Objective: To determine the reliability of a delay in the microscopic examination of synovial fluid (SF) to detect and identify crystals.

Methods: Ninety one SF samples were examined, 31 with monosodium urate (MSU) crystals, 30 with crystals of calcium pyrophosphate dihydrate (CPPD), and 30 containing no crystals. The specimens were stored with EDTA, sodium heparin, and without anticoagulant at 4°C before examination at 24 and 72 hours with ordinary and polarised light microscopy. Another aliquot of the same samples was stored in a plastic container without anticoagulant at −80°C and examined after two months.

Results: When the samples stored at 4°C were re-examined after 24 hours, intracellular crystals of MSU were seen in 90/93 (97%) cases where they had been identified previously and 89/93 (96%) cases after 72 hours. Similarly, CPPD crystals were identified in 90/90 (100%) and 87/90 (97%) cases after 24 and 72 hours. Examination of the samples stored at −80°C showed intracellular MSU crystals in 25/31 (81%) of cases and CPPD crystals in 25/30 (83%). No crystals were seen in any sample which had previously been diagnosed as crystal-free.

Conclusions: Deferred microscopic examination of refrigerated or deep frozen SF provides a strong probability of detecting MSU or CPPD crystals if these are present initially.

There are also discrepant views about the use of anticoagulants if a sample is to be stored before examination for microcrystals.¹ ³ ¹³ ¹⁴ ¹⁶

The objective of our study was to ascertain whether the storage of samples (with or without anticoagulant) which were known to contain MSU and CPPD crystals for 24 and 72 hours at 4°C or for longer periods at −80°C affected the identification of these crystals or whether morphological changes would alter the results in these samples and others which served as control.

METHODS

Ninety one SF samples were obtained for diagnostic or therapeutic purposes from patients attending the rheumatology unit at the Morales Meseguer University Hospital, Murcia, SE Spain, between October 1999 and November 2000.

Thirty one samples were from patients with uric gout and 30 from patients with definite CPPD crystal deposition disease.¹² As controls we used 30 samples taken from patients with several arthropathies: 14 cases of osteoarthritis, five of rheumatoid arthritis, three of chronic monarthritis of the knee, two of psoriatic arthritis (with hyperuricaemia), two of septic arthritis, two chronic juvenile arthritis, one CPPD deposition disease (with no crystals identified in SF on this occasion), and one of undifferentiated oligoarthritis. All SF samples were taken from the knee, except two which were taken from the shoulder joint.

Excluded from the study were samples with less than 4 ml of SF, those in which only extracellular crystals were seen, and those for which there was no agreement between two observers about the initial examination.

SF samples were analysed as follows: the samples were examined immediately after arthrocentesis by ordinary and polarised light microscopy to detect and identify crystals.
three observers were also noted. In the study period, the commentaries of the sample and each of the observers carried out a re-examination of the refrigerated samples on days of the study. The third set of test tubes were kept at 4°C. A more detailed examination was carried out on a sample from the test tube containing no anticoagulant and stored in a refrigerator for two months after 24 and 72 hours. After 24 hours intracellular crystals could be seen in all 31 of the samples kept in EDTA, in 29/31 (94%) of those kept in heparin and 30/31 (97%) of those kept without preservative (table 1). The results after 72 hours were similar: 31/31 (100%) and 29/31 (94%) in heparin and no preservative.

When the SF samples kept at −80°C were examined MSU crystals could still be seen in most preparations: intracellularly in 25/31 (81%), extracellularly in 26/31 (84%), and intracellularly or extracellularly in 29/31 (94%). There were no differences in the figures for two, three, or more months. When possible modifications in the concentration of MSU crystals with time were evaluated, the number of extracellular crystals increased significantly after two months (table 2). Although there was a slight reduction in the number of intracellular MSU crystals, these differences were not significant.

Table 1 Crystals observed in the SF samples preserved in EDTA, heparin, or no anticoagulant after 24 and 72 hours (at 4°C) and after two months (at −80°C)

<table>
<thead>
<tr>
<th></th>
<th>MSU (n=31)</th>
<th>Control (n=30)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EDTA Heparin SF alone EDTA Heparin SF alone EDTA Heparin SF alone</td>
<td></td>
</tr>
<tr>
<td>24 Hours</td>
<td>31 (100)* 29 (94) 30 (97) 30 (100) 30 (100) 30 (100) 0 0 0</td>
<td></td>
</tr>
<tr>
<td>72 Hours</td>
<td>31 (100) 29 (94) 29 (94) 29 (97) 29 (97) 29 (97) 0 0 0</td>
<td></td>
</tr>
<tr>
<td>&gt;2 Months</td>
<td>– – 25 (81) – – 25 (83) – – 0</td>
<td></td>
</tr>
</tbody>
</table>

*Values expressed as number (and percentage) of samples showing intracellular crystals.

Table 2 Change in the number of extracellular crystals (EC) and intracellular crystals (IC) in the SF samples preserved at 4°C and −80°C without anticoagulant. Results expressed as mean (SD)

<table>
<thead>
<tr>
<th></th>
<th>MSU (n=31)</th>
<th>CPPD (n=30)</th>
<th>Control (n=30)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EC IC EC IC EC IC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial</td>
<td>2.0 (4.2)* 2.2 (3.4) 1.8 (2.7) 3.8 (5.2) 0 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 Hours</td>
<td>2.3 (3.0) 3.2 (7.1) 1.3 (1.6) 3.8 (5.3) 0 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>72 Hours</td>
<td>1.3 (2.1) 2.2 (4.7) 1.3 (2.4) 3.1 (4.2) 0 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;2 Months</td>
<td>3.1 (4.5)† 1.4 (3.1) 1.8 (2.8) 2.2 (2.9)† 0 0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Number of crystals/400x field; †p<0.05.

RESULTS

We excluded from the study five samples in which CPPD crystals were suspected but not confirmed by a second observer because the supposed crystals were small, scarce, atypical, and with a very weak or absent birefringence which hindered definitive identification. Similarly, one sample with possible MSU crystals was excluded, in which the crystals were very scarce and all extracellularly located, needle shaped, and with intense negative birefringence. For this reason, the number of remaining samples was 91. Three cases of MSU crystals and one of CPPD were excluded from the statistical analysis because a countless number of crystals were found in all of them.

Monosodium urate crystals

MSU crystals were preserved in most of the samples refrigerated at 4°C and re-examined after 24 and 72 hours. After 24 hours, no intracellular crystals were observed in any of the samples (table 1). Only in one case were no CPPD crystals observed after 72 hours: 29/30 (97%). In those samples showing CPPD crystals and stored at −80°C for 8–18 weeks, intracellular crystals continued to be seen in 25/30 samples (83%), extracellular crystals in 27/30 (90%) and intracellular or extracellular crystals in 27/30 (90%) cases. Crystals were identified with the same frequency after 8, 12, or more weeks.

The number of extracellular CPPD crystals remained stable throughout the study period, while the number of intracellular crystals decreased significantly after two months (table 2). Although there was a slight reduction in the number of intracellular MSU crystals, these differences were not significant.

CPPD crystals

CPPD crystals were seen after 24 hours in most of the samples examined, regardless of whether anticoagulant was used (table 1). Only in one case were no CPPD crystals observed after 72 hours: 29/30 (97%). In those samples showing CPPD crystals and stored at −80°C for 8–18 weeks, intracellular crystals continued to be seen in 25/30 samples (83%), extracellular crystals in 27/30 (90%) and intracellular or extracellular crystals in 27/30 (90%) cases. Crystals were identified with the same frequency after 8, 12, or more weeks.

The number of extracellular CPPD crystals remained stable throughout the study period, while the number of intracellular crystals decreased significantly after two months (table 2).

Control group

No MSU or CPPD crystals were seen in the 30 control samples when re-examined after 24 and 72 hours, nor in the samples kept at −80°C and examined after two months and more.
Observers' comments
The samples were carefully examined with ordinary light and compensated and non-compensated polarised light in a search for crystals, especially in the fibrinous clumps. CPPD crystals frequently showed scant or no birefringence, although such birefringence was sometimes intense.

Occasionally, other microcrystals were seen in the initial or subsequent examinations—for example, ovoid birefringent crystals in the form a Maltese cross (compatible with tcalc), small pleomorphic intensely birefringent crystals compatible with methylprednisolone acetate (a corticosteroid frequently used in our unit for intra-articular infiltration), and other amorphous microcrystals of variable birefringence similar to dust. No attempt was made to determine the time of appearance or the length of time of these crystalline artefacts.

The cell elements deteriorated with time in the samples stored at 4°C and in those frozen at −80°C and examined after two months' storage. In general, samples preserved in EDTA kept better, the cell outlines being more clearly delineated and the cells showing less tendency to agglomerate.

A careful re-examination of the preparations in which crystals were known to be present, but which had not been detected after two months' storage at −80°C, showed crystals in only two out of five cases.

No significant variations in the ability of the observers to detect crystals was observed. The $\kappa$ index for concordance between observers was $\kappa = 0.825$.

DISCUSSION
It is recommended that examination of SF should be made promptly, preferably within a few hours after arthrocentesis because a rapid reduction in the cell count and a significant fall in the number of CPPD crystals may occur and thus hinder correct classification. Other experiments, however, suggested that CPPD crystals did not dissolve completely even after long periods of storage.

Our results for the CPPD crystal count agree with those obtained by McNight and Agudelo13 and McGill et al.14 Our study shows that when MSU and CPPD crystals were initially detected in SF could they still be seen 24 and 72 hours later in most cases when the samples were stored at 4°C, whether or not anticoagulant was used. The same was true in most cases when the samples were deep frozen at −80°C for 2 to 4 months.

A temperature of 4°C was chosen for storing samples because it is widely accepted that this will improve the probability of survival of the crystals and reduce the risk of microbiological contamination compared with storage at room temperature.2 14

Prolonged deep freezing did not greatly affect the detection of microcrystals and the results to a great extent agree with the observations made in samples stored at 4°C; it was possible to detect intracellular MSU and CPPD crystals in approximately 80% of the samples. As already shown,2 14 deep freezing permits samples to be kept for a long period of time and can be useful for keeping microcrystals for teaching purposes and for quality control of SF examination.

In the few studies which do exist, the sensitivity to detect MSU and CPPD crystals in SF was approximately 70% with discrepancies existing between the sensitivity and specificity of different observers, suggesting that some quality control is necessary in these examinations.14 Although most laboratory tests are submitted to quality control checks, SF examination has not yet been included in such a programme.15 However, several methods exist to preserve SF in order to carry out subsequent quality controls of the examinations.2 15

Some authors have proposed a different method, which involves staining, for the delayed examination of SF preparations as a method for carrying out quality controls of the cytological examination and identification of crystals.21

There is wide disagreement between authors about the advisability of using anticoagulant to preserve SF samples until they are examined for the presence of microcrystals.7 13 15 18 We examined different ways of preserving samples and found that the number of crystals was the same in samples preserved with or without anticoagulant (EDTA and sodium heparin). In a very interesting study, Salinas et al reported that the results of the cellular counting of the SF samples preserved with EDTA are still accurate at 24 and even 48 hours, at least for clinical purposes.22

Although the number of urate and pyrophosphate crystals was the same after storage for 24 and 72 hours at 4°C and for longer periods at −80°C, the detection of CPPD crystals was more difficult. For this reason, we found it useful to include examination by ordinary light microscope in the exhaustive examination of the preparations, which sometimes took more than 10 minutes, as recommended by several authors.22 Other factors contributing to the high sensitivity of our results are the systematic search for crystals in fibrinous clumps, the systematic examination with non-compensated polarised light, and the fact that the examination was not completely “blind”. This last fact might have influenced the observer in some cases to continue (or not) the search for crystals, although it might not have been a determining factor because the examination of the deep frozen samples (which was a “blind” test) provided substantially similar results. It must not be forgotten, too, that we did not exclude from the study those cases in which intra-articular steroid infiltration had been carried out in the preceding weeks.

Our results point to a high degree of specificity because no crystals were seen in any of the control samples and there was no confusion in identifying the different crystals. Neither did we see cases of MSU crystals formed “de novo”, even in the two cases of psoriatic arthritis with hyperuricaemia.

We found no significant decrease in the number of crystals stored at 4°C during the three days of observation. In the deep frozen samples some changes were seen, including a significant increase in the number of extracellular crystals of urate and a significant reduction in the number of CPPD intracellular crystals. The exact significance of these changes is difficult to ascertain, although they may be due to the destruction of cells, which we know occurs in stored samples.

Our work has some limitations. The exclusion criteria which were introduced to improve the specificity of the method may add a certain bias. Furthermore, the scope of the study might have been affected by the fact that the sample examination was not completely blind.

In summary, our results suggest that SF analysis for the detection of MSU or CPPD crystals can be deferred up to 72 hours when the samples are stored at 4°C with or without EDTA or sodium heparin as anticoagulants because there is a high degree of probability that the crystals will still be present after this time. The same applies, although with lower probability, when samples are kept without anticoagulant at −80°C and examined after two, three, or four months.

These findings have a practical clinical interest because although it is advisable to examine SF samples soon after arthrocentesis to minimise the possibility of any error, this is sometimes impossible. For example, samples may be obtained in emergency units, in primary care centres, or any other parts of the Health Service, where it may be impossible to make an immediate examination, or only a partial examination may be possible without the availability of polarised light microscopy. In such cases, we think deferred examination of the SF samples stored at low temperature will pose no real problem for the detection and identification of MSU and CPPD crystals.

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Delayed examination of synovial fluid by ordinary and polarised light microscopy to detect and identify crystals
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Ann Rheum Dis 2002 61: 444-447
doi: 10.1136/ard.61.5.444