**Clinical question:** Does acetic acid iontophoresis accelerate the resorption of calcium deposits in calcific tendinitis of the shoulder?

The purpose of "Evidence in Practice" is to illustrate the literature search process to obtain evidence to guide clinical decision making. This article is not a case report. The examination, evaluation, and intervention sections are purposely abbreviated.

A 48-year-old man, who was otherwise in good health, developed pain and a "clicking" sensation in his right shoulder during movement. The patient, who was referred to me by his physician, stated that this problem began approximately 2 months ago and has been getting steadily worse ever since. The patient is an avid skier and tennis player; however, he did not recall any serious direct trauma to the shoulder. Shoulder passive range of motion (ROM), measured using standard goniometric techniques as discussed by Riddle et al,[1] was 0 to 170 degrees for flexion, 0 to 165 degrees for abduction, 0 to 70 degrees for internal rotation, and 0 to 75 degrees for external rotation. Manual muscle testing did not reveal any major strength deficits in the shoulder musculature, with the primary muscle groups graded between 4+ and 5 on scale of 0 to 5. Active humeral abduction, however, resulted in pain, especially near the midpoint of shoulder abduction. Radiographs that had been ordered by the physician showed a calcium deposit in the tendon of the right supraspinatus muscle. This deposit was approximately 175 $mm^2$ in area, had well-defined borders, and was uniformly dense throughout the lesion. This patient, therefore, appeared to have calcific tendinitis of the right supraspinatus muscle.

Based on my evaluation of these and other examination data, my diagnosis for this patient was "Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion Associated With Localized Inflammation" (Practice Pattern 4E, *Guide to Physical Therapist Practice* [Guide][2]). Consistent with the Guide, I decided to implement an intervention program that included passive, active, and active resistive ROM exercises. I also decided to apply ultrasound to this patient's shoulder, a decision that was based on the results of a study by Ebenbichler et al.[3] I became aware of this study after reading a systematic review on the effectiveness of therapeutic ultrasound that appeared in *Physical Therapy*.[4] Ebenbichler et al found that pulsed ultrasound, applied for 15 minutes at 2.5 $W/cm^2$ and at a frequency of 0.89 MHz, was associated with clinical improvement in patients with calcific tendinitis compared with sham ultrasound in patients with calcific tendinitis. Patients who received ultrasound in this study were treated over a 6-week period, for a total of 24 treatments. At the end of the 6-week treatment period, Ebenbichler et al found that patients treated with ultrasound had greater decreases in pain and greater improvements in quality of life

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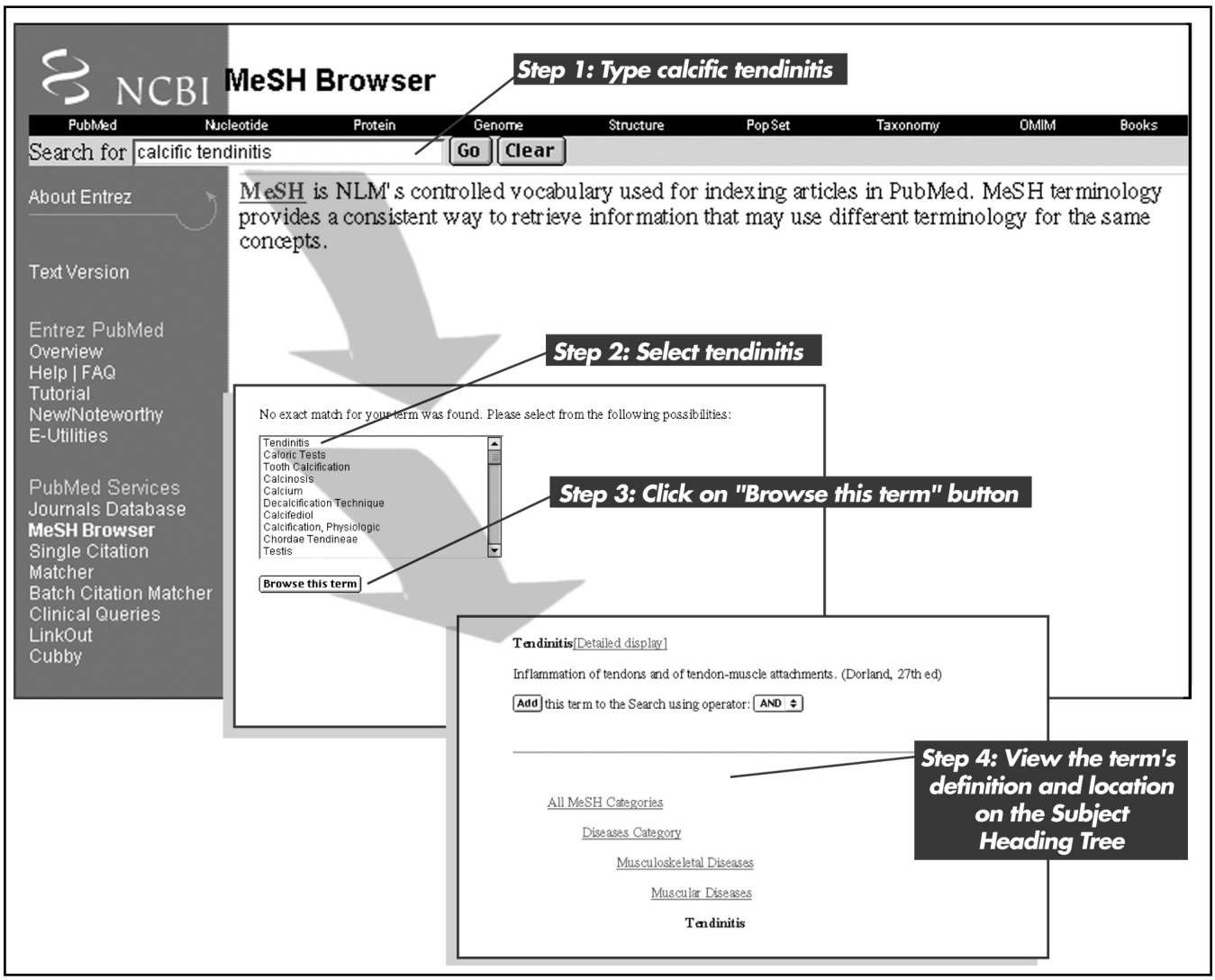


**Figure 1.** The Procedure for Determining the Proper Search Term Using PubMed's MeSH Browser Starting With "Calcific Tendinitis." Reproduced with permission of the National Library of Medicine.

compared with patients who received the sham treatment. They concluded that ultrasound appears to promote short-term clinical improvements because these improvements occurred at the end of the 6-week treatment period, but the 2 groups reported similar pain levels and quality of life 9 months after the treatments ended. I decided to include ultrasound using treatment parameters similar to Ebenbichler et al to help provide some initial improvement in my patient's pain.

This patient was highly motivated and wanted to resume pain-free activities as soon as possible. I therefore was interested if any additional interventions might be included to help dissolve the calcium deposit. I knew that iontophoresis using acetic acid had been advocated as a technique that might accelerate resorption of calcific lesions. I recalled a case report that appeared in *Physical Therapy* describing the use of acetic acid iontophoresis in a patient with traumatic myositis ossificans in the thigh musculature.[5] The rationale for using acetic acid iontophoresis is based on a chemical reaction where insoluble calcium carbonate molecules combine with acetic acid to form calcium acetate, which is more soluble and, therefore, more easily dissolved within tendons and other soft tissues than calcium carbonate.[5] When administered by iontophoresis, acetic acid should be applied from the negative electrode (cathode) because the acetate ion is purportedly negative at the pH that is present during clinical iontophoresis. Acetate therefore will be repelled from the cathode.

As is the case with other agents administered by iontophoresis, we do not have any direct measurement of how deeply acetic acid penetrates into subcutaneous tissues in humans or the extent to which iontophoresis will enhance the penetration and binding of acetic acid to the calcific lesion. Nonetheless, I felt that the scientific rationale for using this intervention was compelling enough to at least consider using acetic acid iontophoresis to help dissolve the calcium

Treatment of calcifying tendinitis of the shoulder by acetic acid iontophoresis and ultrasound [Spanish]; Rioja Toro J; Romo Monje M; Cantalapiedra Puentes E; González Rebollo A; Blázquez Sánchez E; Rehabilitacion; 2001; 35(3), p. 166-70

Modes of sensory stimulation: clinical trials and physiological aspects; Näslund J; Physiotherapy; 2001 Aug; 87(8), p. 413-23

A review of therapeutic ultrasound: effectiveness studies; Robertson VJ; Baker KG; Physical Therapy; 2001 Jul; 81(7), p. 1339-50

Effects of acetic acid iontophoresis on heel spur reabsorption; Gulick DT; Bouton K; Detering K; Racioppi E; Shafferman M; Physical Therapy Case Reports; 2000 Mar; 3(2), p. 64-70

Electrical stimulation: a reflection on current clinical practices; Bertoti DB; Assistive Technology; 2000; 12(1), p. 21-32

Considerations for evaluation and treatment of overuse tendon injuries; Fitzgerald GK; Athletic Therapy Today; 2000 Jul; 5(4), p. 14-9, 32-3, 64

Calcific tendinitis of the shoulder: diagnosis and simple, effective treatment; Wolf WB III; Physician and Sportsmedicine; 1999 Sep; 27(9), p. 27-33, 87-8

Acetic acid iontophoresis and ultrasound for the treatment of calcifying tendinitis of the shoulder: a randomized control trial; Perron M; Malouin F; Archives of Physical Medicine and Rehabilitation; 1997 Apr; 78(4), p. 379-84

**Figure 2.** Citations Retrieved by the Search in CINAHL Using the Keywords "Iontophoresis," "Acetic Acid," and "Tendinitis."

deposit in my patient. I was unaware, however, of any evidence that this technique results in more rapid dissolution of calcium deposits in people with supraspinatus tendinitis. I decided to search the literature to find this evidence.

■ **Database used for search:** MEDLINE

MEDLINE is the National Library of Medicine's computerized bibliographic database covering selected physical therapy journals and other journals related to medicine, nursing, and health and rehabilitation sciences. I selected this database because I wanted to first explore a large database that offered extensive coverage of a wide range of scientific literature. Access to MEDLINE is free to the public, and I accessed MEDLINE via its online version, PubMed, at www.ncbi.nlm.nih.gov/PubMed. This search was performed on October 1, 2002.

■ **Initial keywords:** iontophoresis AND acetic acid AND tendinitis

I selected the intervention (iontophoresis) as the first keyword. I typed **iontophoresis** in the query box, and this action retrieved 5,699 citations. Adding **AND acetic acid** to the first keyword narrowed the search to 61 citations. A quick glance at the titles indicated that many of the articles dealt with nonclinical uses of iontophoresis (ie, use of electrical current as a research tool to investigate various physiologic issues related to membrane transport).

I therefore decided to add one more keyword: calcific tendinitis. Because PubMed might not use this keyword, I decided to consult PubMed's Medical Subject Headings (MeSH) to verify that this keyword could be used in the search. According to information in the database, MeSH is the National Library of Medicine's "controlled vocabulary used for indexing articles. MeSH terminology provides a consistent way to retrieve information that may use different terminology for the same concepts." To search the MeSH list, I clicked on **MeSH Browser** under "PubMed Services" on the left side of the PubMed search screen. (For an illustration of this search, see Figure 1.)

I typed **calcific tendinitis** in the entry box on the browser. PubMed informed me that there was no exact match for this term and provided a dropdown list with alternative terms, including "tendinitis." I clicked on **tendinitis** and then the **Browse this term** button. The MeSH Browser then displayed the definition of tendinitis and the term's location on the MeSH Subject Heading Tree (a hierarchy of subject headings from the more general to the more specific). Because I did not want to make this search term too specific and thus risk the possibility that I might miss a key citation, I did not click on the **Detailed Display** link next to the MeSH term (which would have allowed me to select subheadings such as "classification," "etiology," or "pathology").

I also selected "tendinitis" rather than a more general term such as "therapy" because I was interested specifically in use of this intervention in this type of soft-tissue lesion. I was not, for example, interested in the use of acetic acid iontophoresis in managing other conditions, such as heel spurs, because the results from studies dealing with other nontendinous lesions might not be applicable to my patient.

After determining that tendinitis was the most appropriate term to use, I hit the **Back** button on my Internet browser until I returned to my search. I added **AND tendinitis** to the query box.

■ **Selection of articles for review:** The inclusion of all 3 keywords further narrowed the search to one article. A glance at the title of this article suggested that it might pertain to my patient. The citation and abstract of that article are printed below.

Perron M, Malouin F. Acetic acid iontophoresis and ultrasound for the treatment of calcifying tendinitis of the shoulder: a randomized control trial. Arch Phys Med Rehabil 1997;78:379-384.

OBJECTIVE: To assess the effects of acetic acid iontophoresis (AAI) and ultrasound on calcifying tendinitis of the shoulder, and to determine the relation between changes in the radiological measures of calcium deposit (CD) and shoulder function. DESIGN: Randomized control trial. SETTING: General community, private practice. PATIENTS: Twenty-two adults (7 men, 15 women) with a calcifying tendinitis of the shoulder, without associated conditions, stratified according to the type of lesions (X-ray: type I, fleecy appearance: type II, homogeneous), were randomly allocated to an experimental (EXP, n = 11) or to a control (CTL, n = 10) group. INTERVENTIONS: CTL group, no treatment; EXP group, nine treatments including AAI (5% acetic acid solution via the negative electrode, 5mA galvanic current, 20 minutes) followed by continuous ultrasound (0.8w/cm2, 1MHz, 5 minutes). MAIN OUTCOME MEASURES: Area and density of the CD, passive shoulder abduction (range of motion [ROM]), pain intensity. RESULTS: Significant reduction in the area and density of CD (ANCOVA, p = .01 and .03) over time in the EXP and CTL groups, but no significant difference between groups for any of the variables measured. The decrease in the area of CD in type I lesions (n = 5) was larger (Mann-Whitney U test, p < .01) than in type II (n = 16) lesions. The relation was stronger (rs = .90) between changes in area and density of CD than between ROM and pain (rs = -.67). Correlations were weak (rs = .21 to .41) between radiological and functional changes. CONCLUSION: The reduction in CD area and density likely results from a natural process rather than treatment (AAI and ultrasound); type I lesions (resorptive phase) are more likely to display resorption of the CD than type II lesions (formative phase). Reduction of the CD area does not necessary result in a functional improvement.



This study seemed very relevant to my patient, so I obtained a copy of the complete article from my institution's medical library. This study was a randomized controlled trial because subjects were randomly divided into experimental and control groups. Patients in the experimental group received 3 treatments each week for 3 consecutive weeks for a total of 9 treatments. The subjects in the experimental group had a mean age of 43 years (range=32–57 years), which is consistent with my patient's age, and about one third of the subjects were men. According to the criteria defined in this paper, my patient appeared to have a type II lesion (ie, my patient had a homogeneous, well-formed deposit rather than a deposit that was already showing signs of resorption). In this study, 8 subjects in each group had type II lesions, with the minority of subjects having a type I lesion (3 subjects in the experimental group, 2 subjects in the control group). Hence, my patient seemed similar to the patients in this sample.

This study, however, provided evidence that patients who received acetic acid iontophoresis, followed by 5 minutes of continuous wave ultrasound, did not have a greater reduction in size of the calcium deposit compared with patients who received no treatment. The iontophoresis treatment parameters seemed adequate for inducing a response, assuming that a response would occur. This study, for example, applied 5 mA of galvanic current for 20 minutes, resulting in a 100 mA•min treatment. Other sources and clinical studies typically report current doses between 40 and 100 mA•min.[6–8] It seemed unlikely that the lack of a clinical effect could be explained by inadequate iontophoresis current application.

I was somewhat surprised that the ultrasound used in this study did not seem to have an effect on pain in these patients. As indicated earlier, Ebenbichler et al[2] reported that therapeutic ultrasound resulted in a clinically significant reduction in pain in patients with calcific tendinitis. Perron and Malouin, however, applied 9 treatments of continuous wave ultrasound for 5 minutes at a frequency of 1 MHz and an intensity of 0.8 W/cm$^2$, whereas Ebenbichler et al[2] applied 24 treatments of pulsed ultrasound (1:4 pulsed mode) for 15 minutes at 2.5 W/cm$^2$ and a frequency of 0.89 MHz. The difference in the effects of ultrasound between these 2 studies is probably explained by differences in the ultrasound dosage applied in each study.

The results from Perron and Malouin suggest that natural processes—rather than this specific treatment (acetic acid iontophoresis followed by 5 minutes of continuous wave ultrasound)—were responsible for decreasing the size of calcific lesions in these patients. I also found it interesting that Perron and Malouin failed to see a strong relationship between reduction in the size of the calcium deposit and functional improvement. I assumed that such a lesion would result in more severe impairment and that resolution of the deposit would be a prerequisite for improving recovery and function. This apparently may not be the case, given that these results

indicated only a weak correlation between radiological appearance (density and size of the deposit) and shoulder function (pain and ROM).

Nonetheless, the fact that my initial search retrieved only one article was somewhat disturbing. I wondered if searching a different database would yield similar results or if an alternative database might provide additional information. I was especially interested in literature from allied health journals that might not be covered by MEDLINE. I therefore decided to search CINAHL.

■ **Second database used for search:** CINAHL

The *Cumulative Index to Nursing and Allied Health Literature* (CINAHL) covers approximately 1,200 journals related to nursing, physical therapy, health care administration, and other allied health professions. The years indexed by this database range from 1982 to the present. More importantly, I believe that CINAHL offers more extensive coverage of physical therapy journals than databases such as MEDLINE. For example, physical therapy journals such as *Advances in Physiotherapy*, *Physiotherapy Theory and Practice*, and the *South African Journal of Physiotherapy* (which are not indexed in MEDLINE) are indexed in CINAHL. According to CINAHL, *Advances in Physiotherapy* and *Physiotherapy Theory and Practice* contain peer-reviewed articles, but the *South African Journal of Physiotherapy* does not.

Although not all of the journals in the CINAHL database would be considered to be "peer-reviewed"—and therefore I would have to view the articles in that light—access to these journals would allow me to retrieve more articles that deal with the use of iontophoresis as a clinical intervention in patients receiving physical therapy. CINAHL also provides additional features, including abstracts to most articles of the articles in the citations and access to the full-text version of some articles. Access to CINAHL is not free to the public; for a fee, the database can be accessed via their Web site (www.cinahl.com). Many college or health care professional libraries, however, provide access directly to CINAHL or enable the user to access CINAHL through another search engine.

I accessed CINAHL through my institution's medical library by first accessing ProQuest (proquest.umi.com/pqdweb).* ProQuest is a search engine that provides access to several databases, including CINAHL. Within ProQuest, I clicked on the option to **Search Professional Research Collections Only (CINAHL)** and then subsequently clicked on **CINAHL**. This search was performed on October 2, 2002.

**Table.**
Number of Citations Retrieved Using Specific Keywords in MEDLINE Compared With CINAHL

| Keyword | MEDLINE | CINAHL |
|---|---|---|
| Iontophoresis | 5699 | 138 |
| (AND) Acetic acid | 61 | 16 |
| (AND) Tendinitis | 1 | 8[a] |

[a] One of these 8 articles was also retrieved in the MEDLINE search (ie, the one article retrieved using all 3 keywords in MEDLINE was also retrieved when these 3 keywords were used in CINAHL).

■ **Keywords used in the second search:** iontophoresis AND acetic acid AND tendinitis

I started this search by clicking on the radio button next to **Basic Search Fields** located on the left side of the initial search screen. I selected the basic search fields (rather than the fields for abstract, author, source, and so forth) because this field contains all the terms needed to index other fields in the citation record, including article titles, main subject headings, and minor subject headings.

I then repeated the same steps from my first search by sequentially typing the same 3 keywords. I first typed **iontophoresis** in the query box at the top of the search interface, which retrieved 138 articles. Typing **AND acetic acid** narrowed the search to 16 articles (as in PubMed, operators such as "AND" or "OR" must be capitalized in CINAHL in order to conduct the search properly). Finally, adding **AND tendinitis** narrowed the search to 8 articles.

The CINAHL search therefore retrieved more articles than the MEDLINE search even though I used the same keywords. The Table indicates the number of articles retrieved by adding each keyword in MEDLINE compared with the number retrieved by CINAHL. I was obviously interested in the 8 articles that were retrieved from the CINAHL search. The citations for these articles are listed in Figure 2.

■ **Selection of articles for review:** I was excited that I now had several articles that might help answer my clinical question. Closer examination, however, revealed that most of these articles were review articles or clinical perspectives rather than research studies. Only 2 articles dealt directly with the use of acetic acid iontophoresis in calcific tendinitis of the shoulder. One article (Perron and Malouin, the last article in Figure 2) was retrieved during my initial PubMed search, so I already knew the results from that study. The only other article that seemed relevant was the first article in Figure 2 (the study by Rioja Toro et al). Although this article was

* ProQuest Information and Learning Co, 300 N Zeeb Rd, Ann Arbor, MI 48106-1346.

in Spanish, the abstract was printed in English. I was able to view a copy of the abstract by clicking on a small, index card–shaped icon next to this article's title. This abstract is reproduced here.

Treatment of calcifying tendinitis of the shoulder by acetic acid iontophoresis and ultrasound [Spanish] Rehabilitacion; 2001; Rioja Toro J; Romo Monje M; Cantalapiedra Puentes E; González Rebollo A; Blázquez Sánchez E

Objective: Assess the efficacy of combined treatment acetic acid iontophoresis and ultrasounds in calcifying tendinitis of the shoulder.

Patients and methods: 34 patients, with a mean age of 48 years and 9 months, participated in the prospective study. Incidence per gender: 23 women and 11 men. Most involved shoulder: right (21 patients), 4 bilateral involvements. The degree of pain (visual analogic scale), and calcification size (simple X-ray) were assessed prior to initiating treatment. After 20 and 40 sessions, a new assessment was carried out on the pain intensity and calcification size.

The treatment consisted in acetic acid iontophoresis at 5% (5 days/week), followed by pulsating ultrasounds for 5 minutes (5 cm effective radiation area).

Results: After 20 sessions, 35.9% of the shoulders treated were pain free and the calcification had disappeared. In 64.1%, the pain decreased by 57% of their initial intensity on an average and the calcification remained the same or was smaller. After 40 sessions, the global results were: the calcification had disappeared in 46% of the shoulders treated and decreased in 18%, which means that the calcification had changed in 64% of the shoulders. The pain decreased, on an average, by 85% of its initial intensity on completion of the treatment.

Conclusion: The treatment is efficacious in calcifying tendinitis of the shoulder for both the modification of the calcification size as well as the solution of the pain picture.



This study discovered that the calcific lesions either disappeared or decreased in about two thirds of the patients receiving 40 treatments of acetic acid iontophoresis and ultrasound. This study was similar to the study by Perron and Malouin in several ways. Both studies used similar patient samples, and both studies applied 5% acetic acid iontophoretically followed by ultrasound (albeit the ultrasound used by Rioja Toro et al was pulsed compared with continuous wave ultrasound in the Perron and Malouin article). Unfortunately, details about the iontophoresis current dosage were not included in this abstract. I would need to get a copy of the complete article and have this information translated from Spanish into English to see if both studies used similar iontophoresis treatment parameters (ie, if they used similar current amperage, duration of application, and so forth).

Details about the iontophoresis application, however, seemed less important than the apparent lack of a control group in this study. Whereas the study by Perron and Malouin included a group that received no treatment, the study by Rioja Toro et al apparently lacked controls. The absence of a control group made it impossible to determine if the calcific lesions changed because of the intervention or because of the natural resorption of these deposits. The study by Rioja Toro et al, therefore, failed to provide conclusive evidence that this intervention (acetic acid iontophoresis followed by pulsed ultrasound) is effective in treating this type of patient. I did not try to obtain the full text of this article because I did not think it would help answer my clinical question.

■ **Clinical decision:** There is a paucity of literature on the beneficial effects of acetic acid iontophoresis in treating clinical disorders such as calcific tendinitis. Based on the study by Perron and Malouin, I decided not to include acetic acid iontophoresis in the plan of care for my patient. Their study concluded that acetic acid iontophoresis, followed by 5 minutes of continuous wave ultrasound, did not result in more rapid resorption of calcium deposits compared with a control group that did not receive treatment. Calcium resorption occurred in both groups, and the fact that resorption did not differ between the groups suggested that this resorption was due to a "natural process" rather than the intervention.

The results of the Perron and Malouin study underscore the necessity of including a control group when trying to establish evidence for an intervention. For example, Rioja Toro et al found that calcium deposits decreased substantially in the majority of patients receiving acetic acid iontophoresis for calcific tendinitis of the shoulder. The absence of a control group, however, prevented me from determining whether acetic acid iontophoresis accelerated the calcium resorption as compared with an analogous group of patients who did not receive iontophoresis. Without such a comparison, I could not determine conclusively that acetic acid iontophoresis effectively increases resorption of calcium deposits in calcific tendinitis of the shoulder. In contrast, the study by Perron and Malouin provides evidence that this intervention is not effective in accelerating resorption of calcific lesions in the supraspinatus tendon. In addition, their results didn't indicate that there was a strong relationship between deposit reduction and improvement in function.

Consequently, I decided against adding acetic acid iontophoresis to my patient's intervention program, and I focused on therapeutic exercise and ultrasound.

**References**


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**In the next Evidence in Practice:** Stephanie Grim, Jordan Duffy, Peter Theodosopoulos, MSc, Dale Fish, PT, PhD, and Patricia Ohtake, PT, PhD, will seek answers to the question, "For a patient with diabetes and a heel ulcer, could electrical stimulation and standard wound treatment improve wound healing more than standard wound treatment alone?" (Coming in March 2003)