VOLUME ONE

CAMPBELL'S OPERATIVE ORTHOPAEDICS

Editors
ALLEN S. EDMONSON, M.D.

A. H. CRENSHAW, M.D.

SIXTH EDITION

VOLUME TWO

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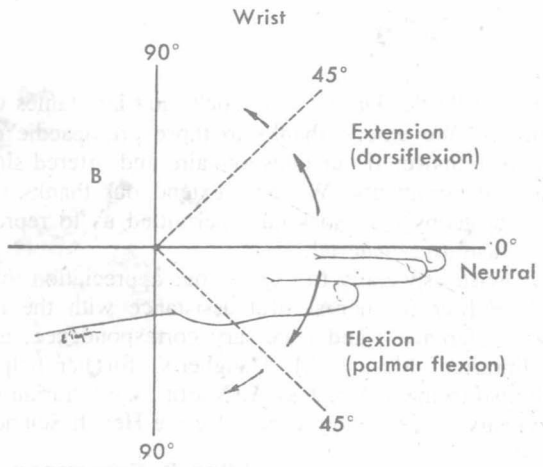
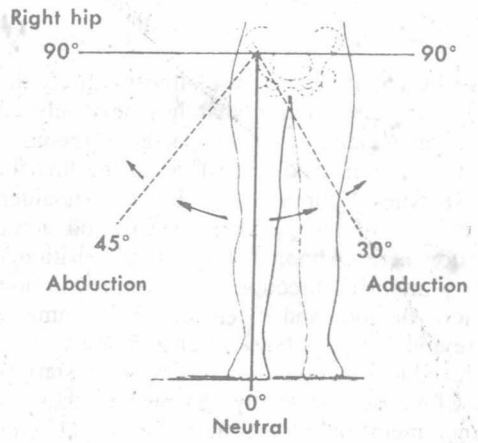
Preface to sixth edition

The material in this edition of *Campbell's Operative Orthopaedics* has been reorganized in several respects. The result has been the creation of new chapters as follows: infections; miscellaneous affections of bones and joints; affections of muscles, tendons, and associated structures; miscellaneous affections of the foot; and the spine (except for spina bifida, which is retained in Chapter 17). The chapter on care before and after surgery has been deleted because this material is discussed more properly in other works.

All chapters have been at least revised to bring them up to date. To the chapter on the hand has been added a new section on microsurgery. The discussion of traumatic affections of joints, especially those of the knee, has been much enlarged. A section on postnatal cerebral palsy in both children and adults (stroke patients) has been added to Chapter 17. The chapter on arthroplasty has been expanded to include total joint procedures for the ankle, knee, hip, and shoulder; the section on Vitallium mold arthroplasty of the hip has been retained.



Sketch 1



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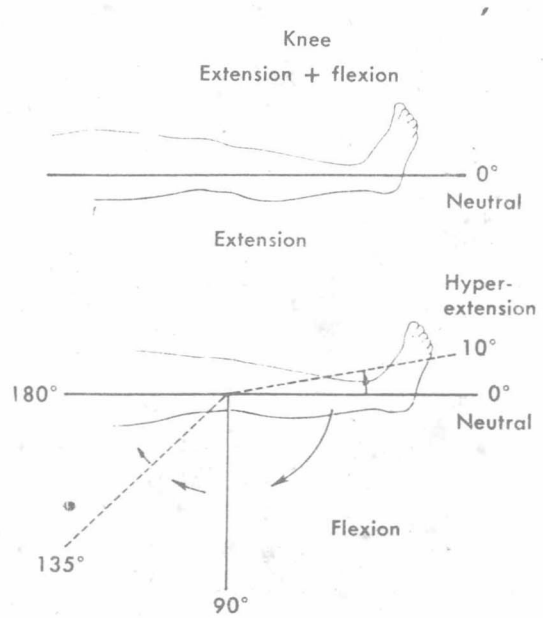

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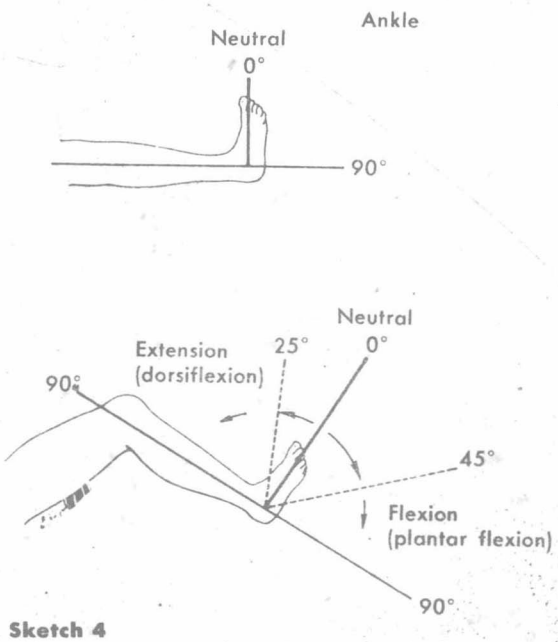

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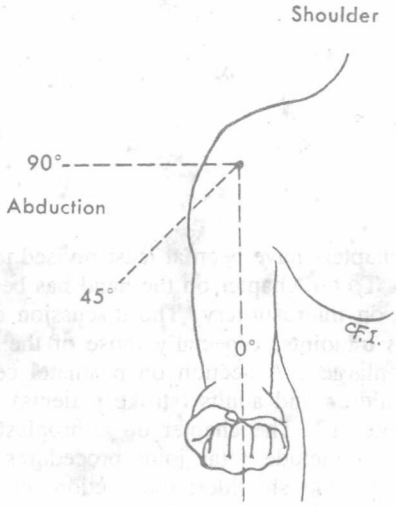

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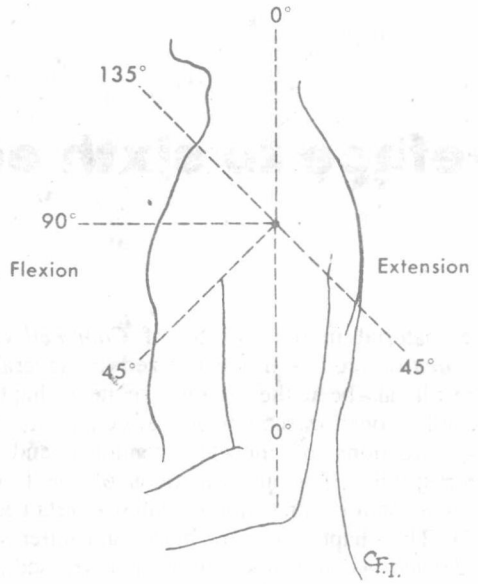

Sketch 6

We have continued to use almost entirely the method of measuring joint motion that has been advocated by the American Academy of Orthopaedic Surgeons. The neutral position is 0° instead of 180° as in the first three editions (see sketches 1 through 4*). For the shoulder, however, the method of the Academy seems too complicated for adoption here. Although the neutral position is 0° as for other joints, the direction of movement in adduction, abduction, flexion, and extension is the same as that used in previous editions (see sketches 5 and 6).

The editors and other members of the staff of the Campbell Clinic are especially indebted to those authors who are not members of the staff: Dr. L. D. Anderson, Dr. Otto E. Aufranc, Dr. J. A. Pitcock, and Dr. James C. H. Simmons. We extend thanks to those orthopaedic chairmen who answered our questionnaire and offered suggestions and comments. We also extend our thanks to the many surgeons who so kindly permitted us to reproduce their illustrative material.

We wish especially to express our appreciation to Mrs. I. C. Harper for her skillful assistance with the manuscript, references, and necessary correspondence, and to our librarian, Mrs. J. M. Daugherty, for her help. We wish also to thank Mr. Jess A. Martin, the librarian of the University of Tennessee Center for the Health Sciences.

Allen S. Edmonson, M.D.

A. H. Crenshaw, M.D.

*Reproduced by courtesy of the American Academy of Orthopaedic Surgeons.

Preface to first edition

The title of this book, *Operative Orthopedics,* is not intended to convey the impression that the chief or most important method of treatment of orthopedic affections is open surgery. Although many orthopedic affections are best treated by operative measures alone, the majority are successfully treated by more conservative means. Further, such measures are often essential adjuncts either before or after operation.

This volume has been written to meet the current need for a comprehensive work on operative orthopedics, not only for the specialist, but also for many industrial and general surgeons who are doing excellent work in some branches of orthopedic surgery, and are making valuable contributions to this field.

The evolution of orthopedic surgery has been exceedingly slow as compared to that of surgery in general. Not until aseptic technic had been materially refined was surgery of the bones and joints feasible. The statement is often made that the World War afforded the experience which made possible the rapid development of orthopedic surgery during the past two decades. The surgery of the war, however, was chiefly the surgery of sepsis; there was little of the refined asepsis which is required in reconstruction surgery. Undoubtedly, the demonstration during the war of the necessity and importance of this field led many able men to specialize in orthopedics, and to them considerable credit is due for its subsequent progress.

No classification of orthopedic affections is entirely satisfactory; consequently, any arrangement of operative procedures is subject to similar criticism. With the exception of the chapters on Arthroplasty and Arthrodesis, operations described in this text are grouped together according to their applicability to a given affection. This involves less repetition as to generalities of etiology, pathology, and treatment than would be necessary in a classification according to anatomic location. Operative procedures appropriate to two or more affections are described in the discussion of the one wherein they are most commonly employed.

To overcome the too widespread conception of orthopedic surgery as a purely mechanical equation, an effort is made in the first chapter of this book to correlate the mechanical, surgical, and physiologic principles of orthopedic practice, and throughout the book to emphasize the practical application of these physiologic principles. A special chapter has been written on surgical technic, for the purpose of stressing certain details in preparation and aftertreatment which vary to some extent from those described in works on general surgery. A thorough knowledge of these phases of treatment is a requisite to success. To avoid constant repetition, chapters have been included on apparatus and on surgical approaches; repeated reference is made to these chapters. The aftertreatment is given in detail for practically all operative technics. This is a most essential, yet too often neglected, factor in the success of any surgical treatment.

In giving the position or range of motion of a joint, only one system has been followed: With the exception of the ankle and wrist, the joint is in neutral position when parallel with the long axis of the body in the anteroposterior and lateral planes. As the joint proceeds from the neutral position in any direction, the number of degrees in which such movement is recorded decreases progressively from 180 to 170, 160, and so on, to the anatomic limit of motion in that particular direction. To illustrate, complete extension of the knee is 180 degrees; when the joint is flexed 30 degrees, the position is recorded as the angle formed between the component parts of the joint, i.e., the leg and thigh, or 150 degrees. Flexion to a right angle is 90 degrees, and full flexion 30 degrees. In the wrist, the joint is at 180 degrees, or in the neutral position, when midway between supination and pronation, and flexion and extension. In the ankle joint, motion is recorded as follows: the extreme of dorsiflexion, 75 degrees; right angle, 90 degrees; and the extreme of plantar flexion, 140 degrees.

In some instances, the exact end results have been given, to the best of our knowledge. So many factors are involved in any one condition, that a survey of end results can be of only questionable value unless the minute details of each case are considered. Following arthroplasty of the knee, for example, one must consider the etiology, pathology, position of the ankylosed joint, the structure of the bones comprising the joint, the distribution of the ankylosis, and the age of the patient, in estimating the end result in each case. Further, a true survey should include the results of *all* patients treated over a period of *many* years, and should be made by the surgeon himself, rather than by a group of assistants, or by correspondence.

In our private clinic and the hospitals with which we are associated, a sufficient amount of material on every phase of orthopedic surgery has been accumulated during the past twenty years or more to justify an evaluation of the various procedures. From this personal experience, we also feel that definite conclusions may be drawn in regard to the indications, contraindications, complications, and other considerations entering into orthopedic treatment. In all surgical cases, mature judgment is required for the selection of the most appropriate procedure. With this in mind, the technics which have proved most efficient in the author's experience have been given preference in the text. In addition, after a comprehensive search of the lit-

erature, operative measures have been selected which in the judgment of the author are most practicable.

Although no attempt has been made to produce an atlas of orthopedic surgery, an effort has been made to describe those procedures which conform to mechanical and physiologic principles and will meet all individual requirements. In any work of this nature, there are sins of omission; also, many surgeons in the same field may arrive independently at the same conclusions and devise identical procedures. We have endeavored, however, to give credit where credit was due. If there are errors, correction will gladly be made. In some of the chapters we have drawn heavily from authoritative articles on special subjects; the author gratefully acknowledges his indebtedness for this material. He also wishes to thank those authors who have so graciously granted permission for the reproduction of original drawings.

In conclusion, I cannot too deeply express my sincere appreciation and gratitude to my associate, Dr. Hugh Smith, who has untiringly and most efficiently devoted practically all of his time during the past two years to collaboration with me in the compilation and preparation of material, which alone has made this work possible. I also desire to express appreciation to Dr. J. S. Speed for his collaboration on the sections on Spastic Cerebral Paralysis and Peripheral Nerve Injuries; to Dr. Harold Boyd for anatomic dissections verifying all surgical approaches described, and for his assistance in preparing the chapter on this subject; to Dr. Don Slocum for his aid in the preparation of the chapter on Physiology and Pathology; to Mrs. Allene Jefferson for her efficient editorial services, and to Mr. Ivan Summers and Mr. Charles Ingram for their excellent illustrations.

Willis C. Campbell

1939

Contents

CHAPTER 14

Tumors

P. G. Carnesale and J. A. Pitcock

A team composed of a surgeon, radiologist, pathologist, and often a medical oncologist and radiotherapist is necessary to treat the spectrum of tumors involving the extremities and spine. The surgeon should be well read and have experience in the surgical techniques necessary to treat tumors. Both the radiologist and pathologist should have a special interest in tumors, especially tumors of bone, and be able to participate in the clinical evaluation including the determination of the optimal site for biopsy. The medical oncologist frequently treats patients with malignancies of soft tissues and bone, as it is increasingly apparent that systemic control of many of these tumors requires adjuvant therapies. The radiotherapist participates either in primary control of the lesion or in adjuvant therapy.

Diagnostic evaluation—general

The history must be the first step in the evaluation of a patient with a tumor. Initial complaints are usually pain, mass, disability of a part, or the incidental discovery of an abnormality on a roentgenogram. Occasionally constitutional symptoms such as anorexia, weight loss, or fever may be present. The age and sex of the patient may be important in differential diagnosis.

The physical examination should include a general evaluation in addition to a careful examination of the extremity or part in question. A mass should be measured and its location, shape, consistency, mobility, tenderness, and local temperature considered. Atrophy of surrounding musculature and restriction of motion of contiguous joints or effusion of joints should be recorded. A careful neuro-

logic examination and an assessment of the status of the arterial and venous circulation should be made.

Laboratory studies performed routinely should include a blood count, urinalysis, sedimentation rate, and serum calcium, phosphorous, alkaline phosphatase, and protein. Other studies such as serum acid phosphatase and serum and urine electrophoresis should be obtained as indicated.

Roentgenograms of the part should, with rare exception, be made in at least two planes. A chest roentgenogram is indicated in the evaluation of a suspected neoplasm. Tomograms of the part, whole lung tomography, arteriography, lymphangiography, arthrography, xeroradiography, and subtraction techniques may be indicated and may contribute to the evaluation. Computerized axial tomography is useful especially in locating or defining lesions of the spine and pelvis.

Radioisotope scanning techniques are often helpful as follows: technetium scans of the bone for detecting occult skeletal metastases and in determining the extent of a bone tumor, gallium scans for detecting soft tissue infection, and liver scans for the detection of liver metastases.

BIOPSY

The ultimate technique of diagnostic evaluation is the biopsy. Bone marrow aspiration is a biopsy technique and is of considerable value in suspected malignancies such as lymphoma or myeloma that involve bone marrow. Biopsy may be either closed (needle) or open. Needle biopsy is becoming increasingly popular with image intensifier control since tissue obtained by an experienced surgeon or radiologist can be diagnosed by an experienced pathologist familiar with cytologic techniques with an accuracy rate of greater than 80% in bone lesions and 90% in soft tissue lesions. Open biopsy may be either excisional or incisional. Excisional biopsy is indicated when the lesion is expected to be benign and thus removal of the lesion constitutes definitive therapy. Incisional biopsy should be used for any lesion suspected of being malignant and should be planned so that the incision does not compromise subsequent definitive therapy. Preferably the entire biopsy site is excised when definitive surgery is ablative. The quality or reliability of interpretation of frozen sections often permits definitive diagnosis at the time of biopsy so that definitive treatment may be possible then if the surgeon and patient are prepared.

NEEDLE BIOPSY

A variety of needles for bone biopsy are available, including those described by Jamshidi, Craig, Ottolenghi, and Turkel and Bethell. Most consist of guide, cannula, and cutting needle. When the bone lesion is purely lytic or if there is an associated soft tissue extension, Westerman-Jensen, Vin-Silverman and Lee have designed needles to be used for soft tissue biopsy. General or local anesthesia may be used. Roentgenographic control is usually necessary, and image intensifier television fluoroscopy is desirable.

Technique. Make a 2 or 3 mm stab incision through the skin to facilitate introduction of the cannula and guide. Direct the guide to the site of the lesion using roentgenographic control if necessary. Introduce the cutting needle through the cannula into the lesion, and apply suction to aspirate lesional tissue into the needle.

NEEDLE BIOPSY OF VERTEBRAE

Open biopsy of lesions of the cervical spine is advised most often; however, Ottolenghi et al. have published a method for needle biopsy of cervical vertebrae. Recently Sage at this clinic has successfully biopsied the second cervical vertebral body using a transpharyngeal needle under image intensifier control. Valls, Ottolenghi, and Schajowicz have introduced needle biopsy of dorsal and lumbar vertebrae.

Technique of needle biopsy of cervical vertebrae. For biopsy of the first three cervical vertebrae use the anterior or pharyngeal approach and general anesthesia. Push the uvula and nasal tube used for endotracheal intubation to the side that affords best exposure for puncture. Perform the puncture with a short, beveled 2 mm needle under roentgenographic control, both anteroposterior and lateral views, or use image intensifier television fluoroscopy. When the needle is correctly placed, aspirate using a syringe with careful penetrating and withdrawal movements as suction is applied. Biopsy the C-4 through T-1 vertebral bodies from a lateral approach. Make roentgenograms of the cervical spine with a metallic marker on the skin to assist in determining the site of puncture. Then place the patient supine with the head rotated to the side opposite the puncture site and palpate the posterior border of the sternocleidomastoid muscle. Make a stab incision through the skin at the posterior margin of the muscle at the level selected for puncture. Use two needles, a 9 cm long, 2 mm diameter needle and a 12 cm long, 1 mm diameter needle. Introduce the smaller needle through the larger needle and direct it toward the midline of the body and anteriorly. Bone should be reached at a level of 3.5 cm. If blood is aspirated, it is most likely caused by puncture of the vertebral artery. Redirect the needle slightly more anteriorly to avoid the transverse process. When the tip of the needle is felt to contact bone, make anteroposterior and lateral roentgenograms to check the position. Once the correct position is verified, push in the 2 mm needle until it contacts the bone. Withdraw the 1 mm needle and aspirate (Fig. 14-1).

Technique of needle biopsy of T-2 through T-9 vertebrae (Valls et al.). Because needle biopsy of T-2 to T-9 vertebrae is usually painful when carried out under local anesthesia, we recommend general anesthesia with endotracheal intubation. Biopsy from the right side to avoid the aorta unless the lesion is in the left side of the vertebral body. Use an aspiration needle that is 2 mm in diameter and 12 cm long with a short sharp tip and external markings to gauge its depth in the tissues. Use the Ottolenghi bar and guide, and insert the needle at an angle of 35° through a small stab wound in the skin 4 cm from the midline of the spine posteriorly. The tip of the needle frequently encounters a rib. Manipulate it to pass superior to the rib. Maintain a partial vacuum in the needle with a syringe so that entering of a vessel or the neural sac is recognized immediately. When the aspiration needle has been advanced about 6 cm, insert a second needle, the

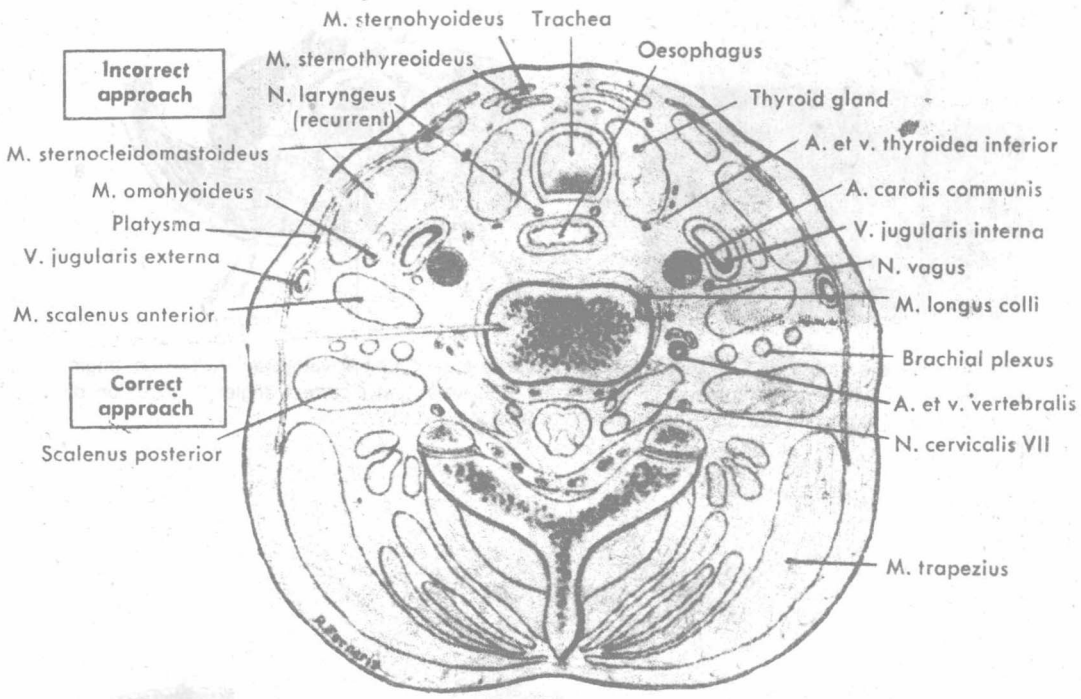

Fig. 14-1. Cross section through neck at level of seventh cervical vertebra to show the anatomic structures and needles correctly and incorrectly placed. (From Ottolenghi, C. E., Schajowicz, F., and De Schant, F. A.: J. Bone Joint Surg. **46-A**:715, 1964.)

exploring needle (18 cm long and 1 mm in diameter), into its lumen. Maintain a partial vacuum and advance this needle. Insert neither needle more than 7 cm. The vetebral body is encountered near the base of the pedicle. When the tip of the exploring needle is thought to be in the correct position, insert a stylet to see that the needle is not clogged and obtain anteroposterior and lateral roentgenograms. If the tip of the exploring needle is found to be at the desired part of the vertebra, advance the aspiration needle over the exploring needle and attempt to puncture the vertebral body. If the aspiration needle cannot penetrate the body of the vertebra, move its tip slightly superiorly or inferiorly and try again, but always keep it in contact with the bone. If necessary, make several roentgenograms during the procedure to be sure of the position of the needle. After penetration, if desired, move the needle around slightly inside the bone to obtain specimens from several parts of the vertebra.

Technique of needle biopsy of T-10 through T-12 and all lumbar vertebrae (Valls et al.). Do needle biopsy of T-10 to T-12 and all lumbar vertebrae under general anesthesia with intubation or under local anesthesia with the patient prone. Using an appropriate local anesthetic solution, make a wheal over the spinous process of the involved vertebra. Make a second wheal 6.5 cm from the midline on either side. Puncture the skin at the second wheal with a sharp knife to prevent epithelial tissue from entering the needle. Place the exploring needle (18 cm long, 1 mm in diameter, and containing a stylet) within the heavier and shorter aspiration needle that is marked to show the distance in centimeters from its point. Insert this combination of needles at an angle of 125° from the horizontal and 6.5 cm from the midline, using the guide bar designed for this purpose (Fig. 14-2). If the angle is more than 125°, the dura may be entered, and if it is less, the vertebral body will not be encountered. Introduce the exploring needle to a depth of 6 or 7 cm so that its tip is at the level of the vertebral body. Check the position of the needle with anteroposterior and lateral roentgenograms or fluoroscopy with an image intensifier. Remove the stylet and apply suction to be sure the needle is not in a vessel or in the dural sac. When the needle is in proper position, advance the large biopsy needle over the exploring needle until it touches the vertebra. Remove the exploring needle and guide bar. While maintaining a partial vacuum in the biopsy needle with a syringe, gradually advance it into the vertebral body, but no more than a total of 9 cm or the aorta may be punctured. If considerable resistance is encountered, move the tip of the needle slightly to find a softer area for aspiration.

Surgical techniques—bone

CURETTAGE

Most benign lesions of bone can be successfully treated by curettage with or without grafting, but this is dependent on the size and location of the lesion (Fig. 14-3). The cortical window made over the lesion should be larger than the lesion when possible. Lesion tissue should then be removed with the largest curet that can be used and the curettage continued into normal bone and marrow in all directions. All reactive bone should be removed. Some authors have suggested use of power burrs on the walls of

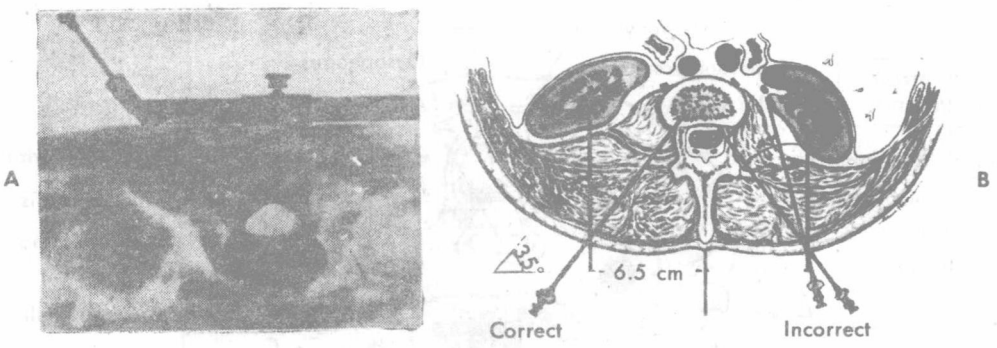

Fig. 14-2. Needle biopsy of T-10 through T-12 vertebrae and of lumbar vertebrae. **A,** Correct angle for insertion of needle is determined by guide bar. **B,** Correct and incorrect angles of insertion of needle. (From Ottolenghi, C. E.: J. Bone Joint Surg. **37-A**:443, 1955).

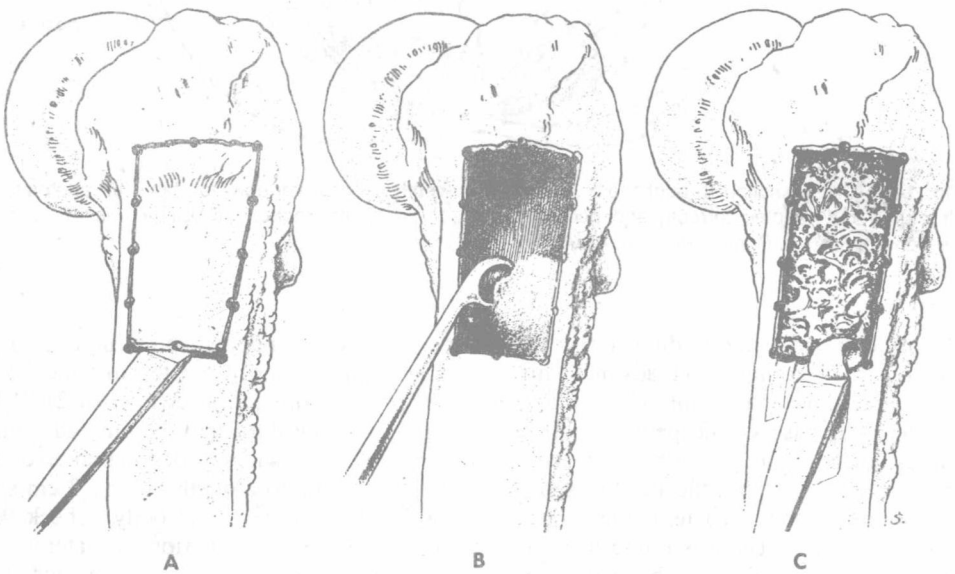

Fig. 14-3. Curettage of benign lesion. **A,** Window has been outlined by holes drilled in cortex. **B,** Lining of cavity is being removed with curet. **C,** Cavity is being filled with chips of cortical or cancellous bone.

the defect after manual curettage has been completed. Cauterization of the walls of the cavity or cryotherapy has been suggested in treating aneurysmal bone cysts or giant cell tumors; their use is controversial, and we do not usually use either procedure. Copious irrigations of the cavity with sterile saline prior to introduction of a graft is advised. We prefer homologous (bone bank) cortical and cancellous grafts to fill defects created by curettage (Tables 14-1 and 14-2).

RESECTION OR EXCISION

"Resection" and "excision" are terms often used interchangably. Both apply to the removal of a lesion with a margin of normal bone or soft tissue or both. Some parts of the skeleton are relatively expendable, such as the proximal fibula, and little function is lost by their excision, while others such as the distal femur and proximal humerus are much more important, and the functional loss is great when they are excised. The "trade-off," greater chance for local control of the lesion with excision versus less funcional loss with use of a less radical approach such as curettage, must be carefully considered. Resection or excision is most often indicated for those lesions that occasionally metastasize and frequently recur such as giant cell tumor and chordoma. Chondroblastoma, chondromyxoid fibroma, and osteoblastoma are best excised also but are not as likely to metastasize or recur. Limited resection is probably the treatment of choice for osteoid osteoma.

Low-grade chondrosarcomas and possibly some small

Table 14-1. Resectable portions of skeleton

Bone	Disability*	Reconstruction
Phalanges of all toes (amputation or resection)	None to mild	Unnecessary
Metatarsals—spare first if possible (amputation or resection)	Mild to moderate	Shifting of bases of other metatarsals with amputation of distal end of ray (Fig. 19-33) Bone graft (Fig. 3-140)
Any tarsal bone except calcaneus (amputation or resection)	Mild to moderate	Resection of compensatory wedges and triple arthrodesis (p. 1426) For talus: calcaneotibial fusion (p. 544)
Calcaneus	Mild to moderate	Unnecessary (p. 1282)
Proximal four fifths of fibula	None to mild	Unnecessary (p. 22)
Distal one third of fibula	Mild to moderate	Bone graft: replace with proximal one third of fibula (p. 1282) or omit reconstruction as possibly unnecessary (p. 1282)
Distal three fourths of medial malleolus	Mild	Unnecessary if angle of mortise preserved (p. 779)
Patella	Mild	Unnecessary (p. 1189)
Ischium	None to mild	Unnecessary (p. 1003, p. 1289)
Coccyx		
Spinous processes, etc.		
Ribs		
Major portion of ilium except acetabular portion and sacroiliac joint, must preserve continuity	None to mild	Unnecessary (p. 1054)
Medial or lateral 2.5 to 3.75 cm of clavicle	Mild	Unnecessary (p. 452)
Entire clavicle	Moderate	
Acromion	None to mild	Unnecessary (p. 1012)
Entire scapula or segment of wing	Severe to moderate	Unnecessary (p. 1293)
Head and tuberosities of humerus	Moderate	Tenoplasty (p. 2415) or prosthesis (p. 668)
Proximal two thirds of humerus	Severe	Fibular transplant (p. 1298)
Olecranon	Mild	Unnecessary (p. 686)
Epicondyle	None to mild	Transplantation of ulnar nerve may be indicated (p. 1684)
Capitulum in adult	Mild to moderate	Supracondylar osteotomy for cubitus valgus (p. 741) Arthroplasty (p. 2421) Arthrodesis (p. 1137)
Head and neck of radius	None to mild	Unnecessary (p. 688)
Distal 5 cm of ulna	None to mild	Unnecessary (p. 752)
Distal one third of radius	Mild to moderate	Replacement by proximal one third of fibula (p. 1299) or arthrodesis to proximal carpal row (p. 185)
Any or all of carpal bones	Mild to moderate	Unnecessary or arthrodesis (p. 185)
Metacarpals—spare first if possible (amputation or resection)	Mild to severe	Bone graft (p. 208) Shifting bases of remaining metacarpals with amputation of affected ray
Phalanges of fingers (amputation)	Mild	Unnecessary
Six inches or less of shaft of any long bone; femur and tibia least desirable	Moderate to severe	Dual grafts (p. 803) Hemicylindric grafts (p. 806)

*Disability estimate is that which is residual after available reconstruction procedures.

Table 14-2. Resection of joints with adjacent bone

Joint	Disability	Reconstruction
Knee with metaphyses of upper tibia or lower femur	Severe	Dual grafts to bridge defect (p. 803) Hemicylindric grafts (p. 806)
Hip with head, neck and/or trochanter, and portions of ilium	Moderate to severe	Arthrodesis of stump to ischium (p. 1127)
Shoulder with acromion, head, and tuberosities of humerus	Moderate	Tenoplastic reconstruction (p. 2415) or prosthesis (p. 668)
Elbow joint	Moderate	Accept unstable joint (p. 1089) or arthrodesis (p. 1137)
Carpus and minimal resection of distal end of radius	Mild to moderate	Arthrodesis (p. 185) and resection of distal ulna (p. 752)

parosteal sarcomas might be satisfactorily treated by excision or resection, but in general most primary malignancies of bone are best treated by amputation.

General technique for resection. When possible, remove a segment of bone extraperiosteally extending 3 to 5 cm beyond the tumor in both directions. When an epiphysis is involved, resect the entire end of the bone. When one surface of a joint is involved, resect the entire joint and include 2.5 cm of the opposing bone. Excise any overlying muscle tissue in contact with or invaded by the tumor. Microvascular surgical techniques may make it feasible to routinely replace resected segments of bone with live grafts; such cases have already been reported.

EXCISION OF CALCANEUS

Tumors of the calcaneus best treated by excision of the bone are rare, but we have so treated several patients with satisfactory results; nearly normal function may be regained in time. Schmidt reported using part of the iliac crest including the anterosuperior spine to replace the calcaneus; the spine served as a tuberosity, and the tendo calcaneus was attached to it. Ottolenghi and Petrocchi successfully replaced a calcaneus with one from the bone bank.

Miltner and Wan described a procedure in which, after excision of the calcaneus, the tendo calcaneus is lengthened and its distal end is fastened to the posteroinferior part of the talus with sutures passed through holes drilled in the bone. Or the proximal end of the plantar fascia can be mobilized and sutured end-to-end to the tendo calcaneus when the foot is in complete equinus; a Bunnell pull-out suture is used to relieve tension. The extremity is immobilized in a long leg cast, with the foot in complete equinus and the knee in 20° flexion.

Aftertreatment. On the second day the cast is windowed, the wound inspected, and the drain removed. At 3 weeks the sutures are removed and a walking boot cast is applied with the foot still in complete equinus. At 2 months a brace with a light steel spring at the ankle is fitted; the spring assists in plantar flexion and prevents dorsiflexion past the position of 15° plantar flexion. An elevation 2 to 2.5 cm high is applied to the heel. In time, function may improve so that the brace is not essential.

RESECTION OF DISTAL THIRD OF FIBULA

The distal third of the fibula may be resected without reconstruction and without creating significant instability or valgus deformity. We have recently seen a patient treated by Willis Campbell 40 years ago by resection of the distal third of the fibula without reconstruction. The ankle is cosmetically and functionally normal (Fig. 14-4). Carrell has devised a procedure to restore the ankle mor-

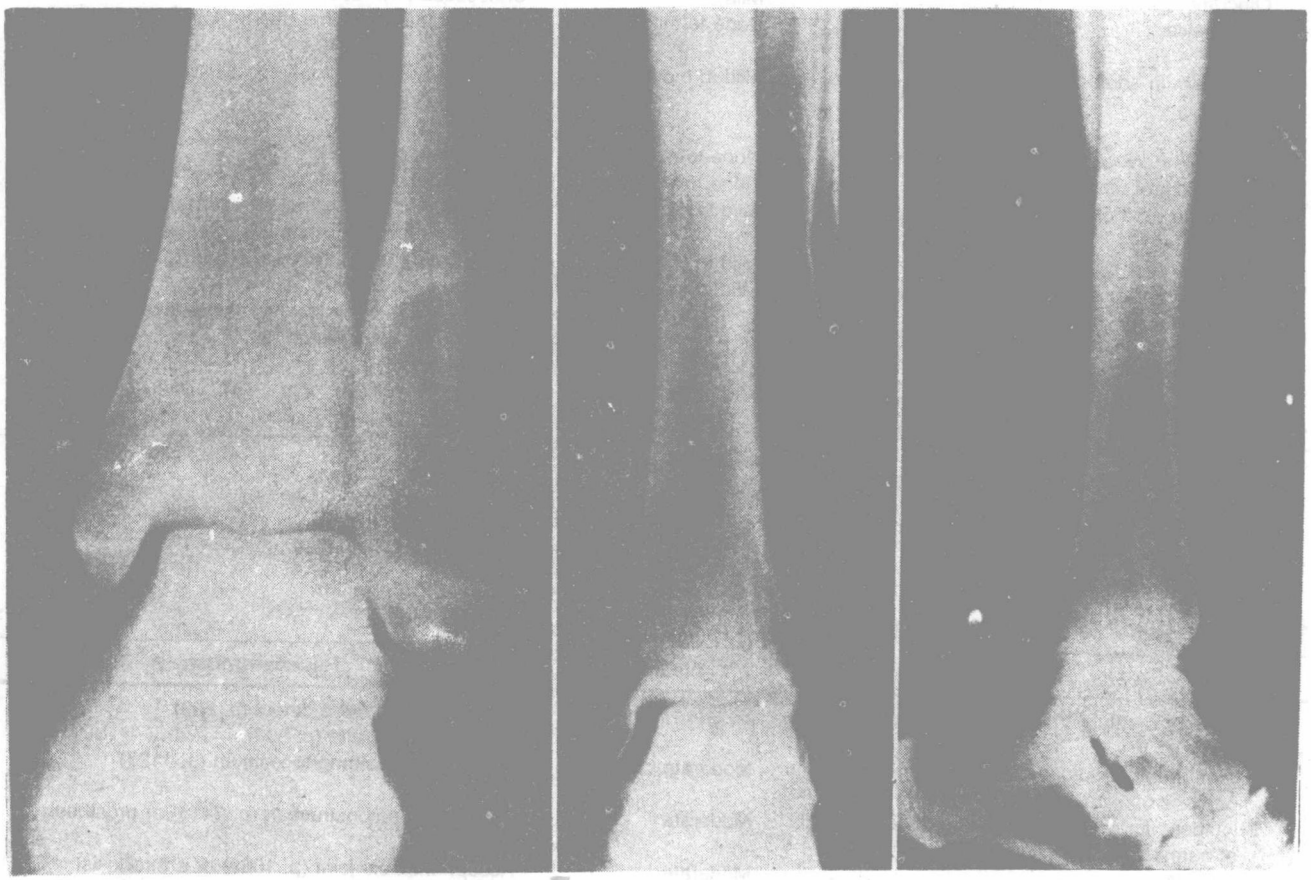

Fig. 14-4. Long follow-up (39 years) of patient with resection of distal fibula for osteogenic sarcoma. No recurrence, deformity, instability, or metastasis occurred. **A,** Preoperative roentgenogram. **B** and **C,** Anteroposterior and lateral roentgenograms 39 years later.

tise after resecting the distal third of the fibula; he reported its use in one patient with a hemangioma and another with a Ewing's tumor (Fig. 14-5).

Technique (Carrell). Through a lateral longitudinal incision resect the entire distal third of the fibula, keeping the tumor intact. Through a separate incision excise the proximal fibula after stripping the soft tissues from its periosteum; suture the insertion of the biceps femoris muscle to the fascia lata and adjacent soft tissues. Then reverse this proximal segment and transplant it to the distal incision to replace the distal fibula. Roughen the surfaces of the tibia and transplanted fibula where they meet, and place the head of the fibula against the lateral aspect of the talus to form a new lateral malleolus. Fix the graft to the tibia with a screw. When the entire shaft of the fibula must be resected, use the proximal third of the opposite fibula to replace the lateral malleolus. In children carefully preserve the proximal fibular epiphysis as a part of the transplant; embed the reversed shaft of the transplant in the tibia just proximal to the distal epiphyseal plate of the tibia, and align it so that the epiphysis of the fibular head is in the same relation to adjacent structures as was the original distal fibular epiphysis. No growth should be expected from the transplanted epiphysis.

RESECTION OF FEMORAL OR TIBIAL CONDYLE USING PATELLAR TRANSPLANT

d'Aubigne has published a method of reconstructing defects caused by excision of femoral or tibial condyles using a pedicle patellar transplant (Fig. 14-6). He published results in eight patients with giant cell tumors so treated; none recurred, and all had motion of 90° or better at the knee.

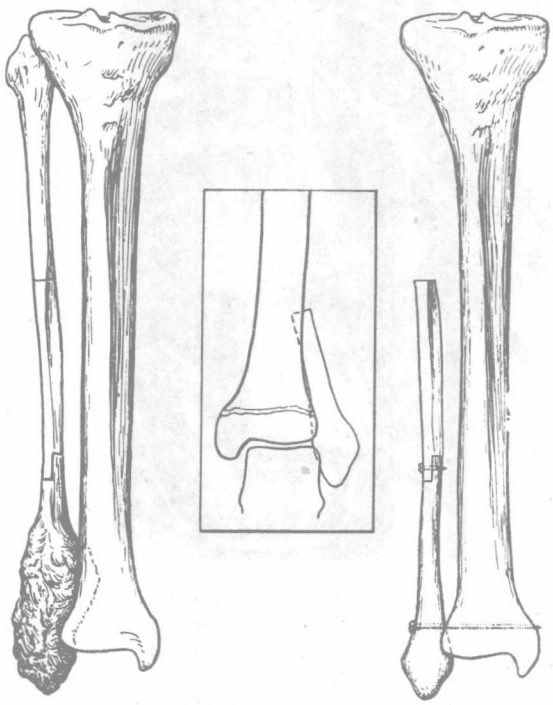

Fig. 14-5. Modification of Carrell technique of substituting proximal fibula for distal fibula. **Inset,** Method of placing transplant when distal tibial epiphysis has not yet fused.

Technique for resection reconstruction of a femoral condyle (d'Aubigne). Make a long anteromedial or anterolateral parapatellar incision. Separate a muscular pedicle 3 cm wide at the inferior border of the vastus medialis or lateralis, preserving as many vessels as possible and extending from the supracondylar portion of the femur to the medial or lateral border of the patella. Then separate the patella from the extensor mechanism along its superior, lateral (or medial), and inferior borders, staying 3 to 4 mm away from the bone to spare the circular artery that supplies blood to the patella. Then expose the femoral condyle, and remove it en bloc with the tumor by cutting the femur with an oscillating saw in a median or paramedian sagittal plane and transversely at the upper limit of the lesion.

Then prepare the patella; its anterior superficial aspect will be used as the articular surface for reconstruction of the femoral condyle. Its curvature is very similar to the condyle, and the preserved tendinous fibers will play the role of cartilage. Freshen its medial or lateral aspect as well as its deep articular surface. Bring the patella in contact with the unresected femoral condyle at the same level as the removed condyle and firmly fix it there by one or two screws (Fig. 14-6, *A*). Fill the gap between the patella and femoral shaft with bone chips from the iliac crest if it is small and either a massive homologous graft or combined cancellous and cortical tibial graft if it is large. Fix the grafts firmly by screws. Then close the gap in the quadriceps using the large aponeurotic tendon of the rectus femoris, turning it down as a flap and fixing it to the patellar tendon, to the remaining expansion of the vastus, and to the investing fascia (Fig. 14-6, *B*). After obtaining hemostasis, close the wound in layers and apply a compression dressing with a posterior plaster splint.

Aftertreatment. The posterior splint is removed for exercise purposes after the first day. Both active flexion and supported extension exercises are performed. Walking with crutches is permitted at the end of the first week, but weight bearing is delayed until after 3 months. Unrestricted weight bearing is allowed only when the grafts are solidly united.

Technique for resection reconstruction of a tibial condyle (d'Aubigne). Follow the technique for resection of a femoral condyle except that after resecting the tibial condyle place the patella horizontally with its articular surface upward in normal relationship with the articular surface of the femoral condyle (Fig. 14-6, *C*).

RESECTION OF DISTAL FEMUR OR PROXIMAL TIBIA AND ARTHRODESIS OF KNEE

Resection of the distal femur or proximal tibia and arthrodesis of the knee are an extensive operation that should be reserved for the vigorous young adult who is willing to spend a prolonged time in convalescence. Amputation is usually preferable for middle-aged or elderly patients. Recently Enneking has published a carefully worked out method for resection arthrodesis (Fig. 14-7) using a specially designed fluted medullary rod curved in its proximal half (radius of curvature 125 or 175 cm) to fit