Operative Pediatric Orthopaedics

CANALE • BEATY

OPERATIVE PEDIATRIC ORTHOPAEDICS

Edited by

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Preface

Although many orthopaedic conditions in children are best treated nonoperatively, when surgery is required for a musculoskeletal problem in a child, the choice, timing, and technique of the procedure are critical because the outcome will affect the child's whole life. The unique characteristics of the child's skeleton have inspired a multitude of techniques. In this text we have attempted to describe those procedures most commonly used for orthopaedic conditions in children. Also included are brief discussions of the etiology and prognosis of various orthopaedic conditions, nonoperative treatment, indications for operative treatment, and complications that may be encountered. This text is intended to be a concise guide to the *surgical* treatment of orthopaedic problems in children and to provide operative descriptions of appropriate techniques. Some of the most commonly performed procedures, applicable to musculoskeletal problems from a variety of causes, are collected in Chapter 1, "Special Techniques," for easy reference. Other techniques are described in chapters discussing the conditions for which they are commonly performed. This book would of course have been impossible without the expertise and experience of our distinguished contributors. They bring to the material a wealth of knowledge and advice and expand the viewpoint beyond a single institution.

We hope that this condensation of information will be helpful to medical students, interns, orthopaedic residents, and practicing orthopaedists and that it will ultimately benefit the children, who are the reason for this undertaking.

We would like to thank Kay Daugherty for her editorial assistance with this undertaking. We also appreciate the efforts of Richard Fritzler, artist; the Campbell Foundation Staff; Joan Crowson, Librarian; and Eugenia Klein and Kathy Falk of Mosby–Year Book, Inc.

In addition to all those who actually had a hand in the preparation of this book, we owe a great debt to our families for their patience and support. Our thanks, too, to our colleagues and partners for their suggestions and encouragement, and to Dr. Alvin Ingram and Dr. Fred P. Sage who, by example and instruction, inspired us always to consider the care of children a special privilege and obligation.

S. Terry Canale, M.D. **James H. Beaty, M.D.**

Contents

Detailed Contents

1 Special Techniques

S. TERRY CANALE

The orthopaedic treatment of children differs in many ways from that of adults because of the differences in musculoskeletal characteristics and the potential for growth in children. Many surgical procedures have been devised or modified especially for treatment of orthopaedic conditions in children, and many are applicable to deformities caused by very different disease processes. To avoid repetition, some of these commonly used special techniques have been collected in this chapter and are referred to in other chapters.

OSTEOTOMIES FOR ANGULAR AND ROTATIONAL DEFORMITIES

General Indications for Osteotomy and Complications of Osteotomy

Angular deformity and shortening of the lower extremity may be caused by congenital, developmental, or traumatic factors. Osteotomy, along with bony bar resection, epiphysiodesis, and bone lengthening and shortening procedures, have long been used to correct these deformities. There are, however, no standard guidelines as to the severity of deformity that requires osteotomy. Commonly cited indications include a significant, progressive, angular deformity that cannot be corrected by bracing, pain, knee or ankle malalignment, and progressive ligamentous laxity about the knee or ankle. The definition of *significant* angulation, however, is imprecise. The amount of true angulation should be determined by comparing standing roentgenograms of both extremities. Leg lengths should be determined by leg length scanograms or by computed tomography (CT). The normal physiologic valgus of 4 to 6 degrees in boys and 5 to 7 degrees in girls should be subtracted from any valgus deformity and added to any varus deformity. Whether the deformity is static or progressive also must be determined. Angulation caused by developmental conditions usually remains static, but physeal growth arrest or retardation usually is progressive.

A

B

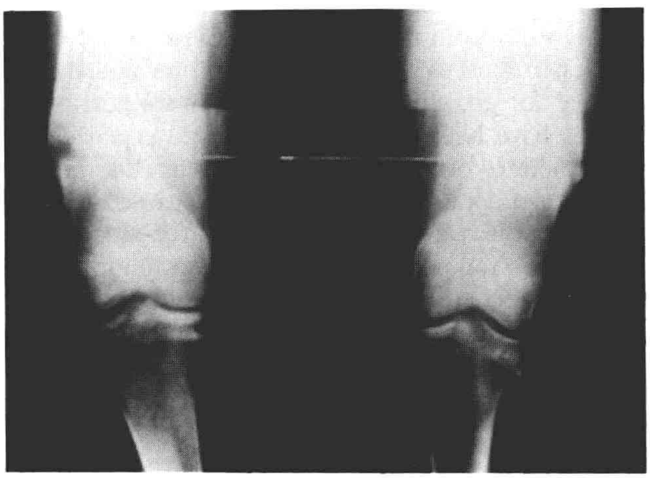

Fig. 1-1 A, Bilateral genu valgum. On left knee *(above)* deformity is in tibia and knee is parallel to floor; on right knee *(below)* deformity appears to be in femur and knee is not parallel to floor. **B,** After supracondylar femoral osteotomy, right knee is parallel to floor. Tibial osteotomy should have been performed on left knee because it is not parallel to floor.

OSTEOTOMIES FOR ANGULAR AND ROTATIONAL DEFORMITIES

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The indications for tibial or femoral osteotomy, with a closing or opening wedge, also are not definitive. In general, if a roentgenogram taken with the patient standing shows that the knee is parallel to the floor, tibial osteotomy is indicated; if the knee is not parallel to the floor, supracondylar femoral osteotomy is indicated (Fig. 1-1). One exception to this general rule is the deformity that occurs in Blount's disease in which the tibial plateau and knee joint are angulated, but the major deformity is in the tibial metaphysis, which requires a proximal tibial osteotomy.

The efficacy of corrective osteotomy as prophylaxis against the early development of arthritis caused by physiologic genu varum and genu valgum has not been substantiated. In some young adults with significant physiologic genu varum, osteotomy may be required for pain relief and for narrowing of the medial joint line (Fig. 1-2).

Neurovascular complications are the most serious sequelae of osteotomy. Some neurovascular complications associated with tibial osteotomy may be avoided by the performance of fasciotomy at the time of osteotomy. If a neurovascular problem develops after surgery, it must be determined whether the cause is a compartment syndrome, kinking of the artery at the trification near the proximal tibia as described by Steel et al, or peroneal nerve palsy. Compartment syndrome usually produces severe, unrelenting pain that increases steadily over a 12- to 24-hour period; passive motion of the toes causes severe pain. All circumferential bandages should be removed, and compartment pressures should be measured. Kinking of the artery or arterial occlusion near the knee (trification), in contrast, usually causes sudden, severe pain immediately after surgery. This is an emergency situation, and prompt action is mandatory. All bandages should be removed and an arteriogram taken. If osteotomy has been performed and the arteriogram confirms kinking or occlusion, the leg should be immediately returned to its original position. Peroneal nerve palsy frequently is painless. The toes may be moved passively but not actively. All constricting bandages should be removed and pressure promptly relieved at the fibular head. Neurovascular compromise must be avoided at all costs. A markedly angulated but functional extremity is superior to a straight but functionless extremity.

A

B

Fig. 1-2 **A,** Bilateral genu varum in young adult. **B,** After valgus osteotomy, which was performed when the patient was 23 years old, because of severe pain and narrowing of medial joint line.

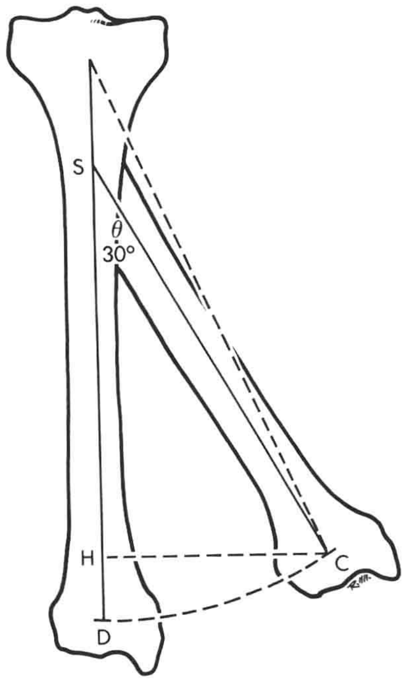
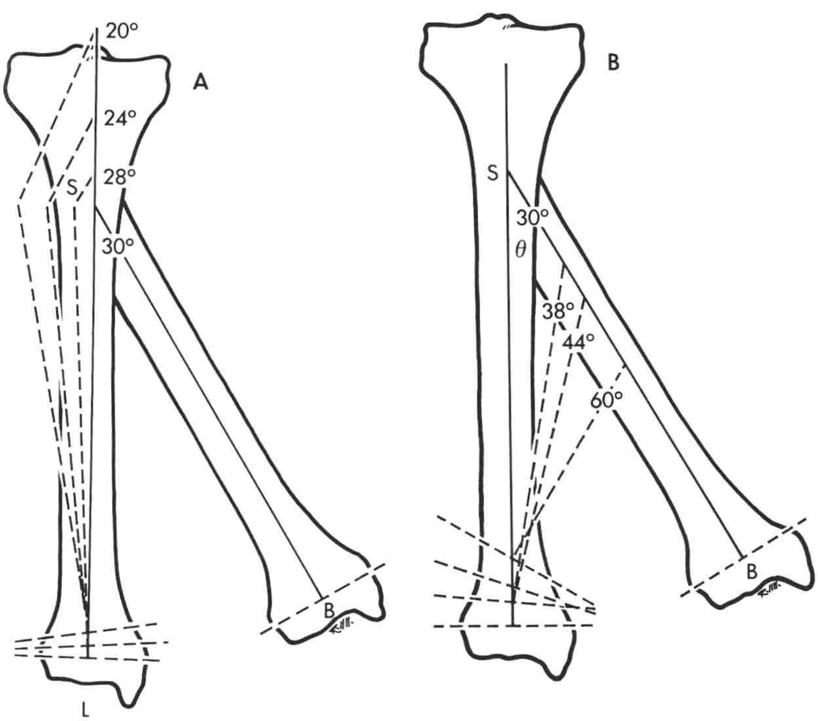


Fig. 1-3 Model and equation proving gain in length if angulated bone is straightened, regardless of type of osteotomy. *S,* Maximum point of 30-degree angulation (ϕ); SC = angulated bone, corrected to SD; thus HD = absolute gain in length from osteotomy. (From Canale ST and Harper MC. In The American Academy of Orthopaedic Surgeons: Instructional course lectures, vol 30, St. Louis, 1981, The CV Mosby Co.)



Biotrigonometric Principles

Although osteotomies have been performed for centuries, much of the information about this procedure has been gained empirically, with techniques and principles handed down from one generation of orthopaedists to the next, without exactness or objectivity. Milch made a significant contribution to the science of osteotomy with his 1947 description of pelvic osteotomy and review of other osteotomies. The effects of the size, shape, and location of the osteotomy determine the choice and timing of procedure. These effects can be determined mathematically if certain basic biomechanical principles are kept in mind.

First, any straightening of an angulated bone results in lengthening of that bone. Although this point seems obvious, the gain in length often is overlooked in calculations for osteotomy. The gain in length actually occurs through an arc and can be computed with the following formula that uses the cosine of the angle of the deformity and the length of the angulated segment:

$$\text{HD} = \text{SD} \times \text{Cosine of the deformity angle}$$

where
HD = Length gained
SD = Length of the angulated segment

As an example, consider a tibia 15 inches long with a 30-degree angulation deformity 3 inches below the knee (Fig. 1-3). In this instance the cosine of the deformity angle is 0.134, and the length of the angulated segment is 12 inches. Thus:

$$\text{HD} = 0.134 \times 12 \text{ inches} = 1.6 \text{ inches (length gained by osteotomy)}$$

Fig. 1-4 **A,** Model showing 30-degree angulation deformity and computation of compensatory osteotomies progressively proximal to maximum deformity *(S).* At one fourth the distance proximal to *S,* 24-degree wedge is required to correct to midline; at one half the distance, a 20-degree wedge is required. **B,** Same model as **A,** and computation of compensatory osteotomies is progressively distal to maximum deformity *(S).* At one fourth the distance from *S,* 38-degree osteotomy is required; at one half the distance, 60-degree osteotomy is required. Note that loss of anticipated gain in length is greater when osteotomy is moved distally than when moved proximally to *S.* (From Canale ST and Harper MC. In The American Academy of Orthopaedic Surgeons: Instructional course lectures, vol 30, St. Louis, 1981, The CV Mosby Co.)

Although the optimal location for osteotomy is at the site of maximum angulation, this area often must be avoided because of scar formation, infection, sclerosis, or poor skin condition. Often the choice for osteotomy location must be the *next* best site. Moving distally to the site of maximum angulation requires increasingly greater degrees of correction and, conversely, moving proximally to the site of angulation requires increasingly fewer degrees of correction. In either case the expected gain in length progressively decreases the farther the osteotomy is removed from the site of angulation (Fig. 1-4).

The size of the wedge of bone removed at osteotomy generally has been determined empirically or with a preoperative "cut-out"; however, a general rule of thumb has been that for every degree of correction required 1 mm of wedge should be removed. This rule is reasonably accurate for high tibial osteotomies in a tibia approximately 6 to 7 cm in diameter (the average adult tibia measures 9 cm). In a child with a tibial diameter of 4 cm or less, the calculation may be in error by as much as 40%. If the angle of correction needed is measured before surgery and the diameter of the bone (in centimeters) is measured during surgery, the appropriate size of the wedge can be determined by means of the following formula (Fig. 1-5):

$$W = D \times 0.02 \times \text{Angle of correction}$$

where
W = Size of wedge
D = Diameter

The exact trigonometric formula multiplies the diameter of the bone by the tangent of the angle of correction; however, because this information must be obtained from a tangent table, this formula has little practical application. The simpler formula has been proved to have only a 10% margin of error when compared with the more complex formula; it is sufficiently accurate for tibial osteotomies between 15 and 40 degrees and is much more useful clinically.

The amount of lengthening or shortening produced by an opening or closing wedge osteotomy equals one half the base of the wedge (W/2) (Fig. 1-6). This gain or loss or length should be combined with the earlier estimate of length gained by straightening the angulated bone.

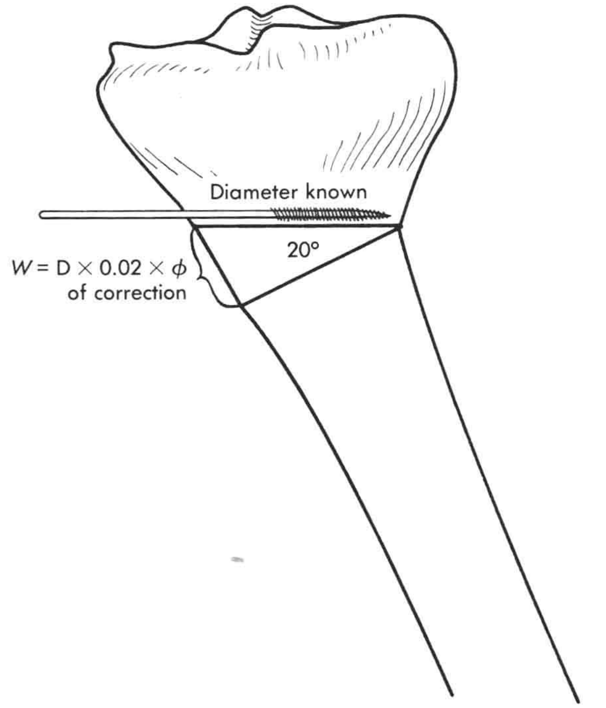


Fig. 1-5 Method of determining length of wedge *(W)* to be removed when desired angle of correction (20 degrees) is known before surgery and diameter of bone is determined at surgery. (From Canale ST and Harper MC. In The American Academy of Orthopaedic Surgeons: Instructional course lectures, vol 30, St. Louis, 1981, The CV Mosby Co.)

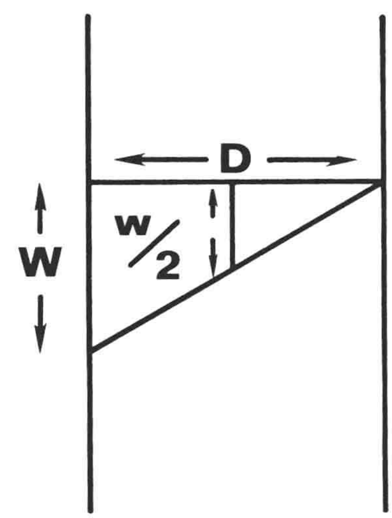


Fig. 1-6 Length lost or gained is equal to one half the base *(W)* of the osteotomy. *D,* Diameter. (From Canale ST and Harper MC. In The American Academy of Orthopaedic Surgeons: Instructional course lectures, vol 30, St. Louis, 1981, The CV Mosby Co.)