FRACTURES OF THE FEMUR IN PAGET'S DISEASE OF BONE

Their Etiology and Treatment

MICHAEL GRUNDY, BLACKBURN, ENGLAND

From the Manchester Royal Infirmary

Sixty-three fractures of the femur occurring in Paget's disease of bone have been studied to elucidate the mechanism of fracture and to compare methods of treatment and results with those of other series.

Although Paget's disease is commonly symptomless, fracture, particularly of the femur, is one of the most frequent complications (Brailsford 1938, Lake 1951). Many small series of fractures have been reported (Table I), but not until 1958 was a series of as many as forty-one fractured femora described (Lake 1958). Barry (1967) has reported a further seventy cases, at the same time commenting on the high incidence of Paget's disease in Australia. Nicholas and Killoran (1965) presented a series of twenty-three fractured femora from New York, but no other large series has been traced by the author.

TABLE I
FRACTURES OF THE FEMUR IN PAGET'S DISEASE. FIGURES FROM SELECTED SERIES

Author	Femoral fractures	Fractures at other sites
Kay, Simpson and Riddoch (1934)	3	2
Rogers and Ulin (1936)	3	5
Traver (1936)	3	22
Dickson, Camp and Ghormley (1945)	9	68*
Newman (1946)	9	9
Lake (1958)	41	37
Nicholas and Killoran (1965)	23	—
Barry (1967)	70	—
de Mourgues, Comtet and Fischer (1967)	4	8

* This number includes forty-eight "compression fractures" of the spine.

MATERIAL

Records are available of forty-eight patients treated at Manchester Royal Infirmary between 1951 and 1967 for fractures of femora affected by Paget's disease. There were five patients with two fractures, two with three and two with four; so a total of sixty-three fractures was available for study.

Age and sex of patients—The forty-eight patients comprised fourteen men and thirty-four women. The men sustained seventeen fractures and the women forty-six. The age at the time of fracture ranged from thirty-three to ninety years. The distribution of the patients by sex and by age at the time of the first femoral fracture is shown in Table II.

FRACTURE AS A PRESENTING SYMPTOM

In forty of the forty-eight patients it was a fracture of the femur that first led to a diagnosis of Paget's disease. Among the forty were some who had noted progressive deformity of lower limbs or skull, but in none had there been complaints sufficient to lead to investigation.

TABLE II
THE SEX AND AGE OF FORTY-EIGHT PATIENTS AT THE
TIME OF THE FIRST FEMORAL FRACTURE

Age (years)	Female	Male	Total
30-39	0	1	1
40-49	2	1	3
50-59	5	3	8
60-69	8	3	11
70-79	16	4	20
80-89	2	2	4
90-99	1	0	1
Totals	34	14	48

In two of the remaining eight patients the diagnosis had been made at the time of earlier fractures at other sites. Another four had been previously investigated for symptoms related to Paget's disease: backache in two and limb pain at the site of subsequent fracture in two. In two patients Paget's disease had been diagnosed in the course of radiological investigation of unrelated conditions.

MECHANISM OF INJURY

No fracture was caused by severe violence and only eleven fractures were sustained in injuries that could be described as moderate. Mild injury, as in a fall caused by tripping, caused thirty-five fractures, but for the remaining seventeen fractures the patients gave clear histories which excluded any trauma: the leg "just gave way". On twenty-two occasions there was a history of increasing pain in the limb for days, weeks or months before the fracture.

ILLUSTRATIVE CASE REPORTS

Case 10—A woman aged sixty-three had been found to have Paget's disease two years before, when she had fractured her pelvis falling downstairs. She made a good recovery but a year later developed "rheumatic pains" in the right leg. In the two weeks before the femur fractured pain in the right knee had become so severe that she could barely walk. The leg then "gave way" and a fracture was found in the shaft of the femur (Fig. 1).

Case 15—A woman aged sixty had, for eight months, suffered from pain in the left thigh when walking. Radiographs six months after the onset of pain had shown Paget's disease of the left femur, with bowing and multiple stress fractures (Fig. 2); she then fell from a ladder and sustained a fracture in the middle of the shaft at the site of one of these (Fig. 3).

Case 47—In a man aged fifty-eight the diagnosis of Paget's disease had been made nine years earlier during radiological investigation of backache. For four weeks he had had increasing pain in the left thigh. Radiographs a week after the onset of pain showed a stress fracture of the femoral neck (Fig. 4). The leg then "gave way" and a radiograph showed a complete fracture at the same site (Fig. 5).

Case 43—A woman aged sixty-four had twice fractured the left femur. For two and a half weeks she had suffered from increasing pain in the leg and from progressive difficulty in walking. The leg then "gave way". Radiographs showed a third fracture through the femoral neck (Fig. 6).

FIG. 1

FIG. 2

FIG. 3

Case 10. Figure 1—Radiograph showing a transverse fracture of the femoral shaft, occurring at the junction of an area of thickening and an area of lysis. Case 15. Figure 2—Radiograph of left femur after the onset of pain which shows bowing and stress fractures. Figure 3—Three months later, after a fall, a complete fracture has occurred through one of the stress fractures.

FIG. 4

FIG. 5

Case 47. Figure 4—Radiograph taken after the onset of pain in the left thigh. There is a stress fracture on the superior surface of the left femoral neck. Figure 5—One month later the fracture has become complete.

SITE AND TYPE OF FRACTURE

The side on which the fracture occurred was evenly distributed, with thirty fractures of the right femur and thirty-three of the left. The commonest site of fracture was the subtrochanteric region (eighteen), followed by the upper third of the shaft (thirteen). Together these two sites account for almost half the fractures in the series. The numbers of fractures at each site are shown in Figure 7.

Fractures in bone affected by Paget's disease are usually at right angles to the long axis. Most of the fractures in this series corresponded to this pattern, and were typically almost vertical when they occurred in the femoral neck, and transverse in the shaft. A common feature of the transverse fractures was the presence of a small bony spike on one fragment with a corresponding notch on the other fragment. This spike appeared to correspond in position to the concave aspect of the femoral bow. The only fractures that were not transverse were those occurring in bone only mildly affected by Paget's disease, and those through bone in a predominantly lytic phase of the disease.

All but seven of the fractures were displaced, the greatest displacement being in fractures of the subtrochanteric region, where the proximal fragment was flexed and abducted (Fig. 8). Fractures occurred in areas of bone uniformly affected by Paget's disease with the exception of two fractures at the junction of areas of thickening and lysis, and two fractures through sarcomata.

Radiographs of the whole length of forty-two of the fractured femora were available, and the extent of involvement by Paget's disease is shown in Table III. The entire femur was involved in almost half, and thirty-three were deformed by lateral bowing, more pronounced proximally, and by increased anterior bowing more pronounced distally—that is, the deformity was a torsional one in three dimensions. In sixteen of these femora one or more stress fractures were visible and they were always on the convex aspect of the deformity—the superior aspect of the femoral neck, the lateral aspect of the upper shaft and the anterior aspect of the lower shaft. Stress fractures were never seen in an undeformed femur.

FIG. 7
The sites of the sixty-three fractures of the femur.

FIG. 6

Case 43. Radiograph showing a spontaneous vertical fracture of the femoral neck. Two healed fractures in the subtrochanteric region and upper third of the shaft are also visible, the former having united in a position of varus.

TREATMENT AND EARLY RESULTS

Fractures of the femoral neck—None of the eleven fractures of the femoral neck united despite a variety of treatments (Table IV). Subtrochanteric osteotomy in the four cases in which it was done did not produce union of the fracture nor was upward displacement of the shaft prevented, though all four osteotomies united.

FIG. 8

FIG. 9

Figure 8—Radiograph of a subtrochanteric fracture showing severe displacement. Figure 9—Radiograph showing union in varus of a subtrochanteric fracture treated conservatively.

Fractures of the trochanteric region—There were two such fractures. Both were treated by internal fixation using a nail-plate, but hardness of the bone made operation difficult. One patient, aged eighty-three and previously bedridden, died of bronchopneumonia and rectal carcinoma one month later. The other patient, a woman of eighty-one, needed a second operation at three weeks when the nut securing the nail to the plate became undone. Infection supervened, and although the fracture united and the patient walked, there was still a discharging sinus two years later. This was the only case of chronic sepsis after operation in this series.

TABLE III
THE EXTENT OF INVOLVEMENT OF
FORTY-TWO FEMORA BY PAGET'S
DISEASE

Uppermost third	.	1
Upper two-thirds	.	14
Lower two-thirds	.	7
Whole femur	.	20

Subtrochanteric fractures—Of the eighteen subtrochanteric fractures one, in a man of seventy-nine, was through a sarcoma. The patient died one year later despite a hindquarter amputation. Of the remaining seventeen fractures seven were treated conservatively and ten by operation and all united.

Conservative treatment with a Thomas's splint resulted in union in an acceptable position if the initial displacement was only slight, as in three of the cases. When initial displacement was greater, as in four cases, the fractures united in a position of varus (Fig. 9); second fractures later occurred at adjacent sites in three.

Internal fixation controlled angulation. Nail-plate fixation was used in two, but hardness of the bone made operation difficult as in the two trochanteric fractures. The insertion of an intramedullary nail was an easier procedure, particularly if the nail was not passed more than a

TABLE IV
FRACTURES OF THE NECK OF THE FEMUR IN PAGET'S DISEASE—TREATMENT AND RESULTS

Case number	Sex	Age	Treatment	Remarks	Result
13	Female	79	Conservative: three days bed rest	Walking at three days	Non-union
17	Female	76	Conservative: six weeks Hamilton Russell traction	Weight-bearing at eight weeks	Non-union
26	Female	71	Conservative: six weeks Hamilton Russell traction	Weight-bearing at twelve weeks	Non-union
27	Female	72	Smith-Petersen nail. Attempted insertion of Judet prosthesis	Nail backed out at six months. Insertion of prosthesis abandoned: haemorrhage	Non-union
29	Male	67	Subtrochanteric osteotomy at six weeks. Hip spica for three months	Undisplaced fracture. No evidence of union after six weeks traction	Non-union
30	Male	77	Conservative: two weeks bed rest	Walking at two weeks	Non-union
35	Female	75	Subtrochanteric osteotomy at two weeks. Hip spica for three months	—	Non-union
37	Female	88	Conservative: twelve weeks Hamilton Russell traction	Fracture undisplaced but displaced within a week of removal of traction	Non-union
40	Male	48	Early subtrochanteric osteotomy. Hip spica for three months	—	Non-union
43	Female	64	Venable screw	Screw fractured at two weeks	Non-union
47	Male	58	Smith-Petersen nail. Late subtrochanteric osteotomy	Nail backed out at three months	Non-union

short distance beyond the fracture; thereafter the added immobilisation of a Thomas's splint or hip spica was used until union was well advanced (Fig. 10). Difficulties arose twice when a long nail penetrated the lateral cortex of a curved femur; one femur refractured at the site of penetration.

Fractures of the femoral shaft—There were thirty-two fractures through the uppermost, middle and lowest thirds of the shaft. Open reduction and internal fixation with an intramedullary nail or Rush pins was done for four fractures in the uppermost third and for two in the lowest third, and all six united. Attempted internal fixation was abandoned twice, leaving twenty-six fractures which were treated conservatively.

Conservative management consisted in manipulative reduction, if necessary, with immobilisation on a straight Thomas's splint. The splint was later replaced by a hip spica plaster in four instances. The total duration of immobilisation varied from six weeks to five months. All patients then walked in a weight-relieving caliper until the fracture was sufficiently consolidated.

Three fractures of the shaft did not unite with conservative treatment, one being a fracture through a sarcoma; the patient died three months later. The second was in a seventy-six-year-old woman with a fracture in the middle third of the femur who, after five months on a Thomas's splint, developed a fibrous union and who walked thereafter with a caliper. The last was in a fifty-six-year-old woman bedridden with rheumatoid arthritis who had osteoporosis in addition to Paget's disease; she eventually had the leg amputated.

In patients with fractures of a laterally bowed femoral shaft treated conservatively it was often found that the bowing was held corrected in the Thomas's splint (Fig. 11). The implications of this finding are discussed below.

FIG. 10

FIG. 11

Figure 10—Radiograph showing union of a subtrochanteric fracture in good position following insertion of a short intramedullary nail. Originally the fracture was displaced. Figure 11—Radiograph showing the correction of lateral bowing of the femur in a Thomas's splint.

TIME REQUIRED FOR UNION

The time to complete union is impossible to define accurately and the best estimate in this series was the time taken for the patient to resume full weight-bearing. Usually this was when a weight-relieving caliper was discarded.

The time to union using this criterion varied from eight weeks to ten months (Table V). The sixteen cases of non-union have been described and are summarised in Table VI.

LONG-TERM RESULTS

Of the forty-eight patients twenty had died and twenty-four were living at the time of writing. Four could not be traced. It was possible to obtain the Certified Cause of Death in every fatal case. Death had occurred after periods ranging from one month to ten years after the last femoral fracture, the average age at death being 75.5 years (Standard Deviation ± 9.2 years). In no patient could death be attributed directly to the effects of the fracture, and in particular to the late development of sarcoma at the fracture site. The most frequent causes of death were cardiovascular disorders.

Of the twenty-four survivors fifteen were reviewed personally and information regarding the remainder obtained by inquiry. The length of follow-up from the last fracture varied from eighteen months to sixteen years.

In the whole series all but five patients walked after treatment of their fractures—the three previously bedridden and the two with sarcomata. Patients were able to walk unaided, however, after only nineteen of the sixty-three fractures, the others needing sticks or tripods thereafter.

Pain persisted after about a quarter of the fractures but it could not be related to the site or state of union. For example four ununited femoral neck fractures caused pain and four did not.

An attempt was made to grade the patients' disabilities in terms of mobility and pain. The patients with nineteen fractures who walked unaided had no pain and disability was slight. After thirty fractures the disability was moderate; the patient used one stick for walking with

TABLE V
TIME TO UNION IN FEMORAL FRACTURES IN
PAGET'S DISEASE

Time	Fractures
Less than three months . . .	6
Three to six months	26
More than six months	8
United, time unknown	7
Non-union	16
Total	63

TABLE VI
NON-UNION OF FRACTURED FEMORA IN PAGET'S DISEASE

Site of fracture	Total fractures	Number ununited	Comment
Femoral neck	11	11	—
Trochanteric	2	1	Aged 83. Bedridden. Died one month post-operatively
Subtrochanteric	18	1	Fracture through sarcoma
Shaft	32	3	One fracture through sarcoma; one patient bedridden and osteoporotic and one fibrous union, no apparent cause
Total	63	16	

or without some discomfort. In the remaining eleven in which the patient survived the fracture the disability was severe, the patient either remaining bedridden (two) or being restricted in mobility by pain and the need for support. The relationship of disability to the site of fracture is shown in Table VII.

DISCUSSION

INCIDENCE

In our experience the bone most commonly fractured in Paget's disease has been the femur. During the period under consideration only twenty-one fractures at other sites—chiefly the tibia, humerus and pelvis—were treated.

Barry (1967) attributed the large number of seventy fractured femora in his series to the high incidence of Paget's disease in Australia. The incidence of Paget's disease in the

population from which the present series is drawn is not known, but Collins (1956), working on necropsy material in nearby Leeds and Sheffield, found 3·7 per cent of patients over the age of forty to be affected (that is, 1·6 per cent of the population). The estimate is probably low because it is unlikely that every bone was examined.

The number of fractured femora in the present series is only a small proportion (2·5 per cent) of the total number of femoral fractures treated in Manchester Royal Infirmary over the same period. This suggests that although fracture of the femur is one of the most frequent

TABLE VII
THE RELATIONSHIP OF DISABILITY TO THE SITE OF
FEMORAL FRACTURE IN PAGET'S DISEASE

Site	Disability		
	Slight	Moderate	Severe
Neck	—	6	5
Trochanteric	—	1	—
Subtrochanteric	11	2	3
Shaft	8	21	3
	19	30	11

The two patients with sarcomata and the one who died one month after fracture are not included.

complications of Paget's disease, the risk of fracture is not greatly in excess of that of the normal population. This must be compared with the estimate of Price (1962) that the risk of sarcoma occurring in Paget's disease is thirty times greater than in the normal population.

Compared with Barry's (1967) Australian series (twenty-seven women: thirty-two men) there were proportionately more women in the present series (thirty-four women: fourteen men). However, the numbers in the two series are not large, and some of the difference may be accounted for by an excess of women in the elderly population of South-East Lancashire as compared to Australia. The relevant figures for the populations over the age of fifty are: for South-East Lancashire, 135 women: 100 men (Registrar General 1963) and, for Australia, 112 women: 100 men (Commonwealth Bureau of Census and Statistics 1967).

MECHANISM OF FRACTURE IN PAGET'S DISEASE

It has long been recognised that the structure of bone affected by Paget's disease gives it less resistance to injury than that of normal bone; it has been likened to breaking rotten wood, chalk, or a peeled banana. Although it is accepted that a mild injury may result in a fracture of abnormal bone, the histories of the patients in this series indicate that other factors might be concerned. There was no injury before seventeen fractures and increasing pain before twenty-two fractures, which suggests a progressive weakening of the bone.

Stress or fissure fractures usually occur in Paget's disease on the convexity of a deformed femur or tibia; that is, in areas of increased tension. In this respect they differ from the "Looser's zones" of osteomalacia which tend to lie in areas of compression, such as in the calcar femorale (Chalmers, Conacher, Gardner and Scott 1967). Although Brailsford (1938) said that stress fractures are "not often associated with a true complete fracture", other authors such as Gutman and Kasabach (1936), Traver (1936) and Allen and John (1937) agree that they may, with slight trauma, become complete fractures. This is confirmed in four patients in the present series for whom radiographs show stress fractures before the complete fractures

(Cases 2 and 3). Three of the four patients were among the twenty-two patients complaining of increasing pain before fracture. Pain is not usually a feature of uncomplicated Paget's disease, and its occurrence suggests extension of a stress fracture as the most likely cause, which is almost certainly a much more common mechanism of fracture in Paget's disease than has been supposed.

Experience in the treatment of painful stress fractures has not been encouraging. Although bracing or bed rest may prevent complete fracture, the stress fractures appear to be inherent in the deformity of the bone and have persisted for several years without healing. Corrective osteotomy may be the best approach to this problem.

TREATMENT OF FEMORAL FRACTURES

Fractures of the neck and trochanteric region—The results of treatment of femoral neck fractures in this series have been disappointing in that all eleven fractures failed to unite whether treated conservatively or by internal fixation. Subtrochanteric osteotomy in the four cases in which it was done did not confer any advantage to the patients in terms of union, stability or the prevention of shortening. Other authors remark on the difficulties of dealing with this fracture. Of four undisplaced fractures treated conservatively by Barry (1967) two failed to unite; in a fifth fracture the femoral head was replaced by a Moore's prosthesis with good results. Nicholas and Killoran (1965) had poor results in three cases in which Moore's prostheses were inserted, but achieved union in a further case by internal fixation with Knowle's pins.

This cumulative experience leads to the conclusion that in Paget's disease the difficulties of internal fixation or prosthetic replacement at this site are best avoided, as is prolonged conservative treatment. Early mobilisation of the patient is advised. This form of treatment carries with it the penalty of certain non-union, but this is not necessarily painful; all eleven patients in this series were able to walk with aid, despite their ununited fractures.

Our experience of trochanteric fractures is too small to draw valid conclusions, but the difficulties of internal fixation may be best avoided by conservative treatment.

Subtrochanteric fractures—Most of these fractures are grossly displaced. Conservative treatment produces union in varus (Fig. 9), and this deformity may predispose to further fracture as occurred in three of four cases so treated.

The use of a short narrow intramedullary nail to control angulation has been successful and not attended by undue technical difficulties (Fig. 10). However, it is felt that attempts to secure absolute fixation by the insertion of a long full-diameter nail are inadvisable where there is any tendency to bowing of the shaft or narrowing of the medullary cavity. Instead, reliance may be more safely placed on the addition of external splintage to protect the fracture and to control rotation.

Shaft fractures—The problem of the treatment of femoral shaft fractures in Paget's disease centres on the relative merits of conservative treatment and of internal fixation. Open reduction and internal fixation are not always easy. If the femur is relatively undeformed and the fracture is in the upper half of the shaft, it may be possible to insert an intramedullary nail. If there is deformity or if the fracture is in the lower part of the shaft other methods are necessary. Both Barry (1967) and Nicholas and Killoran (1965) have used plates and screws in these circumstances. Vascularity of the bone and surrounding soft tissues also creates problems; the latter authors' average blood replacement in the operative treatment of femoral shaft fractures was 2,400 millilitres. Such operations are thus of much greater magnitude than those on normal bone.

One of the theoretical advantages of internal fixation is the possibility of earlier mobilisation of both the limb and the patient, but the six femora so treated in this series were also given external fixation and bed rest for periods comparable to those treated conservatively. Nicholas and Killoran (1965) found that internal fixation with screws and plates required longer external

support and impaired the end-results considerably compared with patients treated by traction alone.

Another possible advantage of internal fixation is the ability to achieve and maintain accurate reduction of the fracture, and it has been suggested above that for this reason the internal fixation of displaced subtrochanteric fractures is indicated. However, in fractures of the shaft the situation differs in that accurate reduction preserves a deformity which conservative treatment can correct. It has been shown that splintage of a bowed and fractured femur on a straight Thomas's splint tends to correct the alignment of the femur (Fig. 11). If it is accepted that complete fractures are often caused by extension of stress fractures and that such fractures are consequent upon the deformity of the femur, it follows that correction of the deformity is desirable, that complete fracture provides the opportunity, and that conservative management is thus the treatment of choice.

Delayed union and non-union may occur following both operative and conservative treatment. The two patients with established non-union of femoral shaft fractures in the present series had both been treated conservatively. Barry (1967) reported two ununited shaft fractures in fifteen treated conservatively and three in thirteen treated by operation. Nicholas and Killoran (1965) had one ununited fracture in three conservatively treated and of seven treated by operation two failed to unite. These figures all apply to patients who survived their fractures sufficiently long for the end-result to become apparent. The cumulative figures are too small to be significant but suggest that non-union is a complication which follows operative treatment (five out of twenty-four fractures) at least as frequently as after conservative treatment (five out of forty-three).

Reifstein and Albright (1944) described "chemical death" from hypercalcaemia and acidosis as a complication of the prolonged immobilisation of patients with Paget's disease. This was not encountered in any patient in this series, and Nicholas and Killoran (1965) also comment on its absence in their series.

For the above reasons we believe that conservative management is the treatment of choice in most fractures of the femoral shaft occurring in Paget's disease.

Time required for union—Despite conflicting views in the early literature of Paget's disease on the rate of fracture healing, the results in this series do not conflict with the accepted view that union of fractures in Paget's disease is neither unduly rapid nor unduly delayed.

LONG-TERM RESULTS

One particular long-term result deserves mention. Platt (1947), Porretta, Dahlin and Janes (1957), and Nicholas and Killoran (1965) have all described the occurrence of sarcoma after fracture in Paget's disease. This complication did not occur in the present series. While not denying that sarcoma may rarely arise at a fracture site, either coincidentally or as a result of fracture healing, Brailsford (1938) was probably correct when he wrote "malignant metaplasia . . . is usually the determining factor of a spontaneous fracture and not a subsequent event".

The eventual outcome of the sixty-three fractures in this series in terms of the patients' mobility and freedom from pain has been surprisingly good, particularly in view of the advanced age of many of the patients treated, and would bear comparison with a similar series of fractures through normal bone.

SUMMARY

1. Sixty-three fractures of the femur occurring in forty-eight patients with Paget's disease are presented.
2. In patients with Paget's disease the femur is the bone most often fractured, although the risk of fracture is probably not much greater than that of the normal population.

3. Many femoral fractures in Paget's disease are spontaneous and are preceded by pain. Extension of a stress fracture is the most likely cause.
4. All eleven femoral neck fractures in this series failed to unite; it is suggested that neither operation nor prolonged conservative treatment is indicated.
5. Subtrochanteric fractures, if severely displaced, are best treated by intramedullary nailing.
6. Most shaft fractures may be satisfactorily treated by conservative means. Deformity of the shaft can be corrected in fractures treated by external splintage.
7. The time required for union has been neither unduly short nor unduly prolonged.
8. The long-term results in this series have been acceptable. Sarcomatous change as a complication of fracture was not observed.

I wish to thank Mr D. L. Griffiths and Mr Norman Shaw for permission to report on their patients and for advice and encouragement in preparation of the manuscript. Thanks are also due to Dr Philip Wood for advice on the statistical aspects of the article and to Dr R. Ollerenshaw of the Department of Medical Illustration, Manchester Royal Infirmary.

REFERENCES

- ALLEN, M. L., and JOHN, R. L. (1937): Osteitis Deformans (Paget's Disease). Fissure Fractures—Their Etiology and Clinical Significance. *American Journal of Roentgenology and Radium Therapy*, **38**, 109.
- BARRY, H. C. (1967): Fractures of the Femur in Paget's Disease of Bone in Australia. *Journal of Bone and Joint Surgery*, **49-A**, 1359.
- BRAILSFORD, J. F. (1938): Paget's Disease of Bone; its Frequency, Diagnosis and Complications. *British Journal of Radiology*, **11**, 507.
- CHALMERS, J., CONACHER, W. D. H., GARDNER, D. L., and SCOTT, P. J. (1967): Osteomalacia—A Common Disease in Elderly Women. *Journal of Bone and Joint Surgery*, **49-B**, 403.
- COLLINS, D. H. (1956): Paget's Disease of Bone. Incidence and Subclinical Forms. *Lancet*, **ii**, 51.
- COMMONWEALTH BUREAU OF CENSUS AND STATISTICS (1967): *Pocket Compendium of Australian Statistics*, No. 52. Canberra: A. J. Arthur.
- DICKSON, D. D., CAMP, J. D., and GHORMLEY, R. K. (1945): Osteitis Deformans: Paget's Disease of the Bone. *Radiology*, **44**, 449.
- GUTMAN, A. B., and KASABACH, H. (1936): Paget's Disease (Osteitis Deformans). Analysis of 116 Cases. *American Journal of the Medical Sciences*, **191**, 361.
- KAY, H. D., SIMPSON, S. L., and RIDDOCH, G. (1934): Osteitis Deformans. *Archives of Internal Medicine*, **53**, 208.
- LAKE, M. (1951): Studies of Paget's Disease (Osteitis Deformans). *Journal of Bone and Joint Surgery*, **33-B**, 323.
- LAKE, M. E. (1958): The Pathology of Fracture in Paget's Disease. *Australian and New Zealand Journal of Surgery*, **27**, 307.
- MOURGUES, G. DE, COMTET, J.-J., and FISCHER, L. (1967): Les fractures dans la maladie osseuse de Paget. *Revue de Chirurgie orthopédique et réparatrice de l'Appareil Moteur* (Paris), **53**, 657.
- NEWMAN, F. W. (1946): Paget's Disease. A Statistical Study of Eighty-two Cases. *Journal of Bone and Joint Surgery*, **28**, 798.
- NICHOLAS, J. A., and KILLORAN, P. (1965): Fracture of the Femur in Patients with Paget's Disease. Results of Treatment in Twenty-three Cases. *Journal of Bone and Joint Surgery*, **47-A**, 450.
- PLATT, H. (1947): Sarcoma in Abnormal Bones. *British Journal of Surgery*, **34**, 232.
- PORRETTA, C. A., DAHLIN, D. C., and JANES, J. M. (1957): Sarcoma in Paget's Disease of Bone. *Journal of Bone and Joint Surgery*, **39-A**, 1314.
- PRICE, C. H. G. (1962): The Incidence of Osteogenic Sarcoma in South-West England and its Relationship to Paget's Disease of Bone. *Journal of Bone and Joint Surgery*, **44-B**, 366.
- REGISTRAR GENERAL (1963): Estimated Home Population by Sex and Age as at 30th June 1963. In *Registrar General's Statistical Review of England and Wales: Part II. Tables Population*, P.6. London: H.M.S.O.
- REIFENSTEIN, E. C. JUN., and ALBRIGHT, F. (1944): Paget's Disease. Its Pathologic Physiology and the Importance of this in the Complications arising from Fracture and Immobilization. *New England Journal of Medicine*, **231**, 343.
- ROGERS, M. H., and ULIN, R. (1936): Fractures in Paget's Disease. *Journal of Bone and Joint Surgery*, **18**, 914.
- TRAVER, C. A. (1936): The Association of Fractures and Paget's Disease (Osteitis Deformans). *New York State Journal of Medicine*, **36**, 242.