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Original article

Effectiveness of imaging-guided intra-articular injection: a comparison study between fluoroscopy and ultrasound

Rita Nely Vilar Furtado[a], *Daniele Freitas Pereira*[a], *Karine Rodrigues da Luz*[a], *Marla Francisca dos Santos*[a], *Monique Sayuri Konai*[a], *Sonia de Aguiar Vilela Mitraud*[b], *Andre Rosenfeld*[b], *Artur da Rocha Correa Fernandes*[b], *Jamil Natour*[a,*]

[a]*Rheumatology Division, Universidade Federal de São Paulo, São Paulo, Brazil*
[b]*Department of Diagnostic Imaging, Universidade Federal de São Paulo, São Paulo, Brazil*

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ABSTRACT

Objective: Compare the effectiveness of ultrasound and fluoroscopy to guide intra-articular injections (IAI) in selected cases.
Material and methods: A prospective study in our outpatient clinics at the Rheumatology Division at Universidade Federal de São Paulo (UNIFESP), Brazil, was conducted to compare the short-term (4 weeks) effectiveness of ultrasound and fluoroscopy-guided IAI in patients with rheumatic diseases. Inclusion criteria were: adults with refractory synovitis undergoing IAI with glucocorticoid. All patients had IAI performed with triamcinolone hexacetonide (20mg/ml) with varying doses according to the joint injected.
Results: A total of 71 rheumatic patients were evaluated (52 women, 44 whites). Mean age was 51.9 ± 13 years and 47 of them (66.2%) were on regular DMARD use. Analysis of the whole sample (71 patients) and hip sub-analysis (23 patients) showed that significant improvement was observed for both groups in terms of pain ($P < 0.001$). Global analysis also demonstrated better outcomes for patients in the FCG in terms of joint flexion ($P < 0.001$) and percentage change in joint flexion as compared to the USG. Likert scale score analyses demonstrated better results for the patients in the USG as compared to the FCG at the end of the study ($P < 0.05$). No statistically significant difference between groups was observed for any other study variable.
Discussion and conclusion: Imaging-guided IAI improves regional pain in patients with various types of synovitis in the short term. For the vast majority of variables, no significant difference in terms of effectiveness was observed between fluoroscopy and ultrasound-guided IAI.

* *Corresponding author.*
E-mail: jnatour@unifesp.br (J. Natour).

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Efetividade da infiltração intra-articular guiada por imagem: comparação entre fluoroscopia e ultrassom

Palavras-chave:
Injeção intra-articular
Fluoroscopia
Ultrassonografia

RESUMO

Objetivos: Comparar a curto prazo (04 semanas) a efetividade das infiltrações intra-articulares (IIA) guiadas por fluoroscopia (FC) e ultrassom (US) em pacientes com enfermidades reumáticas.

Material e métodos: Foi realizado um estudo controlado e prospectivo em pacientes portadores de doenças reumáticas captados dos ambulatórios da Disciplina de Reumatologia da Universidade Federal de São Paulo (UNIFESP), Brasil. Critério de inclusão: adultos com indicação de IIA com corticosteróide por sinovite refratária. Todos os pacientes forma infiltrados com hexacetonide triancinolona (20 mg/mL) com doses variáveis, de acordo com a articulação estudada.

Resultados: Foram avaliados 71 pacientes (52 mulheres; 44 brancos), portadores de enfermidades reumáticas variadas. A média de idade era 51,9 ± 13 anos e 47 deles (66,2%) faziam uso de drogas modificadora do curso da doença (DMARD). Na análise global da amostra (71 pacientes) e na subanálise coxofemoral (23 pacientes), observou-se melhora estatística ($p < 0,001$) em ambos os grupos quanto à EVA de dor. Na análise global observou-se aumento significativo da flexão articular ($p < 0,001$) e um Δ de flexão maior a favor do grupo guiado por FC. A avaliação de melhora segundo Likert Scale mostrou diferença significativa ($p < 0,05$) entre os grupos na avaliação global, nas proporções inalterado e melhor, a favor do grupo guiado por US. Não foi observada diferença estatisticamente significante entre os grupos para qualquer outra variável.

Conclusão: A IIA guiada por imagem melhorou a dor regional, a curto prazo, relacionada à sinovite de vários tipos de articulações. Para a grande maioria das variáveis avaliadas não houve diferença entre a efetividade da IIA guiada por US ou FC.

Introduction

Intra-articular injections (IAI) with glucocorticoids have been used for more than half a century for the treatment of refractory articular disorders either as monotherapy or associated with systemic interventions in multiple rheumatic conditions. Nevertheless, the efficacy of IAI is often questioned and part of the controversy might be related to its low accuracy when performed as a blind procedure by inexperienced physicians or in joints with very difficult access techniques.[1,2]

Imaging methods easily available, such as ultrasound and fluoroscopy can be used to guide IAI and improve its accuracy,[3] especially in deep joints with the greatest chance of technical error, such as the hip.[4] Other imaging methods such as computed tomography (CT) and magnetic resonance imaging (MRI) can also be used for this purpose, but are much less available for clinical use.

Fluoroscopy is often used to guide IAI in joints with difficult access. Its use in glenohumeral approach was first described in 1933 by Oberholzer and modified by Schneider.[5] One of its advantages is related to the fact that it is found in most hospitals, and therefore the technique is easily available, unlike CT and MRI scans. Technological advances have made fluoroscopy able to reproduce high resolution images using less radiation. New generations of these devices are more compact, portable and easy to handle.[6]

Ultrasound (US) is usually practical and safe to evaluate intra-articular structures (synovium, cartilage and subchondral bone)[7] and soft tissue involvement in rheumatic diseases. Intra and periarticular corticosteroid ultrasound-guided IAI is quick, safe and reduces the risk of injury to the cartilage, tendon, nerve and/or vessels.[2] Its safety and practical issues have made most rheumatologists prone to accept the technique in their clinical practices.

In spite of their broad use to guide IAI, these methods (fluoroscopy and ultrasound) are different in terms of cost, safety, training curve, interface with other medical specialties, and usefulness in the management of periarticular structures.[5] The best imaging technique to guide IAI has not been defined since there are no studies comparing the cost-effectiveness of these methods in a controlled manner. The purpose of the present study is to compare fluoroscopy and ultrasound in terms of their effectiveness to guide IAI with corticosteroids.

Material and methods

Patients

A single blind controlled prospective study was conducted with 71 consecutive patients from the outpatient clinics of the Rheumatology Division at the Federal University of São Paulo, Escola Paulista de Medicina, São Paulo, Brazil. The study was approved by the ethics committee of the Institution.

This study aimed to compare the short term effectiveness of ultrasound versus fluoroscopy-guided IAI in patients with refractory synovitis caused by either autoimmune or degenerative disorders.

The sample size of 24 individuals in each group was considered appropriate, once the VAS (visual analogue scale) for pain was the most important primary outcome of the study. In order to calculate the study size we used a standard deviation 2.0, a power of 80%, and a 5% significance level.

To participate in the study, the patient should meet the following inclusion criteria: IAI indication due to synovitis with duration of at least one month, and age between 18-65 years-old. Patients with uncontrolled hypertension or diabetes mellitus; damage of any kind to the skin site to be punctured; suspected infection, severe clotting disorder, and known allergy to contrast media were all excluded from the study.

Intervention

Convenience non-random sampling was used and the patients were divided into two intervention groups, according to the imaging technique available to guide the procedure: fluoroscopy group (FCG) and ultrasound group (USG).

All IAI were performed by a physician experienced in musculoskeletal intervention. Triamcinolone hexacetonide (TH) was used in all procedures. HT doses varied according to the size of the joint (20-100 mg; 1-5 mL). Hips were systematically injected with HT 100 mg.

For both groups, sterile material and gloves were used and 2% lidocaine was injected in the intra-articular space. In USG patients, IAI followed the technique of insertion of the needle parallel with respect to the transducer[2] using a sterile shield to cover it. In patients in the FCG, iobitriol contrast medium was applied to certify the intra-articular positioning of the needle before injecting HT.

All patients were instructed to maintain joint rest after injection for 48 hours without weight bearing activities.

Evaluation and outcomes

Patients were evaluated by an examiner "blind" to the procedures at two time points: T0 (before intervention) and T4 (04 weeks after intervention) and the following assessment measures were performed:

- VAS (visual analogue scale, 0-10cm) for pain;
- Improvement Likert 5-point scale (much worse, somewhat worse, unchanged, better, much better);
- Joint flexion measured by goniometry;
- Percentage change for joint flexion (Δ: final flexion - initial flexion / initial flexion × 100);

Statistical analsys

The software SPSS 17.0 was used for statistical analysis. In order to asses normatility of data in SPSS, it was used the Shapiro-Wilk test. Chi-squared test was used for the analysis of categorical variables. Student's *t* test was used for the analysis of numerical variables. ANOVA for repeated measures was used for the intergroup and intragroup analyses. The significance level was set as $P < 0.05$.

Results

A total of 71 patients underwent imaging-guided IAI as shown in Table 1. Joints receiving IAI are also listed in Table 1. Global analyses refer to the whole group of 71 patients undergoing IAI in the present study. A sub-analysis of 23 patients undergoing hip IAI is presented separately.

Whole group analyses

Eighteen men and 52 women participated in the present study (mean 51.9 ± 13 years old). Twenty-four patients (33.8%) had IAI guided by fluoroscopy (FCG) while 47 others (66.2%) had the procedure performed under ultrasound imaging (USG). In this study, the data were distributed normally. At baseline, mean age for patients in the FCG was significantly higher than that observed for the USG (60.9 versus 48.2 years-old, respectively, $P = 0.006$). As shown in Table 2, groups did not differ in terms of age and gender.

Intra-group analyses demonstrated that both groups had significant improvement over time ($P < 0.001$). Intra-group analyses demonstrated that joint flexion improved at 4 weeks after intervention as compared to baseline only for patients in the FCG ($P < 0.001$).

VAS scores for both FCG and USG during the study as well as joint flexion are shown in Table 3. Mean VAS scores for pain at baseline were not different between the two groups (7.4 cm and 6.6 cm for FCG and USG, respectively). On the other hand, no significant difference was observed between groups as far as VAS for pain is considered.

Table 1 – Injected joints: whole group analysis (n = 71).

	IAI guided by fluoroscopy	IAI guided by ultrasound
Naviculocuneiforme (n)	0	1
Glenohumeral (n)	4	3
Acromioclavicular (n)	0	2
Hip (n)	12	11
Wrist (n)	1	30
Ankle (n)	5	0
First metacarpophalangeal (n)	1	0
Sacroiliac (n)	1	0
Total n %	24 (33.8)	47 (66.2)

Table 2 – Demographic and general characteristics: whole group (n = 71).

	Group guided by FCG (n = 24)	Group guided by USG (n = 47)	P value
Age in years (± SD)	62 (16.9)	49 (10.8)	0.006
Gender (M/F)	8/16	10/36	0.292
Skin color (white/ no white)	12/9	32/12	0.141
Initial VAS for pain (± SD)	7.4 (2.2)	6.6 (1.9)	0.076
Initial joint flexion (± SD)	74.7° (29.3)	53.2° (28.3)	0.001

Table 3 – Visual analogue scale (VAS) for pain, joint flexion and percentage change for joint flexion between groups: whole group analysis (n = 71).

	Fluoroscopy group (24)	Ultrasound group (47)	Intergroup P value
	VAS for pain (± SD)		0.076
T0 (± SD)	7.4 (2.2)	6.6 (1.9)	
T4 (±SD)	3.4 (2.8)	2.6 (2.3)	
Intragroup P value	< 0.001	< 0.001	
	Joint flexion (± SD)		< 0.001
T0 (±SD)	74.7° (29.3)	53.2° (28.3)	
T4 (±SD)	96.0° (33.7)	56.8° (31.0)	
	< 0.001	0.074	
	Change for joint flexion (±SD)		0.016
T4 (±SD)	23.5° (46.1)	8.1° (27.7)	

Anova; t-student.

Joint flexion measured at baseline was significantly different between groups. FCG patients had significantly higher mean joint flexion as compared to USG patients (74.7° ± 29.3° vs. 53.2° ± 28.3°, respectively; P = 0,011). As shown in Table 3, inter-group analyses demonstrated that joint flexion improved significantly better in the FCG as compared to the USG (P < 0.001). The same trend was also observed when the percentage change for joint flexion was evaluated (P = 0.016).

A specific analysis of joints that had flexion improvement higher than 10% was also performed comparing fluoroscopy and ultrasound-guided procedures. The percentage of patients in the FCG who had joint flexion improvement higher than 10% (72.2% of the patients) was significantly higher than that seen for the USG (45.5% of the patients, P = 0.055).

Table 4 shows the results for Likert scale for improvement. About 8.3% of the patients in the FCG reported improvement as compared to 30.4% of the patients in the USG (P = 0.041); Accordingly, 16.7% of the patients in the FCG had no improvement while the percentage of no improvement for the USG was only 2.2% (P = 0.044). Different results were found when Likert scale scores for improvement (better and much better) and worsening (worse and much worse) were counted together. About 97.8% of the patients (N = 45) in the USG reported some improvement (better or much better) during the study as compared to about 75% of the patients (N = 18) in the FCG (P = 0.005). Accordingly, the percentage of unchanged patients in the FCG (20.8% - 5 patients) was significantly higher than that seen for the USG (2.2% - 1 patient) (P = 0.016).

Table 4 – Likert Scale between groups: whole group analysis (n = 71).

	Fluoroscopy group	Ultrasound group	P value
Much worse (%)	1 (4.2)	0 (0)	NS
Somewhat worse (%)	0 (0)	0 (0)	NS
Unchanged (%)	4 (16.7)	1 (2.2)	0.044
Better (%)	2 (8.3)	14 (30.4)	0.041
Much better (%)	17 (70.8)	31 (67.4)	NS

Chi square. NS, no significant.

Hip IAI analyses

A subanalysis of patients undergoing hip IAI under fluoroscopy or ultrasound was performed as an attempt to homogenize the sample. As shown in Table 5, no statistically significant difference was observed between the two groups at baseline in terms of age, gender, race, VAS for pain and joint flexion.

Intra-group analyses demonstrated significant improvement for VAS for pain and joint flexion in both groups, from baseline to the end of the study (P < 0.002).

In Table 6 data regarding VAS and joint flexion for both groups are presented. No significant difference was detected between groups.

Differently from the data observed for the whole population, inter-group analyses did not demonstrate any significant difference in joint flexion between fluoroscopy and ultrasound groups. There was a trend in favor of the FCG when the percentage change for joint flexion was evaluated but that did not reach statistical significance (P = 0.07).

Likert scale scores for improvement perception by the patient did not differ significantly between groups.

Discussion

IAI is a therapeutic option for the treatment of refractory synovitis, either chronic or acute, and of joints that are difficult to access. However, factors such as the method chosen to guide the procedure, good knowledge of the anatomical landmarks and the professional's expertise, all interfere with the correct positioning of the needle and the success of the procedure.[2]

Table 5 – Demographic characteristics: hip sub-analysis (n = 23).

	FCG group (n = 12)	USG group (n = 11)	P value
Age in years (+- SD)	60.6 (19.3)	50.5 (14.6)	0.187
Gender (M/F)	7/5	7/4	1.000
Skin color (White/ no white)	6/4	5/6	0.762

SD, standard deviation. t-Student; Fisher's exact test; chi square.

Table 6 – Visual analogue scale (VAS) for pain, joint flexion and Percentage change for joint flexion between groups: hip sub-analysis (n =23).

	FCG group (n = 12)	USG group (n = 11)	P value
	VAS		0.753
T0 (± SD)	7.8 cm ± 1.6	7.6 cm ± 2.0	
T4 (± SD)	3.4 cm ± 3.2	3.1 cm ± 2.3	
	Flexion		0.692
T0 (± SD)	70.0° (19.1)	82.7° (21.0)	
T4 (± SD)	96.6° (19.4)	89.9° (23.6)	
	Chance for joint flexion		0.07
T4 (±SD)	39.0° (50)	10.0° (30.5)	

Anova; t-Student.

IAI with corticosteroid has been used since the 50s, especially in the rheumatologists' practice.[8] Despite the routine use of the procedure, only a few randomized controlled trials have been performed on the matter and most concepts have been raised from those rare studies. Some of these concepts are well established, especially in the field of rheumatoid arthritis. It is known that triamcinolone hexacetonide is the most effective corticosteroid to be used to cause chemical synovectomy.[6,9-16] Other studies have demonstrated that the use of intra-articular corticosteroid, either as monoarticular or polyarticular injection, is more effective and better tolerated than the systemic use of drugs.[17,18] However, it has not been yet established in the literature, among other concepts, which dose of triamcinolone hexacetonide is the ideal to be used for each joint, the cost-effectiveness of IAI with radioisotopes or the cost-effectiveness of using imaging techniques to guide IAI and increase its accuracy.

There are several studies on the accuracy of IAI with conflicting results. Some authors argue that blind IAI conveys low accuracy even for approaches of the knee.[19] Others have suggested that blind IAI accuracy might be improved when the physician is well trained in the procedure. For these authors, the ankle is still the joint with the lowest accuracy for blind injection (77%).[20] For some joints as the hip, the glenohumeral and interapophyseal joints, common sense has made imaging techniques almost mandatory for injection approaches.

The use of imaging techniques to guide IAI allows for therapeutic and diagnostic procedures in deep joints and structures, the intra-articular use of radioisotopes and the appropriate approach for joint deformities.[21] Of the various methods used to guide IAI, fluoroscopy and ultrasound are the more easily available for the clinician. The advantages of fluoroscopy have been listed: the approach of any joint, including axial, besides panoramic and direct visualization of the structures. Visualization of soft tissue, convenience and portability, and the lack of contrast and radiation in the procedure are recognized as advantages for the use of ultrasound.[3,22-26]

Fluoroscopy has been used for decades to address the intra-articular space.[21,27] However, only a few studies have evaluated the effectiveness of fluoroscopy-guided IAI as compared to blind procedures. Hegedus et al.[28] have found that the effectiveness (pain and function) for glenohumeral IAI (103 shoulders) was not related to the accuracy of the procedure as confirmed by fluoroscopy. Other colleagues[29] have also found no difference in terms of effectiveness of periarticular corticosteroid injections of the trochanteric bursa when blind procedure was compared to fluoroscopy-guided intervention in 65 patients. The use of potent intra-articular corticosteroids (triamcinolone hexacetonide, for example) has been restricted to fluoroscopic control in some Institutions. However, despite the practice, controlled studies are needed to establish the cost-effectiveness of fluoroscopy-guided IAI.

Ultrasound has become a very interesting tool increasingly used by clinicians as an extension of physical examination and also to guide diagnostic and therapeutic procedures. In rheumatology, ultrasound has become very useful for the detection of subclinical synovitis and joint damage (bone erosion) not detected by conventional X ray.[2,30].

The use of non-ionizing technique, the low cost and portability have made the ultrasound the best choice to guide muscle skeletal interventions.[2,5,25,31] However, the size of the joint, the operator experience and patient obesity should be taken into consideration when choosing ultrasound.[32,33] Despite its usefulness to guide procedures and the growing interest of clinicians in the method, effectiveness studies comparing blind to ultrasound-guided IAI have presented conflicting results. Greater effectiveness has been reported for ultrasound-guided IAI or periarticular of the subacromial space,[3] the plantar fascia,[34] adhesive capsulitis[35] and various types of appendicular joints.[36] However, several other studies have found different results for the subacromial space[5,37] and the wrist (radiocarpal joint).[38]

No studies have compared the effectiveness of ultrasound versus fluoroscopy-guided IAI. In a study with a different aim (evaluation of accuracy), it was observed that ultrasound was superior to fluoroscopy to guide the placement of the needle for infiltration of the piriformis muscle in 20 cadavers (95% accuracy for ultrasound versus 30% for fluoroscopy).[39] In a sample of 25 shoulders undergoing IAI, Rutten et al.[5] observed that ultrasound was better than fluoroscopy for accuracy, pain caused by the procedure (tolerance) and time to carry out the procedure. In that study, no prospective evaluation of effectiveness of IAI guided by the two methods is reported.

This is the first study to compare IAI with triamcinolone hexacetonide performed either under fluoroscopy or ultrasound having "effectiveness" (pain, goniometry and perception of improvement by the patient) as the main outcome. The variables chosen in the study are not only relevant for the clinical rheumatologist, but also easily measurable in a routine setting. In agreement with the uncontrolled experience of the authors, the present study demonstrated significant improvement in joint pain and function in both groups after four weeks of the procedure. No significant difference was detected between groups in terms of joint pain.

Some important limitations proper to the design of our study need to be pointed out. In the first part of the study (Whole group analyses), significant heterogeneity of the injected joints was observed in both groups and that hindered the comparison of some variables (as was the case for joint flexion). That was due to both the difficulty of addressing some joints with ultrasound and also the lower availability of fluoroscopy in some scenarios.

In spite of the low number of patients, the second part of the study (Hip IAI sub-analysis) had suitable homogeneity between groups at baseline. Because of non-randomization and the high number of wrists in the US group, sampling may have had a selection bias. Despite these many limitations, the present study displays a very good external validity and portrays the routine of a rheumatology service where interventional procedures are performed on an outpatient care basis.

Hip analysis is particularly interesting given that this joint is not commonly approached blindly. In this analysis, differences between groups detected in the overall analysis in terms of joint flexion, percentage change of joint flexion and improvement according to the Likert scale were not confirmed. In other words, when homogeneity of the sample was reached, no significant difference in effectiveness was observed between fluoroscopy and ultrasound-guided IAI.

Our study demonstrated that in a homogeneous sample of patients with indication for IAI of the hip (refractory sy-

novitis), fluoroscopy and ultrasound-guided procedures are equally effective. This finding needs further confirmation in studies involving a larger number of patients. Our results suggest that the choice of either one or other method to guide IAI might be based on other variables such as cost, the physician's skill in handling or the availability of the method, since their effectiveness is quite similar.

Conflicts of interest

The authors declare no conflicts of interest.

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