LECTURE NOTES ON ORTHOPAEDICS AND FRACTURES

T. DUCKWORTH

SECOND EDITION

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Preface to second edition

A specialty which is advancing as rapidly as orthopaedics has an inevitable tendency to fragment, making it increasingly difficult to survey the whole field. There are now hand surgeons, knee surgeons, spinal experts, traumatologists, specialists in paediatric orthopaedics and even 'trouble shooters' dealing mainly with their colleagues' failures and complications.

It is clearly not the purpose of a short textbook such as this to try to explore deeply into these expanding lagoons of knowledge. Nevertheless, whilst keeping the picture broad, an attempt has been made to draw attention to some of the newer concepts and developments. The section on fractures is a good example. There is much interest at the moment in the ways in which fractures heal and about the best methods of holding them to promote healing. Ligamentous injuries, particularly of the knee, are receiving more attention and arthroscopic surgery is becoming an increasingly important subject. In many countries the population structure is changing, with a steady increase in the problems posed by fractures and joint disease in the elderly. Unhappily, attitudes within society are also changing, resulting in a casual attitude to personal violence, so that gunshot and other inflicted wounds have become almost commonplace in some communities. These points are reflected in the text. More optimistically, it must be said that there is undoubtedly greater scientific collaboration. Bio-engineering, in particular, is playing an increasing role, but there are also important contributions from biochemists, bacteriologists and many others. As far as possible, some of the fruits of this cross-fertilisation have been included in the second edition.

The general layout of the book remains as before. I have been fortunate in having had many helpful comments from students and colleagues. Wherever possible, their suggestions have been adopted. Some would have involved a complete change in the style and philosophy of the book. Here, rightly or wrongly, I have had to let my own judgement stand on what the modern student, with his packed timetable, might want to know about a subject which at the moment seems to have a lot of vitality.

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Preface to first edition

At first sight there would appear to be little difficulty in compiling a short textbook of orthopaedics and fractures to meet the needs of medical students, general practitioners and others with a non-specialist interest in the subject. They are all likely to require a quick and reliable source of reference and some practical advice on management. But how much material, how much detail, and how much practical advice?

Many medical schools have reduced the time available for the study of disorders of the musculo-skeletal system. The medical student is now lucky if he can gain experience in the techniques of clinical examination, let alone become familiar with those common orthopaedic conditions which occupy so much of the average general practitioner's time and encroach on every branch of medicine.

It would be a short textbook indeed which covered only the contents of this type of course. Students often complain that they are given no guidance as to how far their reading should take them beyond the confines of their limited clinical experience. They often ask in desperation for a syllabus or a list of reading material: how much do we need to know? Unfortunately, although examiners may be prepared to confine themselves within pre-determined limits, patients rarely do so. They present with obscure problems, or, worse still, common problems in unfamiliar guises. No matter how well he has been taught and has understood the principles of diagnosis and management no textbook can provide the new doctor with what will become his most valuable asset—experience. It can however provide him with other peoples' experience and also with something almost equally valuable—an awareness of what are the possibilities. Without this awareness, a diagnosis can rarely be made.

In the absence of clear guidance from the medical faculties about what their end-product, the newly qualified doctor, is supposed to be, it seemed reasonable to try to produce a book which would attempt to provide answers, albeit often brief and incomplete ones, to most of the questions the interested and intelligent student and post-graduate would be likely to ask about the subject.

In doing so, emphasis has been placed on the principles of diagnosis and management and on classification. It is hoped that the latter will be an aid to understanding relationships and also perhaps to memory. Common conditions have been allocated relatively more space, and some details of the management of such conditions, which might be of value to junior staff, are included, with short sections on orthopaedic and operative procedures. Rarities are either excluded or simply receive a brief mention to make the student aware of their existence. Inevitably, some sections will appear too condensed and others too detailed. The section on ankle fractures, for example, is perhaps more appropriate for a trainee orthopaedic surgeon than a student, but here, as in other places, it was felt that the subject could become almost meaningless if less detail were included.

The layout of the book may be found convenient by some readers, irrational and perhaps irritating by others. This particular arrangement has been chosen so that answers will be easy to find, embedded in related information which will make the subject more of a whole. The regional chapters provide an alternative approach to the same information, and cross-references have been provided to avoid repetition.

The content is, of course, the author's choice, based on experience of what has been found useful and of interest to students. Orthopaedics is a strongly clinical subject with a high visual content. This is reflected in the relatively large number of illustrations. X-rays are so much a part of the world of orthopaedics, that it is difficult to imagine the specialty without them, and wherever possible these have been used to illustrate the various conditions. Nevertheless, some experience is required in their interpretation, and where this could be a problem diagrams have been substituted for their extra clarity.

Finally, and in response to suggestions from students, an appendix has been added, giving useful pathological and clinical data for rapid reference.

If this volume proves useful on the wards and in the clinics, and stimulates an interest in a fascinating subject, it may justify adding to the rising tide of published material which threatens to overwhelm students and practising doctors alike.

GENERAL PRINCIPLES

Chapter 1. The Connective Tissues

1. STRUCTURE

The connective tissues of the body are composed of cells embodied in a matrix which varies in its quantity and composition. The cells can be categorised by the nature of the intercellular material, of which there are three types:

COLLAGENOUS TISSUE (produced by fibroblasts)
CHONDROID (produced by chondroblasts)
OSTEOID (produced by osteoblasts)

In each case the main constituents of the matrix are a complex mixture of proteoglycans and glycoproteins forming a ground substance in which is embedded a meshwork of fibrils, mostly of collagen, a protein. At least four genetically different types of collagen are now recognised—bone contains Type I and hyaline cartilage Type II. Skin contains Types I and III and, being a convenient tissue for biopsy, is used for the study of certain collagen-related bone diseases. Elastin, a prominent constituent of one type of cartilage is also thought to be a component of collagen.

(a) BONE

is essentially osteoid heavily infiltrated with calcium salts, which give it hardness and strength, its resilience being due to its organic content. The mechanism of mineralisation is not well understood. The mineral is mainly deposited in crystalline form as hydroxyapatite but there is also an amorphous phase which is found particularly in newly formed bone. It is worth noting that various ions such as strontium, fluoride and lead can enter the crystal lattice of bone mineral.

A normal bone is composed of concentric cylinders of matrix with layers of cells lying in lacunae between the layers, the whole forming a 'Haversian System'. In the hard cortex of the bone the Haversian Systems are packed tightly together; in the spongy or cancellous bone they are more loosely arranged (Figure 1.1). The bony trabeculae are orientated to withstand the stresses of weight-bearing and muscle activity. The interstices of the cancellous bone and the hollow centres of the shafts of long bones are filled with marrow. Haemopoiesis occurs throughout the bone in the child, but in

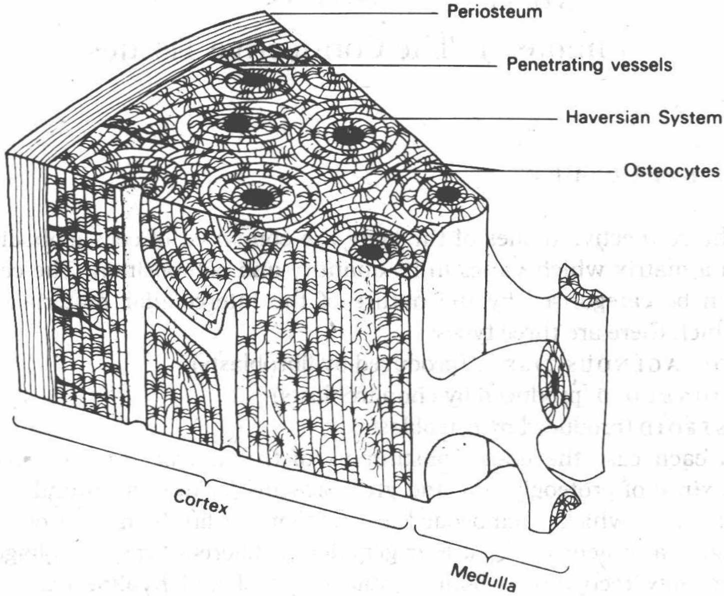

Figure 1.1.

the adult it is confined to the short bones, particularly the vertebral bodies, and to the ends of the long bones.

The bone is ensheathed by fibrous periosteum with an underlying layer of osteoblasts, and is vascularised from the periosteum and by one or more nutrient arteries penetrating the cortex.

(b) CARTILAGE

varies in its appearance and physical characteristics depending on the predominent type of fibril and the density of the matrix. Two types of fibril-collagen and elastin are found in varying proportions. Three types of cartilage are normally recognised:

1 Hyaline cartilage. The unossified epiphyses and the articular surfaces both consist of hyaline cartilage and are indistinguishable by ordinary histological techniques, but have different properties and, of course, different functions.

2 White fibro-cartilage found mainly in midline structures, such as intervertebral discs and symphyses. The collagen content is much greater than in hyaline cartilage and the fibres are much more obvious. This type of cartilage has the ability to bear heavy compressive loads.

3 Yellow or elastic fibro-cartilage found in the nasal and aural cartilages and containing the highest proportion of elastin.

(c) COLLAGENOUS

or fibrous tissue is widespread throughout the body and consists mainly of collagen fibres with relatively little matrix.

Disorders of collagen metabolism are being extensively studied because of their dramatic effects on body structure and development. These conditions are sometimes called 'true collagen diseases', as opposed to the non-developmental diseases such as rheumatoid arthritis.

2. GROWTH AND DEVELOPMENT

Connective tissues grow by cell proliferation and deposition of intercellular material.

(a) BONES

develop initially in early intrauterine life as condensations of mesenchymal tissue in the axis of the limb (Figure 1.2a), and by the

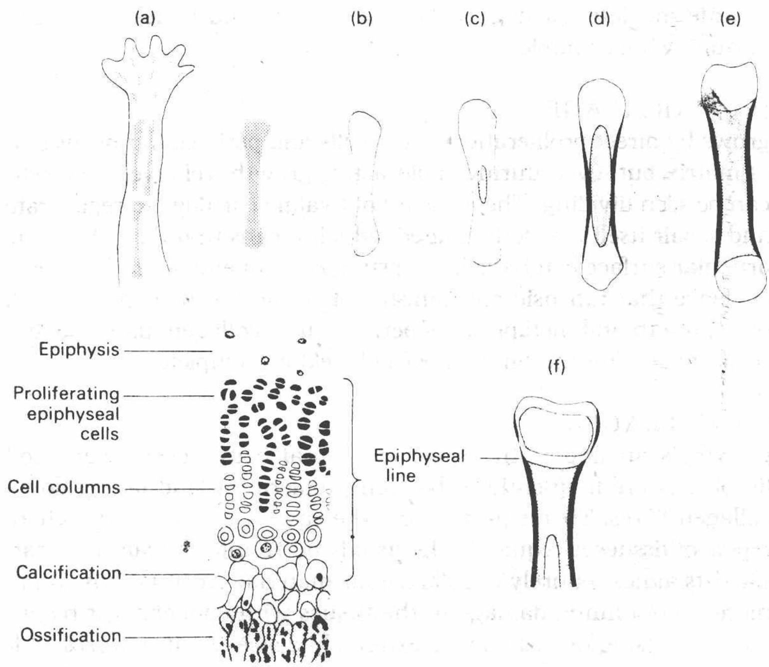

Figure 1.2. Bone growth and development

6th week the connective tissue cells have started to lay down cartilage to form the shape of the future bone (Figure 1.2b). At the centre of the cartilage mass the cells hypertrophy and apparently die, and with the ingrowth of vascular connective tissue the matrix calcifies and eventually ossifies (Figure 1.2c). This process spreads along the bone (Figure 1.2d), so that it eventually consists of a bony shaft with cartilaginous ends (Figure 1.2e) which become the sites of secondary ossification centres (Figure 1.2f). The intervening or epiphyseal cartilage remains until maturity as the growth point for bone length, the proliferating cartilage cells forming into columns and undergoing a series of changes, eventually 'ballooning' as the zone of vascularisation reaches them and ossification of the matrix begins. This results in a gradual growth of the epiphysis away from the centre of the shaft. Growth in width occurs by deposition of non-cartilaginous sub-periosteal bone and the whole bone is constantly remodelled as the child grows.

The earliest bone to be laid down is often called 'woven bone', because its histological structure shows the fibrils to be randomly distributed, unlike the regular lamellar structure of mature bone. Some bones develop entirely by intramembranous ossification, with no intermediate cartilage stage, the clavicle and bones of the calvarium being examples.

(b) CARTILAGE

grows by direct proliferation of the cells and peri-cellular deposition of matrix but, even during rapid active growth, relatively few cells can be seen dividing. The capacity of hyaline cartilage to regenerate and repair itself is strictly limited, which means that damage to the articular surface can have long-lasting consequences. There is some evidence that intrinsic mechanisms of repair can be supplemented by ingrowth and metaplasia of peri-articular collagenous tissue, but repair of any but the smallest defect is seldom complete.

(c) COLLAGEN

growth is an important aspect of general body development and fibroblasts are frequently to be seen proliferating and laying down collagen fibres. This is particularly the case in any situation where repair of tissues is required. The usual end-result of repair, the scar, consists almost entirely of collagenous material. In situations where there is continuing damage to the tissues with concomitant repair, the scar tissue formed can be extremely dense. As it matures, collagenous scar tissue tends to contract, sometimes producing distortion and obstruction of internal structures and contractures of skin and joints. Occasionally the healing of a skin wound may be complicated by the formation of over-exuberant scar tissue, producing a wide and thickened scar known as 'keloid'.

3. PHYSIOLOGY

Connective tissues are by no means inert, and play an important role in biochemical processes in the body.

Ground substance is an important water binding agent and acts as an ion exchange resin in controlling the passage of electrolytes. Its deposition is influenced by many factors such as hormones and vitamins, and its composition reflects abnormalities in supply of these factors.

Cartilage 'turnover' is relatively little understood, but has been shown to continue throughout life, with synthesis and degradation of the ground substance. Bone is known to play a vital role in metabolism, mainly because of its calcium and phosphate content. These minerals enter into the formation of crystals of the hydroxyapatite type and their deposition is sensitive to many influences. There is some evidence that bone surfaces are bathed in a special type of extracellular fluid which is different from that of the rest of the body. Diseases such as rickets, osteomalacia and hyperparathyroidism are associated with dramatic changes in bone development (Chapter 40).

Demineralisation of bone results in loss of strength and may be caused by diminished matrix formation, inadequate calcification or bone resorption. The latter occurs as a result of the activity of special cells—osteoclasts—which remove both the organic and inorganic components. The radiographic appearances of loss of density are the same whatever the cause of the demineralisation.

Chapter 2. The Skeletal Structures

BONES

A long bone is characteristically tubular with expanded ends and is remarkably strong for its weight. The shaft is often called the *diaphysis* and the zone adjacent to the epiphyseal line the *metaphysis*. This is the part of the developing bone most likely to be the seat of disease, probably because it is the most metabolically active area with the greatest blood supply. Damage to, or abnormal development of, the epiphyseal plate may result in growth disturbance.

Growth does not occur equally at the two ends of a long bone and is more active at the ends farthest from the elbow and those nearest to the knee. Diseases such as osteomyelitis and tumours are noticeably more common at these sites. The spongy ends of the bone have a complex architecture and it is here that the trabeculae can be seen to follow the lines of greatest stress (Figure 2.1).

The normal bone can resist large compressive forces and considerable bending stresses and breaks only as a result of considerable violence. It may, however, be weakened by disease and then usually fractures transversely, sometimes as a result of minimal trauma.

The short bones consist of a cancellous core surrounded by a layer of cortical bone, partly covered by articular cartilage. They contain red marrow in their trabecular spaces and the vertebral bodies in particular are important sites of blood formation throughout life.

The bones form fixed points for muscle attachments and their periosteal sheath blends with the collagen of the tendons and ligaments.

Remodelling of bone continues throughout life, but particularly during growth and after fracture healing. In the young child, even severe residual deformities can be corrected fully, with the possible exception of rotational deformities; the capacity for remodelling is less in the adult and although the bone smoothes itself out it is usually possible to spot the site of a fracture many years later (Figure 2.2).

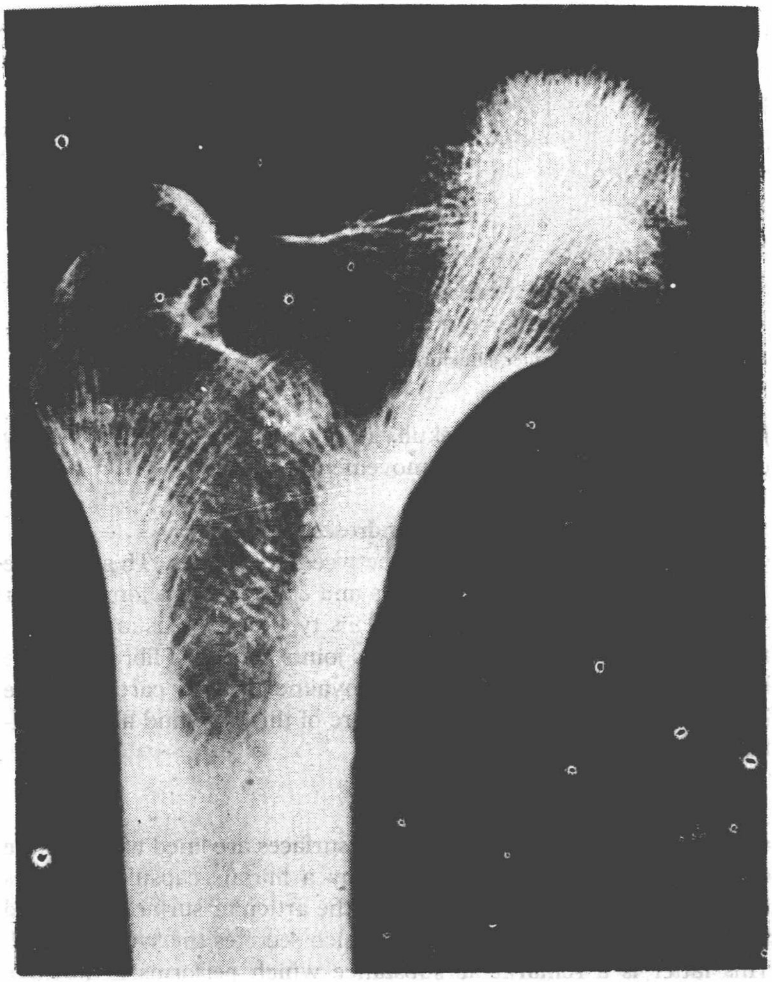

Figure 2.1.

JOINTS

The function of a limb is heavily dependent on the smooth working of the joints, and joint diseases are common and troublesome.

Three types of joint are usually described.

1. Fibrous joints or **syndesmoses**

As their name suggests these consist of a continuous band of fibrous tissue connecting the bones, as for example the inferior tibio-fibular

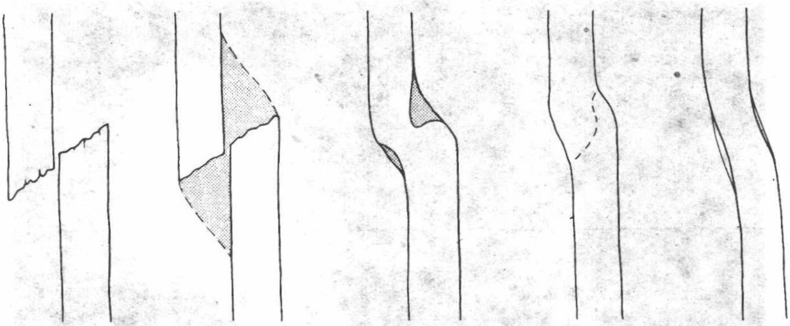

Figure 2.2. Remodelling after a fracture

joint or the sutures of the skull. They are strong and not readily disrupted and they allow little movement.

2. Cartilaginous joints or synchondroses
consist of a cartilaginous band between the bones. This may be hyaline as between the metaphysis and epiphysis of a long bone or between some of the skull bones. This type of joint usually ossifies at maturity. Secondary cartilaginous joints consist of fibro-cartilage lying between two thin plates of hyaline growth cartilage. The intervertebral discs and symphyses are of this type and all are midline structures.

3. Synovial joints
allow the greatest mobility. The joint surfaces are lined with hyaline cartilage and the joint is enclosed by a fibrous capsule which is usually attached close to the edge of the articular surface. It is lined by a vascular synovial membrane which secretes the synovial fluid. This latter is a remarkable substance which performs a nutritive function and has important lubricating properties.

The articular cartilage, apart from its deepest layer, derives most of its nutrition from the synovial fluid which must therefore have access to the whole articular surface. There is some evidence that degenerative joint disease may be, at least partly, due to an interruption in the free flow of this fluid.

Some joints contain fibro-cartilaginous discs partly separating the joint surfaces. The menisci of the knee are examples of this and they have been shown to have an important stress-distributing function.

Articular cartilage, normally smooth and elastic, may be pitted or eroded by disease or completely worn away to reveal the under-