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# Grading of films for sacro-iliitis in population studies

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Substantial disagreement has occurred between different observers reading the same films in population studies which have included the grading of films for sacro-iliitis. Reliable radiological interpretation of the sacro-iliac joint is difficult but accurate grading of sacro-iliitis is crucial for epidemiological studies of ankylosing spondylitis. These facts have prompted the present investigation.

## Material and methods

The radiographs were studied within the context of a family study of ulcerative colitis. The pelvis of each family member was *x*-rayed antero-posteriorly on a 17 × 14 in. film at 40 in. anode-film distance with the subject undressed. A 4 in. gonadol screen was used for male patients. A standard film marking system was used, and the subject's name did not appear on the film although the age and sex were known. A control group of subjects matched for age and sex was obtained from preliminary films used in intravenous pyelography (IVP) examination. All films were read independently by two observers on the basis of the recommendations made at the New York Conference on Population Studies (Bennett and Burch, 1967) and the Atlas of Standard Radiographs in Arthritis (1963).

Agreed standards of abnormality were established between the observers by a preliminary combined reading and discussion of a large number of films. Following this, the survey and control films were read independently. If the readings revealed differences in grading which could affect the diagnosis of ankylosing spondylitis, the films were read again later.

## Results

### (1) COMPARISON OF GRADING BETWEEN OBSERVERS ON FIRST READING OF ALL FILMS

#### *Sclerosis*

1,209 joints were read, and of these 194 (16 per cent.) were graded as abnormal (*i.e.* grades 2, 3, or 4). There were 23 joints (1·9 per cent.) in which the observers disagreed by more than one grade (Fig. 1).

| Grade | Normal | Suspicious | Minimal | Moderate | Advanced |
|---|---|---|---|---|---|
| Normal | 556 | 164 | 10 | 0 | 0 |
| Suspicious | 95 | 200 | 20 | 0 | 0 |
| Minimal | 7 | 66 | 62 | 4 | 0 |
| Moderate | 0 | 4 | 11 | 7 | 0 |
| Advanced | 0 | 0 | 2 | 0 | 1 |

Total joints read: 1,209
Grades 2-4: 194 (16 per cent.)
Disagreement by more than one grade 23 (1·9 per cent.)

FIG. 1 *Interpersonal grading of sclerosis.*

#### *Erosion*

1,233 joints were read and 78 (6 per cent.) graded as abnormal. Disagreement by more than one grade occurred in forty (3 per cent.) (Fig. 2).

| Grade | Normal | Suspicious | Minimal | Moderate | Advanced |
|---|---|---|---|---|---|
| Normal | 873 | 104 | 2 | 0 | 1 |
| Suspicious | 108 | 70 | 4 | 0 | 1 |
| Minimal | 20 | 22 | 5 | 3 | 0 |
| Moderate | 10 | 5 | 2 | 2 | 0 |
| Advanced | 0 | 0 | 1 | 0 | 0 |

Total joints read: 1,233
Grades 2-4: 78 (6·3 per cent.)
Disagreement by more than one grade: 40 (3·2 per cent.)

FIG. 2 *Interpersonal grading of erosion.*

#### *Ankylosis*

During the preliminary discussion of film grading it was found that a significant proportion of otherwise normal films appeared to show partial ankylosis. It was considered that this appearance was an artefact and, in order to force a clear-cut decision, the grading 'doubtful partial ankylosis' was removed. This effectively removed cases where no other sign of sacro-iliitis occurred. Of the 1,258 joints read, 33 (3 per cent.) were graded as abnormal, but, despite the adoption of the procedure mentioned, one-third of these joints were considered normal by one or other observer. Total ankylosis, in contrast, produced little variation in interpretation (Fig. 3).

| *Grade* | *Normal* | *Suspicious* | *Partial ankylosis with sacro-iliitis* | *Total ankylosis* |
|---|---|---|---|---|
| **Normal** | 1,168 | 16 | 1 | 0 |
| **Suspicious** | 35 | 14 | 1 | 0 |
| **Partial ankylosis with sacro-iliitis** | 8 | 1 | 11 | 2 |
| **Total ankylosis** | 0 | 0 | 1 | 8 |

**Total joints read: 1,258**
**Grades 2-4: 33 (2·6 per cent.)**
**Disagreement by more than one grade: 11 (0·9 per cent.)**

FIG. 3 *Interpersonal grading of ankylosis.*

*Joint width*

1,258 joints were read, of which 422 (34 per cent.) were considered abnormal by one or other observer. There was disagreement on joint width in 282 (23 per cent.) (Fig. 4).

| *Grade* | *Normal* | *Narrow* | *Wide* |
|---|---|---|---|
| **Normal** | 836 | 15 | 58 |
| **Narrow** | 63 | 37 | 0 |
| **Wide** | 146 | 4 | 99 |

**Total joints read: 1,258**
**Graded narrow or wide: 422 (34 per cent.)**
**Disagreement: 286 (23 per cent.)**

FIG. 4 *Interpersonal grading of joint space.*

A summary of these findings is shown in Table I.

**Table I** *Summary of interpersonal grading*

| *Observation* | *No. of joints read* | *Abnormal joints* | | *Disagreement by more than one grade* | |
|---|---|---|---|---|---|
| | | *No.* | *Per cent.* | *No.* | *Per cent.* |
| Sclerosis | 1,209 | 194 | 16·0 | 23 | 1·9 |
| Erosion | 1,233 | 78 | 6·3 | 40 | 3·2 |
| Ankylosis | 1,258 | 33 | 2·6 | 11 | 0·9 |
| Joint width | 1,258 | 422 | 34·0 | 286 | 22·0 |

(2) COMPARISON OF GRADING OF FILMS READ BY THE SAME OBSERVER ON DIFFERENT OCCASIONS

The practice of having more than one observer reading $x$ rays for epidemiological purposes arises from the likelihood that the standards of a single observer may vary throughout the lengthy procedure of reading the films. We had the opportunity to investigate the extent of this variation by analysing the differences in grading when each observer read for a second time the 57 films on which there had been initial disagreement. The readings of the two observers are shown in Table II. Of the total of 228 readings, there was a difference from the previous assessment of more than one grade for sclerosis in six joints (2·6 per cent.), erosion in eighteen (8 per cent.), ankylosis in nine (3·9 per cent.), and joint width in 58 (25 per cent.).

**Table II** *Paired observations on 114 joints read twice*

| *Observation* | *Disagreement by more than one grade* | |
|---|---|---|
| | *Observer A* | *Observer B* |
| Sclerosis | 5 | 1 |
| Erosion | 12 | 6 |
| Ankylosis | 7 | 2 |
| Joint width | 28 | 30 |

(3) FINAL GRADING OF SACRO-ILIITIS

638 films were read, and of these only 57 did not have an agreed grading for sacro-iliitis after a single reading. When these were re-read, only fourteen still had no agreed grading. Thus at the end of one reading, the grades were agreed in 91 per cent., and after two readings agreement had been reached in 98 per cent. (Table III).

**Table III** *Overall grading for sacro-iliitis*

| *Reading* | *No. of films read* | *Grade* | | |
|---|---|---|---|---|
| | | *Disagreed* | *Agreed* | |
| | | | *No.* | *Per cent.* |
| First | 638 | 57 | 581 | 91 |
| Second | 57 | 14 | 43 | — |
| Total agreed after second reading | | | 624 | 98 |

(4) DIFFICULTIES

The standard of the films was high and very few had to be rejected for technical reasons, despite the fact that only a single film was taken. The most common difficulty arose from overlying bowel shadow, which is illustrated in Fig. 5. Foreshortened views of the sacro-iliac joints in subjects with exaggerated lumbar lordosis were difficult to interpret. The presence of an ileostomy appliance was readily apparent on some films (Fig. 6) but caused little difficulty. Phleboliths and calcified glands were readily recognized as such.

Certain other conditions were borne in mind, since they may mislead the observer. These included Paget's disease of bone and secondary malignant deposits. Anatomical abnormality of the lumbo-sacral junction could produce areas of sclerosis, usually localized to the area of the abnormal joint (Fig. 7).


FIG. 5 *Sacro-iliac joints obscured by bowel shadow.*

## Discussion

The high degree of inter- and intra-personal agreement of film grading achieved in this study, which is of a similar order to that recorded by Dixon and Lience (1961), demonstrates that reliable sacro-iliac joint interpretation is within the powers of careful observers. It is disappointing to find in the literature so little practical advice on film interpretation. The 'Atlas of Standard Radiographs', which provides invaluable help with most problems of radiological interpretation and grading, is restricted in the case of sacro-iliitis to the illustration of a small number of examples with no evaluation of the grading method. We hope that recording our own experience may be of value to subsequent workers and examples of our grades are shown in Figs 6-10.

### RADIOLOGICAL TECHNIQUE

Throughout the survey we have taken *x* rays of the whole pelvis antero-posteriorly, as recommended by CIOMS, and we consider these to provide the most consistently satisfactory films. The postero-anterior view has advocates (Romanus and Ydén, 1955; Grainger 1957), but the increased joint-film distance increases distortion through magnification effect and the advantages expected to result from a divergent *x*-ray beam traversing a divergent joint space are rarely found since most sacro-iliac joints are not planar (Solonen, 1957), and this results in a confusing superimposition of the anterior and posterior joint margins. This view is also unconventional, most routine *x* rays of the pelvis being antero-posterior thus reducing the observer's past experience of normality.

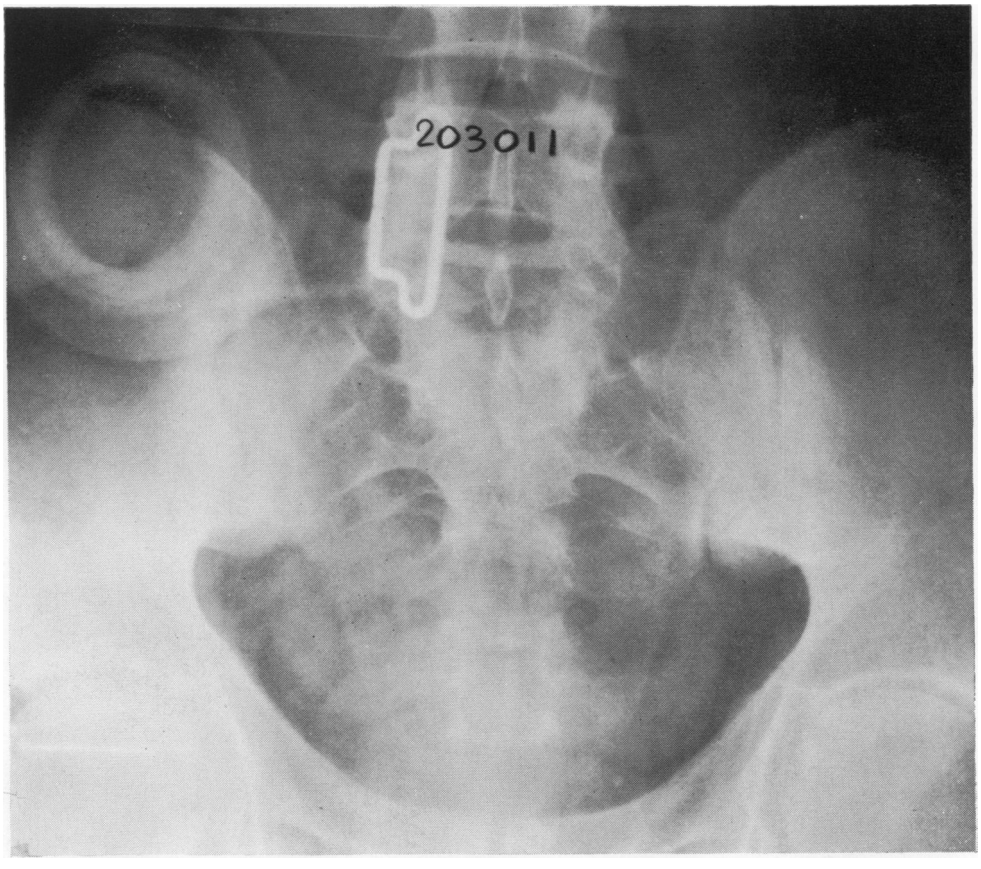


FIG. 6 *Agreed grades: Sclerosis R.3.L.2. Erosion R.1.L.1. Ankylosis R.0.L.0. Overall sacro-iliitis grade 3.*

It is important that the subjects are undressed, since a plethora of radio-opaque objects may otherwise confuse or obliterate the joints. None of our subjects, who included large numbers of asymptomatic relatives, objected to this. Limiting the *x* ray to the sacro-iliac joints, rather than including the whole pelvis, not only denies the observers information gleaned from general observation of the whole pelvis, but is also technically more difficult, and often calls for repeat films which could not be undertaken in a population survey. In contrast to Dixon and Lience (1961), we never relied on information from lumbar spine films, as the sacro-iliac joints are frequently incompletely represented on them, or distorted by their proximity to the edge of the exposed area of film. Although tomography of the sacro-iliac joints may have occasional value (Wilkinson and Meikle, 1966), it has no place in population surveys and oblique views have no advantages over antero-posterior views (Wilkinson and Bywaters, 1958). The use of an abdominal compression pad as a means of reducing the thickness of soft tissues has previously been advocated by Romanus and Ydén (1955). We have observed that, though film quality tended to be inferior in obese subjects, the presence of bowel shadow was a far greater cause of difficulty in interpretation. In the control series of IVP films, in which it is assumed that there had been previous bowel preparation, the frequency of troublesome bowel shadows was undiminished. We noted in some pyelogram films taken with an abdominal compression pad that there was an almost complete absence of bowel shadow. This suggests that routine use of abdominal compression may be worthwhile. Grainger (1957) referred to the foreshortened view of the sacro-iliac joints which may be obtained in patients with an exaggerated lumbar lordosis. We found a number of films of this type difficult to interpret, and suggest that it may be possible to anticipate this problem and allow for it by caudal tilting of the *x*-ray source.

## SCLEROSIS

We found sclerosis to be the most useful single parameter of sacro-iliitis. It is, however, merely a subjective impression of the observed density of

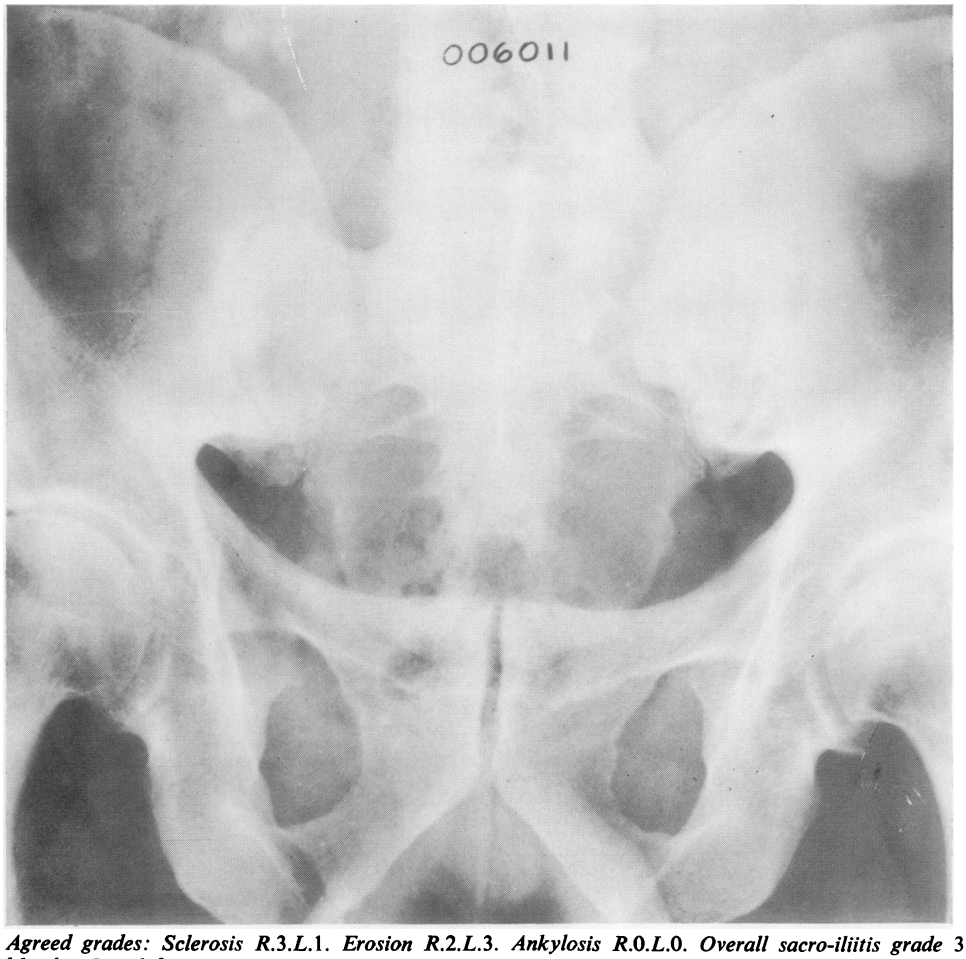


FIG. 7 *Agreed grades: Sclerosis R.3.L.1. Erosion R.2.L.3. Ankylosis R.0.L.0. Overall sacro-iliitis grade 3. Hemi-sacralized lumbar 5 on left.*

bone at the joint margins, and is open to technical error from many sources. Although the general high standard of our films was a tribute to the skill of our radiographers, occasional films were so over-exposed as to render reading for sclerosis impossible. The right joint in some probands was partially obscured by their ileostomy apparatus and both joints were occasionally masked by a loaded colon. Abnormalities of the lumbo-sacral junction are common, and osteoarthrosis at this site may give rise to confusion, as may the superimposition of calcified lymph-nodes over the joints. In contrast to Dixon and Lience (1961), we did not mask the sacro-iliac joints, and we consider this practice undesirable since it not only hampers assessment of the subject's age, but prevents cognisance being taken of bony abnormalities such as Paget's disease, osteitis condensans ilii, and carcinomatous deposits, especially osteosclerotic prostatic secondaries.

EROSION

The interpretation of erosive change was only slightly less satisfactory than that of sclerosis. Two sources of potential error were apparent. Overlying shadow from the loaded colon occasionally precluded interpretation of one or other joint, but small gas shadows in an otherwise unvisualized bowel were a more insidious source of potential error. There is no doubt that the anatomy of a small proportion of joints is such that they appear to be eroded, the usual site of such confusion being on the lateral margin of the joint at the junction of the lower and middle third. Where an apparently smooth erosion, unaccompanied by sclerosis, occurred at this site with bilateral symmetry, it was ignored.

ANKYLOSIS

Although ankylosis is the hallmark of advanced sacro-iliitis, it proved a difficult sign to interpret. The

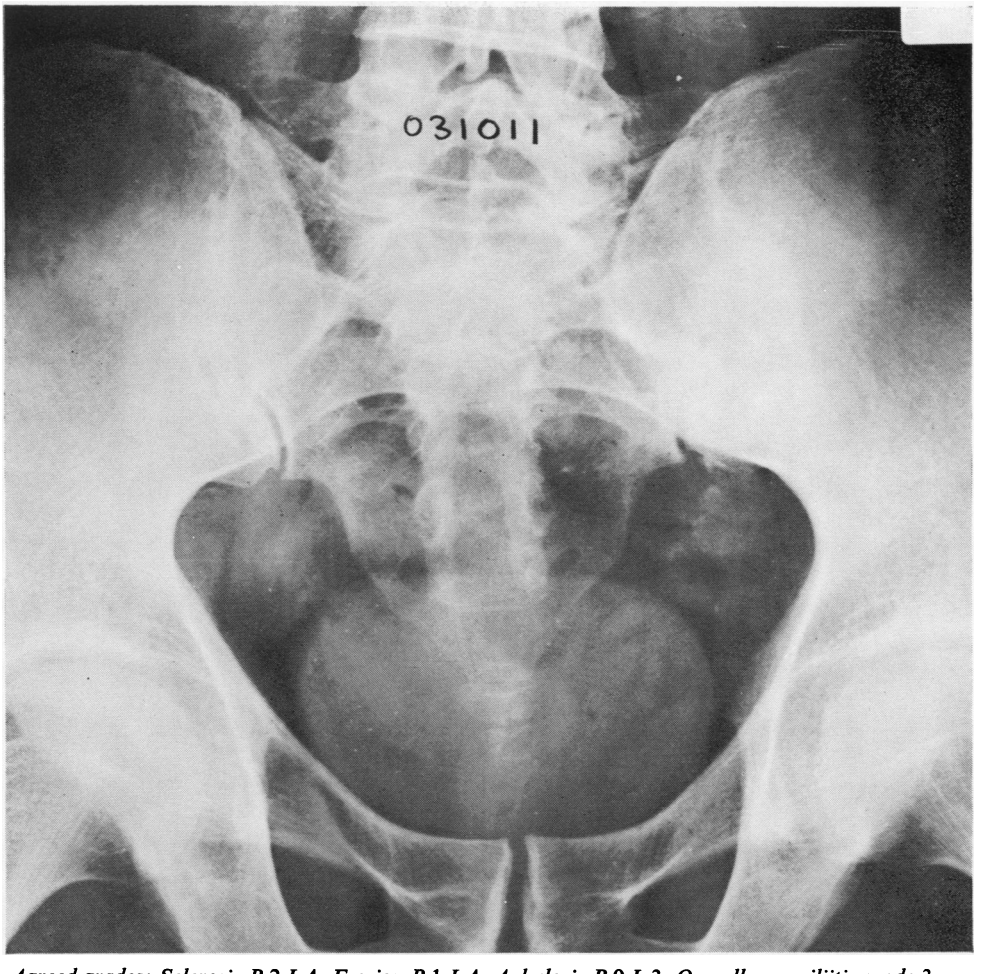


FIG. 8 *Agreed grades: Sclerosis R.2.L.4. Erosion R.1.L.4. Ankylosis R.0.L.3. Overall sacro-iliitis grade* 3.

category 'doubtful ankylosis' was eliminated, since it was too nebulous to be of value. The main source of confusion is easily recognized when the radiographic anatomy of the joint is considered. In the standard antero-posterior film, no clear view of the joint space is obtained, and it is apparent that what is interpreted as the sacro-iliac joint is in fact a view of the anterior and posterior joint margins superimposed on intervening ilium and ischium. Casual observation suggests that such a joint is ankylosed because of the apparent continuity of bone trabeculae across it. Consideration of the lower third of the joint, with no superimposed bone, usually confirmed total normality. Even with experience, however, this sign could prove vexing, particularly as a similar appearance is produced by the 'ghost' joint of total ankylosis.

JOINT WIDTH

This parameter proved to be so inaccurate in its interpretation that we would recommend its exclusion from the criteria for sacro-iliitis. Its source of error is again obvious from the radiographic anatomy; accurate interpretation of the width of a slit of varying aperture cut at an inconstant angle a variable distance from the *x*-ray plate is impossible. The fact that some examples of severe sacro-iliitis show gross abnormalities of apparent joint width should not cause the sign to be regarded as essential, since it is never the only sign in these cases.

CHANGES WITH AGE

On anatomical ground it was anticipated that difficulty would be encountered in interpreting the joints of elderly patients, because of the increasing incidence of partial ankylosis and osteoarthrosis shown by dissection (Sashin, 1930). In practice, however, this did not prove a source of error, although patches of ankylosis are revealed by tomography (Wilkinson and Meikle, 1966). Severe

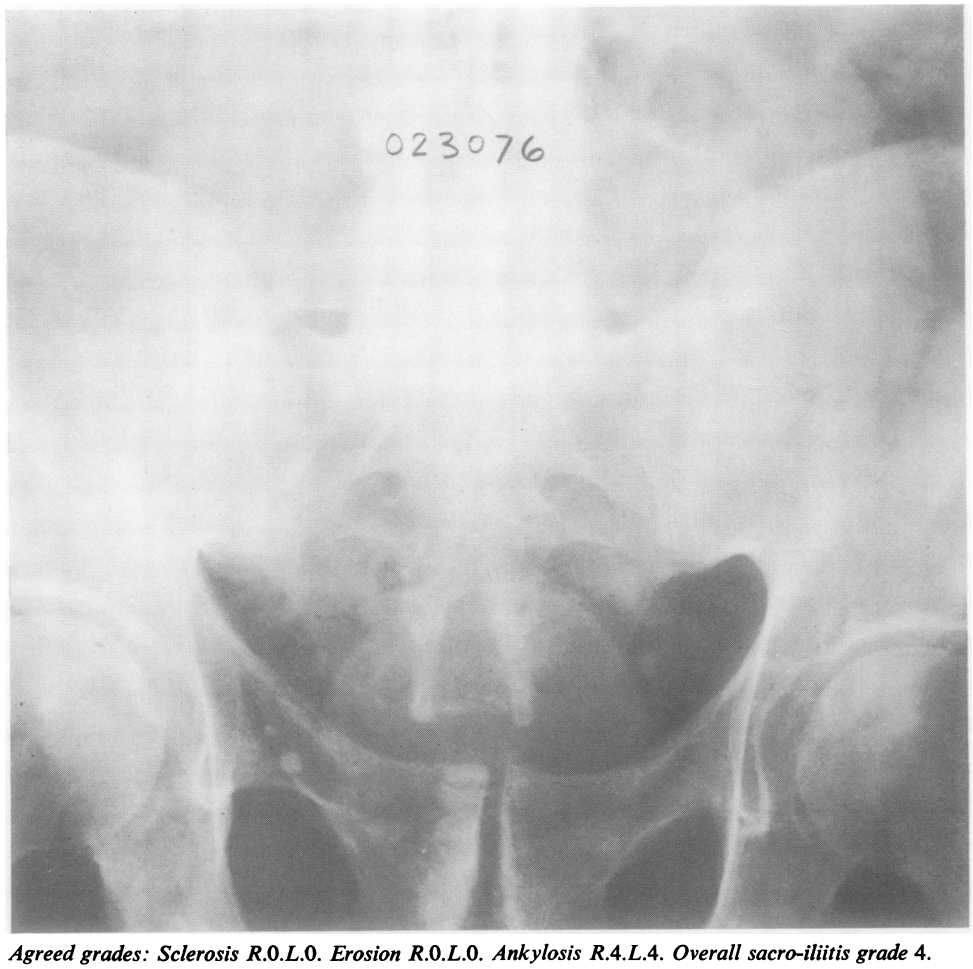


FIG. 9 *Agreed grades: Sclerosis R.0.L.0. Erosion R.0.L.0. Ankylosis R.4.L.4. Overall sacro-iliitis grade* 4.

osteoporosis makes all joint margins appear prominent, and in such cases we always made comparisons with the margins of the hip joint before arriving at a final grading. The youngest subjects, in contrast, often proved much more difficult, as the adolescent sacro-iliac joint appears wide, fluffily eroded, and sclerotic. This was originally described as a pathological syndrome (Rogers and Cleaves, 1935), but is now recognized as normal (Carter, 1962; Jacobs, 1963). This appearance may persist into the third decade, but was not seen after closure of the iliac crest epiphyses. The presence of distinctive features in youth and age reinforces the need for age and sex matching of controls.

## Conclusions

Satisfactory grading of sacro-iliac joints in population surveys can be achieved by careful observers. Observation must be made by two observers independently, and knowledge of the age and sex of the subjects is desirable. Sclerosis and erosion are the most useful parameters; ankylosis requires careful interpretation and joint width was valueless in our experience. Possible sources of error include overlying bowel shadow, exaggerated lumbar lordosis, Paget's disease of bone, secondary malignant deposits, and anatomical abnormalities of the lumbosacral junction.

## Summary

(1) Assessment of 638 pelvic radiographs for sacro-iliitis was made in the context of a family study of ulcerative colitis. The films were of standard format and were obtained from probands with ulcerative colitis, their first- and second-degree relatives, and their spouses. A control group of preliminary films

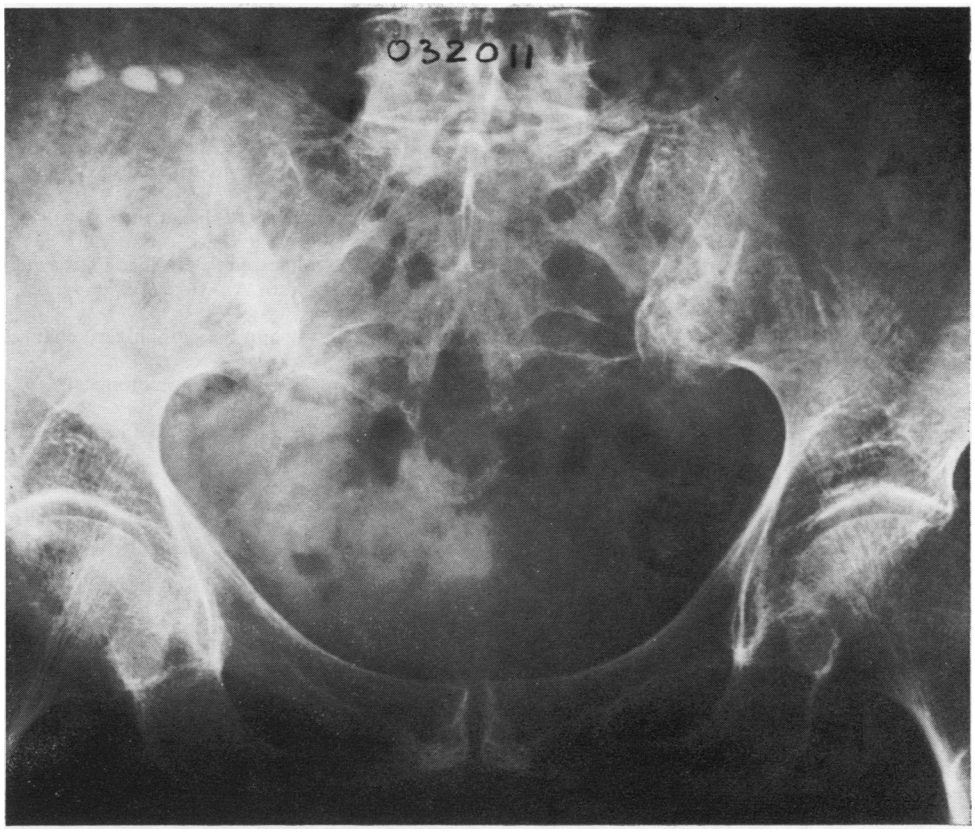


FIG. 10 *Agreed grades: Sclerosis R.2.L.0. Erosion R.0.L.1. Ankylosis R.4.L.4. Overall sacro-iliitis grade* 4.

from IVP examination of patients matched for age and sex was included.

**(2)** In view of the paucity of the literature relating to sacro-iliac joint interpretation, the method used was evaluated by two observers. As a result of this evaluation the term 'possible partial ankylosis' was discarded.

**(3)** Inter-observer error was low in sclerosis (1·9 per cent.), erosion (3 per cent.), and ankylosis (0·9 per cent.), but was unacceptably high for joint width (23 per cent.). Intra-observer error was assessed only on the films on which previous disagreement had occurred. Despite the disproportion of 'difficult' films in this group, satisfactory results were obtained for sclerosis (2·6 per cent.), erosion (8 per cent.), and ankylosis (3·9 per cent.), but not for joint width (25 per cent.).

**(4)** On the basis of these results it is suggested that joint width be discarded as a parameter for sacro-iliitis.

**(5)** Sources of potential errors in interpretation, particularly overlying bowel shadow, exaggerated lumbar lordosis, Paget's disease of bone, secondary malignancy, and anatomical abnormalities at the lumbo-sacral junction, and methods of minimizing them are discussed. The importance of considering the subject's age is stressed.

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