally, there was not a simultaneous or previous similar group for control, what would have allowed us to determine the real impact of the use of intraoperative arthrography. Despite these limitations, we believe that this work re-appreciates the use of intra-articular contrast fluid in the surgical approach of pediatric fractures.

Conclusions

Adequate treatment of intra-articular fractures in children depends on an appropriate assessment of images. Occasionally, images are difficult to interpret due to cartilaginous structures and variability in ossification patterns. Arthrography is a simple and affordable procedure that takes little surgical time and allows the surgeon to assess intra-articular structures better for intraoperative decision-making. It is a useful tool that should be taken into account at the time of treating some pediatric fractures.

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