TENTH EDITION 10

BONTRAGER'S TEXTBOOK OF
Radiographic Positioning and Related Anatomy

JOHN P. LAMPIGNANO | LESLIE E. KENDRICK

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Radiographic Positioning and Related Anatomy

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JOHN P. LAMPIGNANO, MEd, RT(R)(CT)

LESLIE E. KENDRICK, MS, RT(R)(CT)(MR)

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Executive Content Strategist: Sonya Seigafuse
Senior Content Development Manager: Lisa P. Newton
Senior Content Development Specialist: Tina Kaemmerer
Publishing Services Manager: Julie Eddy
Senior Project Manager: Richard Barber
Design Direction: Amy Buxton

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Acknowledgments and Dedication

John P. Lampignano

First, I must acknowledge the contributions from students and imaging faculty throughout the United States and various aspects of the world, including Puerto Rico and South America. We hear frequently from them, as they provide feedback on the text and ancillaries. They have provided us with fresh ideas and perspectives for the text and how to improve it. A special thank you to Chris Wertz, with Idaho State University, for being so instrumental in this edition. Chris and his brother, Dr. Joss Wertz, provided many of the images for the tenth edition. Chris is an excellent writer and the contributor for Chapters 5 and 6.

The Radiologic Sciences faculty and staff at Boise State University are outstanding role models for their students and the profession—Joie Burns, Leslie Kendrick, Cathy Masters, Travis Armstrong, Natalie Mourant, and Sue Antonich. They have made my transition to Boise State a positive and supportive experience. Special recognition to Michele Patrícia Müller Mansur Vieira, who is a lecturer at Federal Institute of Paraná - Campus Curitiba in Brazil. Michele is a valued colleague and good friend. Michele contributed to Chapters 12 and 13.

The contributing authors for the tenth edition did an outstanding job in researching and writing the content for numerous chapters. My heartfelt gratitude to each of them for making this edition truly reflective of the current practice in medical imaging. Special thanks to Andrew Woodward and the faculty at GateWay Community College, Bradley Johnson, Nicole Hightower, Janelle Black, and Michelle Wilt. Andrew redesigned Chapters 1 and 18 in this edition, served as consultant for all of the digital imaging concepts, and provided numerous photographs and images. The GateWay faculty and their students helped us secure many of the new images for this edition.

Ken Bontrager was dedicated to this text and other instructional media in radiologic technology for more than 48 years. Ken gave of himself fully to this text and its ancillaries. We hope our profession never forgets Ken Bontrager and his contributions.

Leslie E. Kendrick formally became co-author for the ninth edition. Leslie is a driven, detailed, and outstanding writer. She took on this huge endeavor while maintaining her program responsibilities at Boise State University, completing her research for a doctorate, and taking care of her family. You can't measure the character of a writer until they are tested by long hours, pressing deadlines, and personal sacrifice. Leslie has the character and heart of a writer. I am privileged to work with her.

More than 250 photographs were taken for the tenth edition. This feat would not have been possible without the special talents of KJ Filmworks, including Jack Quirk, Renee Settlemires, and Ken Helms.

Our gratitude to photography models Jamie Blum, Tina Kaemmerer, Misti Walker, Livia Kendrick, Travis Kendrick, Atticus Rosenkoetter, Aubrie Rosenkoetter, Robyn Pedraza, Carlos Pedraza, Calliope Pedraza, and Deborah Lampignano, who served as models for this edition. They maintained a high degree of professionalism and tremendous patience throughout the long photo shoots.

We were honored to have Jamie Blum and Sonya Seigafuse as our Executive Content Strategists. Jaime was our editor for the tenth edition from inception to near completion. Sonya helped us navigate through the final stages of the tenth edition. Both of these individuals made the process of creating the tenth edition seamless.

Our Senior Content Development Specialist, Tina Kaemmerer, was simply incredible. She is a perfectionist who challenged us to bring forth our best effort in a loving way. Her support was ongoing, professional, and always positive. We shall always treasure our friendship with Tina.

Rich Barber is the Senior Project Manager who led us through the production phase. We couldn't have produced this edition without his expertise.

Most importantly, a thank you to Elsevier Publishing for allowing us to continue to be part of this wonderful reference for the past 46 years.

Finally, my thanks to my family for their ongoing support. My wife Deborah, son Daniel, daughter Molly, and granddaughter, Tatum. I'm especially proud that Daniel and Molly have entered the medical profession. They are both excellent professionals and they understand the importance of treating their patients with dignity and compassion. They have always been important to me, even though I don't express it adequately. My true inspiration is my granddaughter, Tatum. Now 14 years old, she has turned into a loving, bright, and caring young person. When things got difficult and overwhelming, I only needed to see her picture or spend a few minutes with her and my spirit was renewed. Tatum will always own my heart. Finally, to Buddy and Segen—the family dogs—and the joy (and occasional challenge) they provide us.

Deborah has been at my side for more than 42 years. She has been the compassionate anchor that provides our family with the stability and encouragement to be successful in all our professional and personal endeavors. My life changed in so many positive ways since I first met her. Meeting the demands of a new edition of the text would not have been possible if it wasn't for her enduring love and support.

Our world has faced a great challenge with the coronavirus pandemic that struck at the end of 2019/beginning of 2020. We wish to recognize the dedication and sacrifice of the many imaging technologists and students who continue to serve their patients and those facing this potentially life-threatening condition. This service is often at risk of their own health and the health of their families. To each of you, we dedicate this tenth edition.

JPL

Acknowledgments and Dedication

Leslie E. Kendrick

John Lampignano has eloquently acknowledged many outstanding individuals from the worlds of medical imaging and publishing. I sincerely echo his appreciation and recognition that this tenth edition has been made possible with the time and talents of many. Special thanks to Dr. José Rafael Moscoso-Alvarez, of the Universidad Central de Caribe, Puerto Rico for serving as technical advisor for this edition. José is a cherished colleague and friend. We respect and appreciate his contributions to this edition. Working alongside and with so many amazing professionals is an incredible honor. Your tireless dedication, compassion for patients, and tremendous respect for each other are what makes this profession such a joy to be part of. I genuinely appreciate the opportunity to give back to the profession as the co-author of this textbook and ancillaries with utmost gratitude.

I am especially grateful to Darlene Travis, O. Scott Staley, Duane McCrorie (rest in peace), Lorrie Kelley, Joie Burns, Cathy Masters, Travis Armstrong, Natalie Mourant, and Sue Antonich of Boise State University for freely sharing your vast knowledge and expertise in the field of radiologic sciences. Thank you for fostering in me the passion and drive for life-long learning. You each stand as a pillar of greatness in the field. It is truly an honor to be your colleague.

I also thank my loving family for their unfailing patience. My youngest, Livia, has sat by patiently many times waiting for mommy to proofread a paragraph just one more time. My incredible husband, Travis, recognizes the honor of my participation in this project and continues to support my insatiable desire to get it right. Words cannot express the pride I feel when I reflect on my family: seven beautiful children—each talented, kind, and a blessing to those around them: CJ, Ren, Robyn, Kade, Atticus, Aubrie, and Livia; seven lovely grandchildren—each filled with wonder and delight: Fox, Killian, Kellen, Charlotte, Haydin, Addison, and Calliope; one amazing husband who loves me unconditionally and makes my life complete. There aren't enough words to express the joy you each bring to me. Thank you for sharing so much of yourselves.

Lastly, I thank John P. Lampignano for opening a whole new world by extending me the invitation of co-authorship. This project continually presents opportunities for collaboration across the United States and around the globe. The professional growth from exposure to new ideas, concepts, and intellects has been exponential. The first time I met John, I was impressed by his professionalism and poise. To now be his colleague is an incredible privilege. I will work hard to uphold the high standards set for this textbook and ancillaries by Kenneth Bontrager and now John. I will continue to recognize the value of collaboration with professionals across the United States and the world to ensure quality and accuracy. I encourage communication from all readers of these materials on how to improve and better meet the needs of the users. It is our goal to be a continued invaluable resource for educators, students, and imaging professionals.

LEK

Contributors

Janelle M. Black, BS(DMIT), RT(R) (ARRT)
Chapter 4
Faculty
Medical Radiography
GateWay Community College
Phoenix, Arizona
Radiologic Technologist
Scottsdale Medical Imaging Ltd.
Scottsdale, Arizona

Joie Burns, MS, RT(R)(S), RDMS, RVT
Chapter 20
Diagnostic Medical Sonography Program Director/Chair
Radiologic Sciences
Boise State University
Boise, Idaho

Shaun T. Caldwell, MS, RT (R)(T)
Chapter 20
Associate Professor
School of Health Professions
The University of Texas MD Anderson Cancer Center,
Houston, Texas

Jeanne M. Dial, MED, CNMT, NMTCB(CT)
Chapter 20
Program Director
Nuclear Medicine Technology
GateWay Community College
Phoenix, Arizona

Cheryl DuBose, EDD, RT(R)(MR)(CT) (QM)
Chapter 2
Department Chair
Medical Imaging and Radiologic Sciences
Arkansas State University
Jonesboro, Arkansas

Frank Goerner, PHD
Chapter 1
Medical Physicist
Medical Physics
The Queens Medical Center
Honolulu, Hawaii

Michele Gray-Murphy, MEd, RT(R)(M), ARRT
Chapter 11
Faculty
Associate of Science in Radiography Program
Allen College
Waterloo, Iowa

Kelli Welch Haynes, Ed.D, RT(R)
Chapter 3
Program Director
Allied Health
Northwestern State University
Shreveport, Louisiana

Chad Hensley, PhD, RT(R)(MR)
Chapters 14 and 16
Clinical Coordinator
Radiography
University of Nevada Las Vegas
Las Vegas, Nevada

Nicolle Hightower, MEd, RT(R)(VI)
Chapter 17
Medical Radiography Faculty and Director of Clinical Education
Health Sciences
Gateway Community College
Phoenix, Arizona

Bradley Johnson, MEd, RT(R)
Chapters 15 and 19
Faculty
Medical Radiography
GateWay Community College
Phoenix, Arizona

Derek Lee, BS, CNMT, PET
Chapter 20
Supervisor Nuclear Medicine, PET/CT & PET/MRI
Nuclear Medicine
Phoenix VA Medical Center
Phoenix, Arizona
Adjunct Faculty
Nuclear Medicine Technology Program
Gateway Community College
Phoenix, Arizona

Michele Patricia Müller Mansur Vieira, MSc TCNL-CRTR-PR (BRAZIL)
Chapters 12 and 13
Professora e Coordenadora do Curso Técnico em Radiologia
Instituto Federal do Paraná
Curitiba, Brazil

Katrina L. Steinsultz, RT(R)(M), MAdm, MPH
Chapter 10
Clinical Assistant Professor
University of North Carolina at Chapel Hill
Chapel Hill, North Carolina

Beth L. Veale, PhD, RT(R)(QM)
Chapter 7
Professor/Interim Chair– The Shimadzu School of Radiologic Sciences
Midwestern State University
Wichita Falls, Texas

Patti Ward, PHD, (RT)(R)
Chapters 8 and 9
Instructor of Radiologic Sciences
Health Sciences
Colorado Mesa University
Grand Junction, Colorado

Sharon Wartenbee, RTR, BD, CBDT, FASRT
Chapter 20
Senior Bone Densitometry Technologist
Radiology
Avera Medical Group McGreevy Clinic
Sioux Falls, South Dakota

Christopher Wertz, MSRS, RT(R)
Chapters 5 and 6
Program Director
Radiographic Science
Idaho State University
Pocatello, Idaho

Michelle A. Wilt, MHA, RT (R)(M) (ARRT)
Chapter 20
Faculty
Medical Radiography
GateWay Community College
Phoenix, Arizona

Kathryn Wissink, AAS, RT(R), (MR) MR Education Development Specialist
Chapter 20
MRI
Siemens Healthineers
Cary, North Carolina

Andrew Woodward, MA, RT(R)(CT) (QM)
Chapters 1 and 18
Assistant Professor (retired)
Radiologic Sciences
The University of North Carolina at Chapel Hill
Chapel Hill, North Carolina

Contributors to Past Editions

Barry T. Anthony, RT(R)
Englewood, Colorado

Patrick Apfel, MED, RT(R)
Las Vegas, Nevada

April Apple, RT(R)
Durham, North Carolina

Alex Backus, MS, RT(R)
Phoenix, Arizona

Daniel J. Bandy, MS, CNMT
Phoenix, Arizona

Kristi Blackhurst, BS, RT(R)(MR)
Gilbert, Arizona

Karen Brown, RT(R)
Phoenix, Arizona

Claudia Calandrino, MPA, RT(R)
Los Angeles, California

Mary J. Carrillo, MBA/HCM, RT(R)(M), CDT
Phoenix, Arizona

Timothy C. Chapman, RT(R)(CT)
Phoenix, Arizona

Donna Davis, MED, RT(R)(CV)
Little Rock, Arkansas

Nancy L. Dickerson, RT(R)(M)
Rochester, Minnesota

Eugene D. Frank, MA, RT(R), FASRT, FAERS
Rochester, Minnesota

Richard Geise, PHD, FACR, FAAPM
Minneapolis, Minnesota

Cecilie Godderidge, BS, RT(R)
Boston, Massachusetts

Jeannean Hall-Rollins, MRC, BS, RT(R)(CV)
Jonesboro, Arkansas

Jessie R. Harris, RT(R)
Los Angeles, California

W.R. Hedrick, PHD, FACR
Canton, Ohio

Dan L. Hobbs, MSRS, RT(R)(CT)(MR)
Pocatello, Idaho

Brenda K. Hoopingarner, MS, RT(R)(CT)
Hays, Kansas

Julia Jacobs, MBA, RT(R)(T)
Phoenix, Arizona

Nancy Johnson, MED, RT(R)(CV)(CT)(QM)(ARRT), FASRT
Phoenix, Arizona

Jenny A. Kellstrom, MED, RT(R)
Klamath Falls, Oregon

Leslie E. Kendrick, MS, RT(R)(CT)(MR)
Boise, Idaho

Molly E. Lampignano, CNMT, PET
Phoenix, Arizona

Linda S. Lingar, MED, RT(R)(M)
Little Rock, Arkansas

James D. Lipcamon, RT(R)
Torrance, California

Kathy M. Martensen, BS, RT(R)
Iowa City, Iowa

Cindy Murphy, BHSC, RT(R), ACR
Halifax, Nova Scotia, Canada

Kathleen Murphy, MBA, RDMS, RT(R)
Apache Junction, Arizona

Manjusha Namjoshi, BS, RDMS, RT(R)
Phoenix, Arizona

Sandra J. Nauman, RT(R)(M)
Austin, Minnesota

Joseph Popovitch, RT(R), ACR, DHSA
Halifax, Nova Scotia, Canada

E. Russel Ritenour, PHD
Minneapolis, Minnesota

Bette Schans, PHD, RT(R)
Grand Junction, Colorado

Mindy S. Shapiro, RT(R)(CT)
Tucson, Arizona

Marianne Tortorici, EDD, RT(R)
San Diego, California

Renee F. Tossell, PHD, RT(R)(M)(CV)
Phoenix, Arizona

Charles R. Wilson, PHD, FAAPM, FACR
Milwaukee, Wisconsin

Donna L. Wright, EDD, RT(R)
Wichita Falls, Texas

Linda Wright, MHSA, RT(R)
Denver, Colorado

Preface

Purpose and Goal of the Tenth Edition

The tenth edition of *Bontrager's Textbook of Radiographic Positioning and Related Anatomy* is a one-volume reference that provides the essential knowledge for the student in radiographic positioning. Positioning remains as one of the critical variables in medical radiography that is solely in the hands of the technologist. Proper positioning displays anatomy and pathology correctly to enable the radiologist and other physicians to make an accurate diagnosis. In many respects, the patient's health and well-being is in the hands of the technologist. The authors and contributors had this goal in mind as we made the revisions for the tenth edition. Each position and procedure were carefully evaluated to provide the most accurate information for the student and practicing technologist. Our goals were to be accurate, use language that was easy to follow, and observe current practices for reducing dose to the patient and technologist. Our aim was to continue this format in the *Workbook*, *Handbook*, and web-based resources.

We hope we have met these goals. We continue to be open to your feedback and suggestions to make this text and its ancillaries more accurate and valuable resources.

Methodology

We apply the principle of presenting information from simple to complex, from known to unknown, and we provide diagrams and images to illustrate these concepts. The chapters are arranged to first describe the more basic radiographic procedures and proceed to the more complex ones in later chapters. This method is continued in the format of the *Workbook* and *Handbook* as well.

New to This Latest Edition

- Chapter 1, ***Terminology, Positioning, and Imaging Principles*** contains examples of terminology, basic principles, both analog and digital system imaging, grids, radiographic quality factors, and radiation protection that provide a central resource for these principles and concepts. Information on digital imaging concepts has been updated and reflects current practices. The information on analog imaging has been reduced due to the predominance of digital imaging. The chapter on radiation protection reinforces the recommendations and practices promoted by the Image-Gently® and ImageWisely® initiatives.
- Chapter 4, ***Upper Limb*** added the AP axial-Brewerton method, which demonstrates early signs of rheumatoid arthritis in the joints of the hands.
- Chapter 5, ***Shoulder Girdle and Humerus*** added PA axial-Bernageau method for the scapulohumeral joint space and the AP axial-Zanca method for assessment of the acromioclavicular (AC) joints.
- Chapter 15, ***Trauma, Mobile, and Surgical Radiography*** was revised extensively to focus on key concepts of mobile, trauma, and surgical radiography. In doing so, we retained key concepts while eliminating procedures no longer performed.
- Chapter 16, ***Pediatric Radiography*** has been updated to reflect best practices in reducing dose to young patients. Image-Gently® principles are stressed in this chapter and Chapter 1. Photographs of pediatric immobilization devices have been updated.
- Chapter 17, ***Angiography and Interventional Procedures*** has new art and photographs added to illustrate current procedures and angiographic devices currently seen in clinical practice.
- Chapter 18, ***Computed Tomography*** was revised to reflect the newest technology available. New procedures and current CT technology were added in this chapter.
- Chapter 19, ***Special Radiographic Procedures*** was updated to reflect new procedures and imaging modalities including Digital Tomosynthesis (DTS).
- Chapter 20 ***Diagnostic and Therapeutic Procedures.*** Each of the modalities were updated to reflect current imaging systems and procedures. Mammography has new digital images and the Magnetic Resonance Imaging (MRI) section was revised to include current technology, current protocols, and high quality images.
- The tenth edition follows closely the procedures and positioning concepts required by the American Registry of Radiologic Technologists (ARRT) Content Specifications for the Radiography Examination.
- More than **250 positioning photographs** have been replaced in the tenth edition. A different perspective was used with these photos. They demonstrate close-ups of the positioning model so students and technologists can better view positioning landmarks, CR centering points, and collimation. Erect versions of positions are now included for many positions to reflect current clinical practice.
- **New images** have been added throughout the tenth edition. We replaced many analog film-based images with digital versions. Several of the commercial medical imaging companies graciously allowed us to use their images for this edition.
- **Revised Radiographic Critique.** At the end of Chapters 2-11 and 18, the radiographic critique section has been revised to provide students a method to compare an ideal image to others than demonstrate common positioning and technical errors. Solutions for these critique assessments are provided in the faculty Evolve site.
- **Digital imaging** continues to be emphasized in the tenth edition. Terminology, technical factors, part centering, and kVp ranges are described with a primary focus on digital systems.
- kVp ranges have been reviewed by experts in the field to ensure they are consistent with current practice and will provide the most diagnostic images while reducing patient dose.
- **Consistent positioning terminology** is used throughout the *Textbook*, *Workbook*, and *Handbook.* Projection names are used that are formally recognized in the profession. All projections match those stated in the ARRT Content Specifications in Radiography.

- **Twenty chapters.** The number of chapters for the tenth edition **remains 20 chapters.** To keep the size and page count of the text to a reasonable size, we kept this edition to the relative size of the previous edition. The body of knowledge in medical imaging continues to grow exponentially. This edition provides the most essential concepts in radiographic anatomy and positioning while keeping the size and weight of this text consistent with past editions.
- The authors and contributors believe the changes and improvements in this latest edition will enhance learning and reflect current clinical practice.

Ancillaries

WORKBOOK

This edition contains new learning-exercise and self-test questions, including more situation-based questions and new questions on digital imaging. All questions have been reviewed by a team of educators and students to ensure the accuracy of the content and answers. The radiographic critique section was expanded to include images in the workbook pages.

EVOLVE INSTRUCTOR RESOURCES

A computerized test bank is available on Evolve to instructors who use this textbook in their classrooms. The test bank features more than 1200 questions. They include registry-type questions, which can be used as final evaluation exams for each chapter, or they can be put into custom exams that educators create. These tests can be administered as either computer- or print-based assessments, and are available in ExamView® format.

Also available on Evolve is an electronic image collection featuring more than 2700 images that are fully coordinated with the tenth edition *Textbook* and *Workbook*. Instructors can create their own customized classroom presentations using these electronic images, which closely follow the *Textbook* and *Workbook*, chapter by chapter.

The Evolve Instructor Resources also provide a complete PowerPoint presentation that correlates with the *Textbook*.

EVOLVE STUDENT RESOURCES

New to the tenth edition, students will have access to 400 additional review questions (20 questions per chapter) to help them review important concepts. Each question will include detailed rationales.

HANDBOOK

The new tenth edition revised pocket *Handbook*, also authored by John P. Lampignano and Leslie E. Kendrick, is now available from Elsevier as one of the ancillary components along with student workbooks and an electronic image collection for a complete current student resource on radiographic positioning.

MOSBY'S® RADIOGRAPHY ONLINE

Mosby's® Radiography Online for Bontrager's Textbook of Radiographic Positioning and Related Anatomy is a unique online courseware program promoting problem-based learning with the goal of developing critical thinking skills needed in the clinical setting. Developed to be used in conjunction with the Lampignano/Kendrick *Textbook* and *Workbook*, the online course enhances learning with animations and interactive exercises and offers application opportunities that can accommodate multiple learning styles and circumstances.

How to Use the Positioning Pages

1 **PROJECTION TITLE BARS** describe the specific position/projection to be radiographed, including the proper name of the position, if such applies.

2 **CLINICAL INDICATIONS** section summarizes conditions or pathologies that may be demonstrated by the examination and/or projection. This brief review helps the technologist understand the purpose of the examination and which structures or tissues should be most clearly demonstrated.

3 **PROJECTION SUMMARY BOXES** list all the specific routine or special projections most commonly performed for that body part.

4 **TECHNICAL FACTORS** section includes the image receptor (IR) size recommended for the average adult; whether the IR should be placed portrait or landscape in relation to the patient; a grid, if one is needed; and recommended kVp ranges. The minimum SID (source-to-image receptor distance) is listed.

5 **IMAGE RECEPTOR ICONS** give a visual display of the IR relative size (cm) and orientation (portrait or landscape), relative collimated field size, location of R and L markers, and the recommended AEC cell location (if AEC is used).

6 **SHIELDING** section describes shielding that is recommended for the projection.

7 **PATIENT POSITION** section indicates the general body position required for the projection.

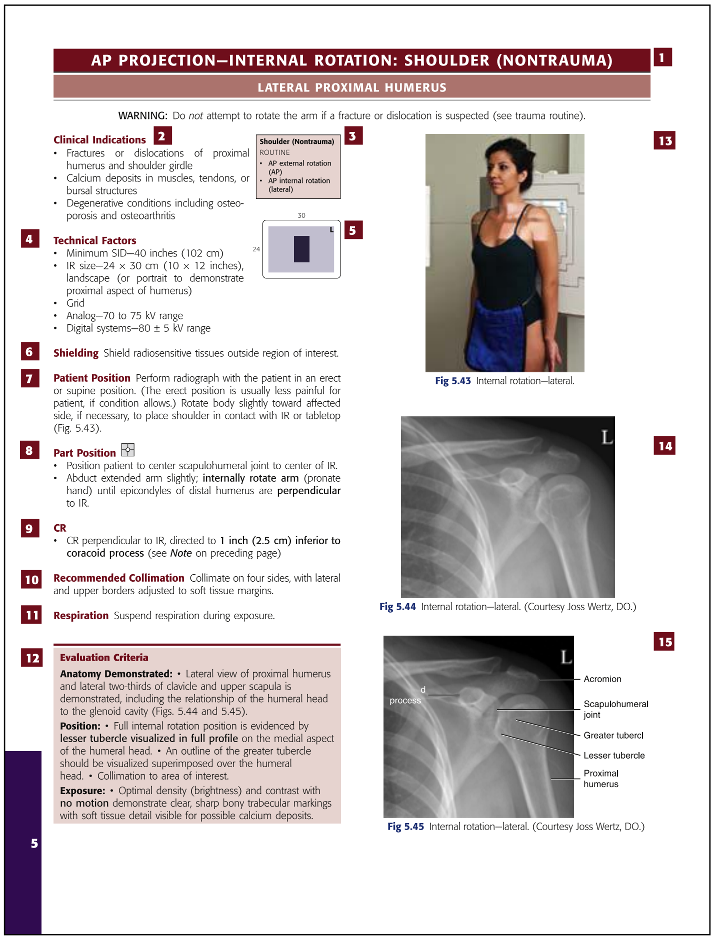
8 **PART POSITION** section gives a clear, step-by-step description of how the body part should be positioned in relation to the IR and/or tabletop. The CR icon is included for all those projections in which the CR is of primary importance to remind the technologist to pay special attention to the CR during the positioning process for that projection.

9 **CENTRAL RAY (CR)** section describes the precise location of the CR in relation to both the IR and the body part.

10 **RECOMMENDED COLLIMATION** section describes the collimation of the x-ray field recommended for that projection.

11 **RESPIRATION** section lists the breathing requirements for that projection.

12 **EVALUATION CRITERIA** boxes describe evaluation/critique process that should be completed for each processed radiographic image. This process is divided into the following three broad categories: (1) anatomy demonstrated, (2) position, (3) exposure.



AP PROJECTION—INTERNAL ROTATION: SHOULDER (NONTRAUMA) 1

LATERAL PROXIMAL HUMERUS

WARNING: Do *not* attempt to rotate the arm if a fracture or dislocation is suspected (see trauma routine).

Clinical Indications 2

- Fractures or dislocations of proximal humerus and shoulder girdle
- Calcium deposits in muscles, tendons, or bursal structures
- Degenerative conditions including osteoporosis and osteoarthritis

Shoulder (Nontrauma) 3
ROUTINE
- AP external rotation (AP)
- AP internal rotation (lateral)

4 **Technical Factors**

- Minimum SID—40 inches (102 cm)
- IR size—24 × 30 cm (10 × 12 inches), landscape (or portrait to demonstrate proximal aspect of humerus)
- Grid
- Analog—70 to 75 kV range
- Digital systems—80 ± 5 kV range

6 **Shielding** Shield radiosensitive tissues outside region of interest.

7 **Patient Position** Perform radiograph with the patient in an erect or supine position. (The erect position is usually less painful for patient, if condition allows.) Rotate body slightly toward affected side, if necessary, to place shoulder in contact with IR or tabletop (Fig. 5.43).

8 **Part Position** ⌖

- Position patient to center scapulohumeral joint to center of IR.
- Abduct extended arm slightly; **internally rotate arm** (pronate hand) until epicondyles of distal humerus are **perpendicular** to IR.

9 **CR**

- CR perpendicular to IR, directed to **1 inch (2.5 cm) inferior to coracoid process** (see *Note* on preceding page)

10 **Recommended Collimation** Collimate on four sides, with lateral and upper borders adjusted to soft tissue margins.

11 **Respiration** Suspend respiration during exposure.

12 **Evaluation Criteria**

Anatomy Demonstrated: • Lateral view of proximal humerus and lateral two-thirds of clavicle and upper scapula is demonstrated, including the relationship of the humeral head to the glenoid cavity (Figs. 5.44 and 5.45).

Position: • Full internal rotation position is evidenced by **lesser tubercle visualized in full profile** on the medial aspect of the humeral head. • An outline of the greater tubercle should be visualized superimposed over the humeral head. • Collimation to area of interest.

Exposure: • Optimal density (brightness) and contrast with **no motion** demonstrate clear, sharp bony trabecular markings with soft tissue detail visible for possible calcium deposits.

13

Fig 5.43 Internal rotation—lateral.

14

Fig 5.44 Internal rotation—lateral. (Courtesy Joss Wertz, DO.)

15

Fig 5.45 Internal rotation—lateral. (Courtesy Joss Wertz, DO.)

13 **POSITIONING PHOTOGRAPHS** show a correctly positioned patient and part in relation to the CR and IR.

14 **RADIOGRAPHIC IMAGES** provide an example of a correctly positioned and correctly exposed radiographic image of the featured projection.

15 **ANATOMY LABELED IMAGES** identify specific anatomy that should be demonstrated on the radiographic image shown. The labeled image, in most cases, matches the radiographic image example on the same page.

Contents

CHAPTER

1

Terminology, Positioning, and Imaging Principles

CONTRIBUTIONS BY **Andrew Woodward,** MA, RT(R)(CT)(QM)

RADIATION PROTECTION CONTRIBUTOR **Frank Goerner,** PhD, DABR

CONTRIBUTORS TO PAST EDITIONS W. R. Hedrick, PhD, FACR, Cindy Murphy, BHSc, RT(R), ACR, Joseph Popovitch, RT(R), ACR, DHSA, Kathy M. Martensen, BS, RT(R), Barry T. Anthony, RT(R), Katrina Lynn Steinsultz, BS, RT(R)(M)

RADIATION PROTECTION PAST CONTRIBUTORS Richard Geise, PhD, FACR, FAAPM, E. Russel Ritenour, PhD

CONTENTS

PART THREE: RADIATION PROTECTION

PART ONE ▪ TERMINOLOGY AND POSITIONING

GENERAL, SYSTEMIC, AND SKELETAL ANATOMY AND ARTHROLOGY

General Anatomy

Anatomy is the study, classification, and description of the structure and organs of the human body, whereas **physiology** deals with the processes and functions of the body, or how the body parts work. In the living subject, it is almost impossible to study anatomy without also studying some physiology. However, radiographic study of the human body is primarily a study of the anatomy of the various systems, with less emphasis on the physiology. Consequently, anatomy of the human system is emphasized in this radiographic anatomy and positioning textbook.

NOTE: Phonetic respelling[1] of anatomic and positioning terms is included throughout this text to facilitate correct pronunciation of the terms commonly used in medical radiography.

STRUCTURAL ORGANIZATION

Several levels of structural organization make up the human body. The lowest level of organization is the **chemical level.** All chemicals necessary for maintaining life are composed of **atoms,** which are joined in various ways to form **molecules.** Various chemicals in the form of molecules are organized to form **cells.**

Cells

The cell is the basic structural and functional unit of all living tissue. Every single part of the body, whether muscle, bone, cartilage, fat, nerve, skin, or blood, is composed of cells.

Tissues

Tissues are cohesive groups of similar cells that, together with their intercellular material, perform a specific function. The four basic types of tissue are as follows:

1. ***Epithelial*** *(ep″-i-the′le-al):* Tissues that cover internal and external surfaces of the body, including the lining of vessels and organs, such as the stomach and the intestines
2. ***Connective:*** Supportive tissues that bind together and support various structures
3. ***Muscular:*** Tissues that make up the substance of a muscle
4. ***Nervous:*** Tissues that make up the substance of nerves and nerve centers

Organs

When complex assemblies of tissues are joined to perform a specific function, the result is an organ. Organs usually have a specific shape. Examples of organs of the human body are the kidneys, heart, liver, lungs, stomach, and brain.

System

A system consists of a group or an association of organs that have a similar or common function. The urinary system, consisting of the kidneys, ureters, bladder, and urethra, is an example of a body system. The total body comprises **10 individual body systems.**

Organism

The 10 systems of the body when functioning together make up the total organism—one living being (Fig. 1.1).

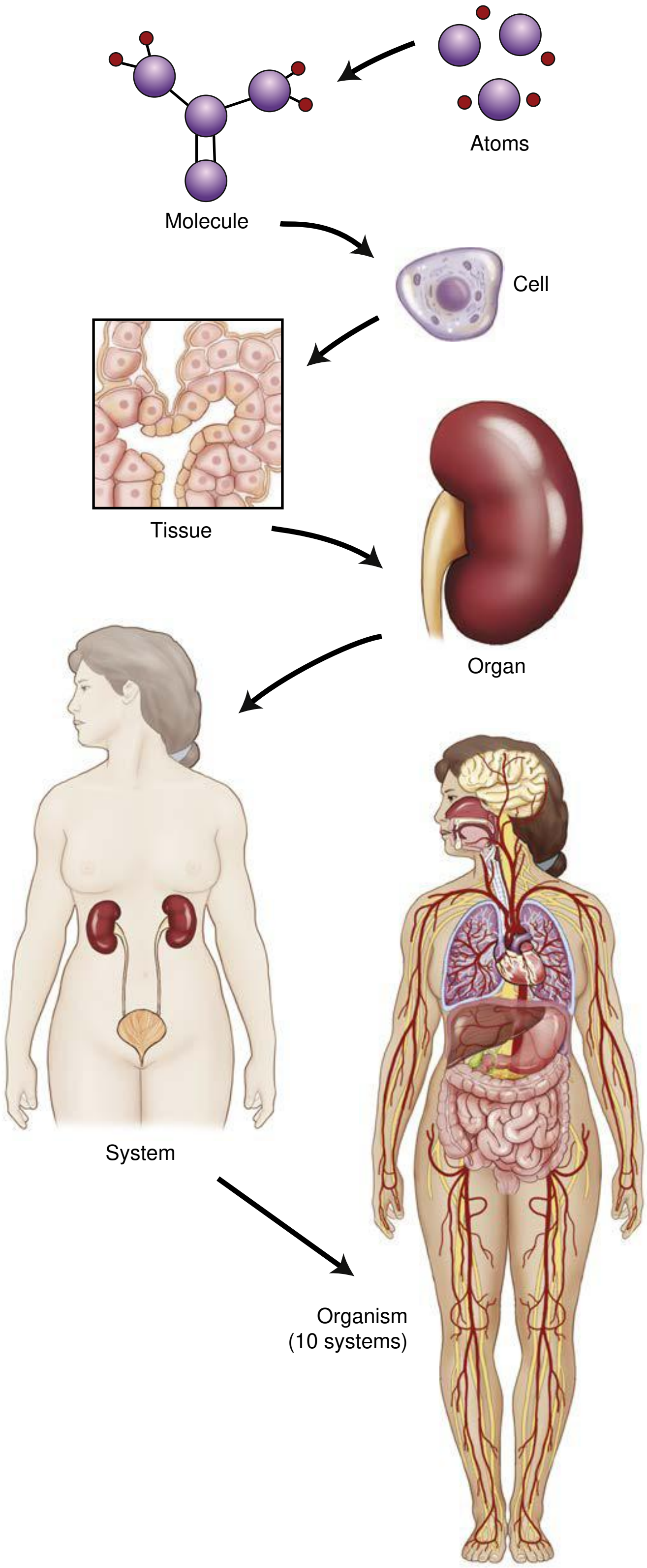


Fig. 1.1 Levels of human structural organization.

Systemic Anatomy

BODY SYSTEMS

The human body is a structural and functional unit made up of 10 lesser units called *systems.* These 10 systems are the (1) skeletal, (2) circulatory, (3) digestive, (4) respiratory, (5) urinary, (6) reproductive, (7) nervous, (8) muscular, (9) endocrine, and (10) integumentary *(in-teg″-u-men′-tar-e)* systems.

Skeletal System

The skeletal system (Fig. 1.2) is important for the technologist to learn. The skeletal system includes the **206 separate bones** of the body and their associated cartilages and joints. The study of bones is termed **osteology,** whereas the study of joints is called **arthrology.**

The four functions of the skeletal system are as follows:

1. Support and protect many soft tissues of the body
2. Allow movement through interaction with the muscles to form a system of levers
3. Produce blood cells
4. Store calcium

Fig. 1.2 Skeletal system.

Circulatory System

The circulatory system (Fig. 1.3) is composed of the following:

- The **cardiovascular organs**—heart, blood, and blood vessels
- The **lymphatic system**—lymph nodes, lymph vessels, lymph glands, and spleen

The six functions of the circulatory system are as follows:

1. Distribute oxygen and nutrients to the cells of the body
2. Transport cell waste and carbon dioxide from the cells
3. Transport water, electrolytes, hormones, and enzymes
4. Protect against disease
5. Prevent hemorrhage by forming blood clots
6. Assist in regulating body temperature

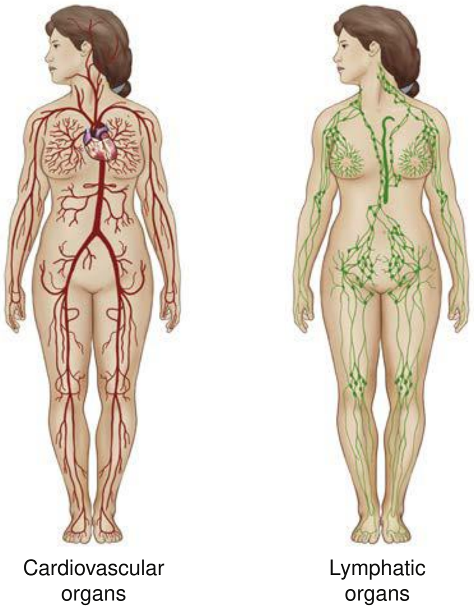


Fig. 1.3 Circulatory system.

Digestive System

The digestive system includes the alimentary canal and certain accessory organs (Fig. 1.4). The alimentary canal is made up of the mouth, pharynx, esophagus, stomach, small intestine, large intestine, and anus. Accessory organs of digestion include the salivary glands, liver, gallbladder, and pancreas.

The twofold function of the digestive system is as follows:

1. Prepare food for absorption by the cells through numerous physical and chemical breakdown processes
2. Eliminate solid wastes from the body

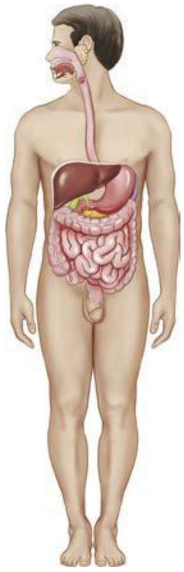


Fig. 1.4 Digestive system.

Respiratory System

The respiratory system is composed of two lungs and a series of passages that connect the lungs to the outside atmosphere (Fig. 1.5). The structures that make up the passageway from the exterior to the alveoli of the lung interior include the nose, mouth, pharynx, larynx, trachea, and bronchial tree.

The three primary functions of the respiratory system are as follows:

1. Supply oxygen to the blood and eventually to the cells
2. Eliminate carbon dioxide from the blood
3. Assist in regulating the acid-base balance of the blood

Urinary System

The urinary system includes the organs that produce, collect, and eliminate urine. The organs of the urinary system consist of the kidneys, ureters, bladder, and urethra (Fig. 1.6).

The four functions of the urinary system are as follows:

1. Regulate the chemical composition of the blood
2. Eliminate many waste products
3. Regulate fluid and electrolyte balance and volume
4. Maintain the acid-base balance of the body

Reproductive System

The reproductive system is made up of organs that produce, transport, and store the germ cells (Fig. 1.7). The testes in the male and the ovaries in the female produce mature germ cells. Transport and storage organs of the male include the vas deferens, prostate gland, and penis. The organs of reproduction in the female are the ovaries, uterine (fallopian) tubes, uterus, and vagina (Fig. 1.7).

The function of the reproductive system is to reproduce the organism.

Fig. 1.5 Respiratory system.

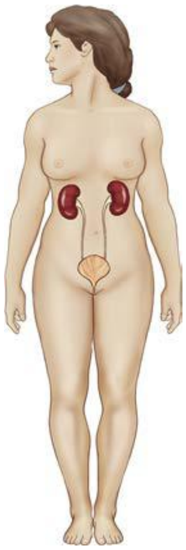
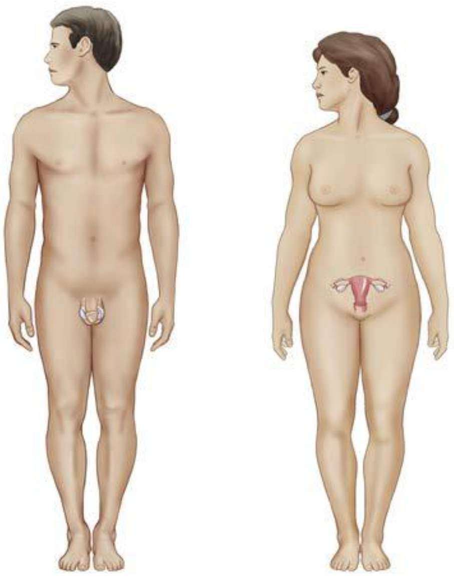


Fig. 1.6 Urinary system.



Male Female

Fig. 1.7 Reproductive system.

Nervous System

The nervous system is composed of the brain, spinal cord, nerves, ganglia, and special sense organs such as the eyes and ears (Fig. 1.8).

The function of the nervous system is to coordinate voluntary and involuntary body activities and transmit electrical impulses to various parts of the body and the brain.

Muscular System

The muscular system (Fig. 1.9), which includes all muscle tissues of the body, is subdivided into three types of muscles: (1) **skeletal,** (2) **smooth,** and (3) **cardiac.**

Most of the muscle mass of the body is skeletal muscle, which is striated and under voluntary control. The voluntary muscles act in conjunction with the skeleton to allow body movement. About 43% of the weight of the human body is accounted for by voluntary or striated skeletal muscle.

Smooth muscle, which is involuntary, is located in the walls of hollow internal organs such as blood vessels, the stomach, and intestines. These muscles are called *involuntary* because their contraction usually is not under voluntary or conscious control.

Cardiac muscle is found only in the walls of the heart and is involuntary but striated.

The three functions of muscle tissue are as follows:

1. Allow movement, such as locomotion of the body or movement of substances through the alimentary canal
2. Maintain posture
3. Produce body heat

Endocrine System

The endocrine system includes **all the ductless glands** of the body (Fig. 1.10). These glands include the testes, ovaries, pancreas, adrenals, thymus, thyroid, parathyroid, pineal, and pituitary. The placenta acts as a temporary endocrine gland.

Hormones, which are the secretions of the endocrine glands, are released directly into the bloodstream.

The function of the endocrine system is to regulate bodily activities through the various hormones carried by the cardiovascular system.

Integumentary System

The tenth and final body system is the **integumentary** *(in-teg″-u-men′-tar-e)* system, which is composed of the **skin** and **all structures derived from the skin** (Fig. 1.11). These derived structures include hair, nails, and sweat and oil glands.

The skin is an organ that is essential to life. The skin is the **largest organ of the body,** covering a surface area of approximately 3000 in^2 (7620 cm^2) and constituting 8% of total body mass in the average adult.

The five functions of the integumentary system are as follows:

1. Regulate body temperature
2. Protect the body, within limits, against microbial invasion and mechanical, chemical, and ultraviolet (UV) radiation damage
3. Eliminate waste products through perspiration
4. Receive certain stimuli such as temperature, pressure, and pain
5. Synthesize certain vitamins and biochemicals such as vitamin D

Fig. 1.8 Nervous system.

Fig. 1.9 Muscular system.

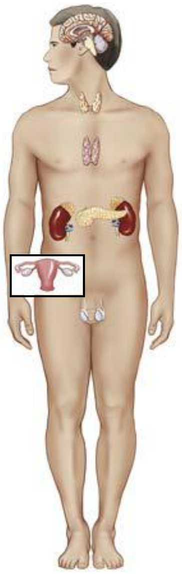


Fig. 1.10 Endocrine system.

Fig. 1.11 Integumentary system.

Skeletal Anatomy

Because a large part of general diagnostic radiography involves examination of the bones and joints, **osteology** *(os″-te-ol′-o-je)* (the study of bones) and **arthrology** *(ar-throl′-o-je)* (the study of joints) are important subjects for the technologist.

OSTEOLOGY

The adult skeletal system is composed of **206 separate bones,** which form the framework of the entire body. Certain cartilages, such as those at the ends of long bones, are included in the skeletal system. These bones and cartilages are united by ligaments and provide surfaces to which the muscles attach. Because muscles and bones must combine to allow body movement, these two systems sometimes are collectively referred to as the *locomotor system.*

The adult human skeleton is divided into the **axial skeleton** and the **appendicular skeleton.**

Axial Skeleton

The **axial** *(ak′-se-al)* skeleton includes all bones that lie on or near the central axis of the body (Table 1.1). The adult axial skeleton consists of **80 bones** and includes the skull, vertebral column, ribs, and sternum (the dark-shaded regions of the body skeleton in Fig. 1.12).

TABLE 1.1 **ADULT AXIAL SKELETON**

Skull	Cranium	8
	Facial bones	14
Hyoid		1
Auditory ossicles (3 small bones in each ear)		6
Vertebral column	Cervical	7
	Thoracic	12
	Lumbar	5
	Sacral	1
	Coccyx	1
Thorax	Sternum	1
	Ribs	24
Total bones in adult axial skeleton		*80*

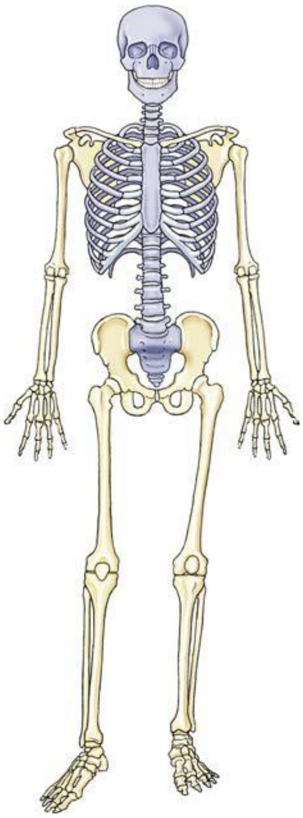


Fig. 1.12 Axial skeleton—80 bones.

Appendicular Skeleton

The second division of the skeleton is the **appendicular** *(ap″-en-dik′-u-lar)* portion. This division consists of all bones of the upper and lower limbs (extremities) and the shoulder and pelvic girdles (the dark-shaded regions in Fig. 1.13). The appendicular skeleton attaches to the axial skeleton. The adult appendicular skeleton comprises **126 separate bones** (Table 1.2).

TABLE 1.2 **ADULT APPENDICULAR SKELETON**

Shoulder girdles	Clavicles	2
	Scapula (scapulae)	2
Upper limbs	Humerus (humeri)	2
	Ulna (ulnae)	2
	Radius (radii)	2
	Carpals	16
	Metacarpals	10
	Phalanges	28
Pelvic girdle	Hip bones **(innominate bones)**	2
Lower limbs	Femur (femora)	2
	Tibia	2
	Fibula (fibulae)	2
	Patella (patellae)	2
	Tarsals	14
	Metatarsals	10
	Phalanges	28
Total bones in adult appendicular skeleton		*126*
Entire number of separate bones in adult skeleton[a]		*206*

[a] This includes the two sesamoid bones anterior to the knees: the right and left patellae.

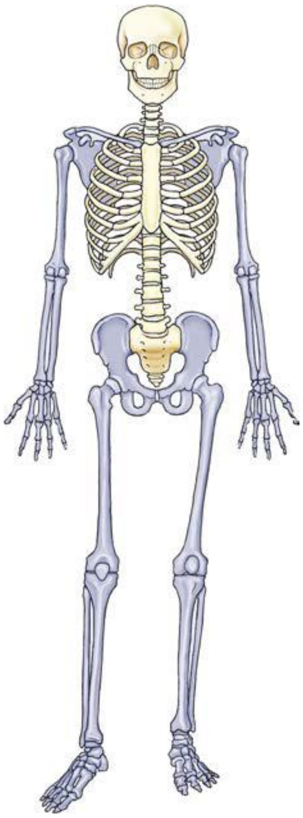


Fig. 1.13 Appendicular skeleton—126 bones.

Sesamoid Bones

A sesamoid bone is a special type of small, oval-shaped bone that is embedded in certain tendons (most often near joints). Although sesamoid bones are present even in a developing fetus, they are not counted as part of the normal axial or appendicular skeleton except for the two patellae, the largest sesamoid bones. The other most common sesamoid bones are located in the posterior foot at the base of the first toe (Figs. 1.14 and 1.15).

In the upper limb, sesamoid bones are found most commonly in tendons near the anterior (palmar) surface of the hand at the base of the thumb. Others may be found in tendons of other upper or lower limb joints.

Sesamoid bone may be fractured by trauma; sesamoid bones can be demonstrated radiographically or by computed tomography (CT).

Fig. 1.14 Sesamoid bones on the posterior base of the first toe.

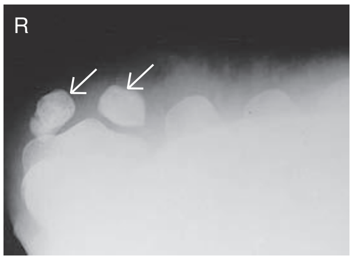


Fig. 1.15 Sesamoid bones. Tangential projection (base of first toe).

CLASSIFICATION OF BONES

Each of the 206 bones of the body can be classified according to shape as follows:

- Long bones
- Short bones
- Flat bones
- Irregular bones

Long Bones

Long bones consist of a **body** and **two ends** or **extremities.** Long bones are found only in the appendicular skeleton. (Fig. 1.16 is a radiograph of a humerus, a typical long bone of the upper arm.)

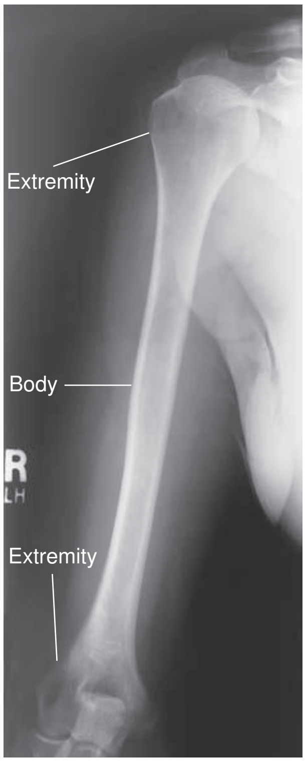


Fig. 1.16 Long bone (humerus).

Composition The outer shell of most bones is composed of hard or dense bone tissue known as **compact bone,** or **cortex,** meaning an external layer. Compact bone has few intercellular empty spaces and serves to protect and support the entire bone.

The **body** (older term is **shaft**) contains a thicker layer of compact bone than is found at the ends, to help resist the stress of the weight placed on them.

Inside the shell of compact bone and especially at both ends of each long bone is found **spongy,** or **cancellous, bone.** Cancellous bone is highly porous and usually contains red bone marrow, which is responsible for the production of red blood cells.

The body of a long bone is hollow. This hollow portion is known as the **medullary** *(med′-u-lar″-e)* **cavity.** In adults, the medullary cavity usually contains fatty yellow marrow. A dense fibrous membrane, the **periosteum** *(per″-e-os′-te-am),* covers bone except at the articulating surfaces. The articulating surfaces are covered by a layer of **hyaline cartilage** (Fig. 1.17).

Hyaline *(hi′-ah-lin),* meaning glassy or clear, is a common type of cartilage or connecting tissue. Its name comes from the fact that it is not visible with ordinary staining techniques, and it appears "clear" or glassy in laboratory studies. It is present in many places, including within the covering over ends of bones, where it is called **articular cartilage.**

The **periosteum** is essential for bone growth, repair, and nutrition. Bones are richly supplied with blood vessels that pass into them from the periosteum. Near the center of the body of long bones, a **nutrient artery** passes obliquely through the compact bone via a **nutrient foramen** into the medullary cavity.

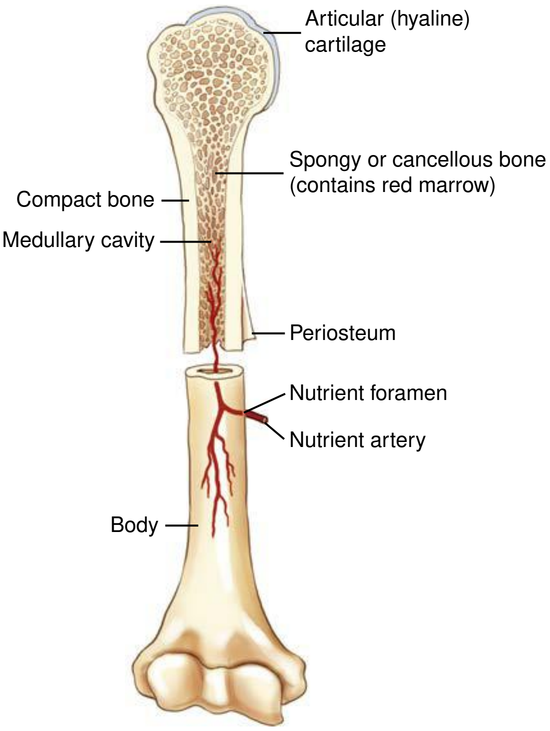


Fig. 1.17 Long bone.

Short Bones

Short bones are roughly cuboidal and are found only in the wrists and ankles. Short bones consist mainly of cancellous tissue with a thin outer covering of compact bone. The eight **carpal bones** of each wrist (Fig. 1.18) and the seven **tarsal bones** of each foot are short bones.

Fig. 1.18 Short bones (carpals).

Fig. 1.19 Flat bones (calvaria).

Flat Bones

Flat bones consist of two plates of compact bone with cancellous bone and bone marrow between them. Examples of flat bones are the bones that make up the **calvaria** (skull cap) (Fig. 1.19), **sternum, ribs,** and **scapulae.**

The narrow space between the two layers of compact bone of flat bones within the cranium is known as the diploe *(dip′-lo-e).* Flat bones provide protection for interior contents and broad surfaces for muscle attachment.

Irregular Bones

Bones that have peculiar shapes are lumped into one final category—irregular bones. **Vertebrae** (Fig. 1.20), **facial bones, bones of the base of the cranium,** and **bones of the pelvis** are examples of irregular bones.

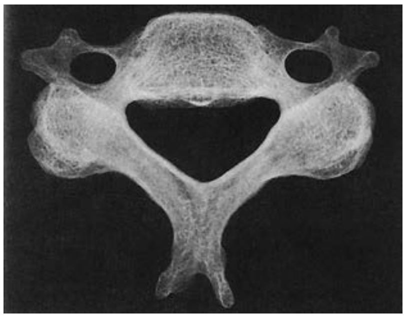


Fig. 1.20 Irregular bone (vertebra).

DEVELOPMENT OF BONES

The process by which bones form within the body is known as **ossification** *(os″-i-fi-ka′-shun).* The embryonic skeleton is composed of fibrous membranes and hyaline cartilage. Ossification begins at about the sixth embryonic week and continues until adulthood.

Blood Cell Production

In adults, **red blood cells (RBCs)** are produced by the red bone marrow of certain flat and irregular bones such as the **sternum, ribs, vertebrae,** and **pelvis,** as well as the ends of the long bones.

Bone Formation

Two types of bone formation are known. When bone replaces membranes, the ossification is called **intramembranous** *(in″-trah-mem′-brah-nus).* When bone replaces cartilage, the result is **endochondral** *(en″-do-kon′-dral)* (intracartilaginous) ossification.

Intramembranous Ossification Intramembranous ossification occurs rapidly and takes place in bones that are needed for protection, such as sutures of the flat bones of the calvaria (skullcap), which are centers of growth in early bone development.

Endochondral Ossification Endochondral ossification, which is much slower than intramembranous ossification, occurs in most parts of the skeleton, especially in the long bones.

Primary and Secondary Centers of Endochondral Ossification (Fig. 1.21)

The first center of ossification, which is called the **primary center,** occurs in the midbody area. This primary center of ossification in growing bones is called the **diaphysis** *(di-af′-i-sis).* This becomes the **body** in a fully developed bone.

Secondary centers of ossification appear near the ends of the limbs of long bones. Most secondary centers appear after birth, whereas most primary centers appear before birth. Each secondary center of ossification is called an **epiphysis** *(e-pif′-i-sis).* Epiphyses of the distal femur and the proximal tibia are the first to appear and may be present at birth in a term newborn. Cartilaginous plates, called **epiphyseal plates,** are found between the metaphysis and each epiphysis until skeletal growth is complete. The **metaphysis** is the wider portion of a long bone adjacent to the epiphyseal plate. The metaphysis is the area where bone growth in length occurs. Growth in the length of bones results from a longitudinal increase in these epiphyseal cartilaginous plates. This is followed by progressive ossification through endochondral bone development until all the cartilage has been replaced by bone, at which time growth of the skeleton is complete. This process of epiphyseal fusion of the long bones occurs progressively from the age of puberty to **full maturity,** which is **between the ages of 20 and 25 years.**[1] However, the time for each bone to complete growth varies for different regions of the body. On average, the female skeleton matures more quickly than the male skeleton. Also, geography, socioeconomic, genetic factors, and disease affect epiphyseal fusion.[1]

Fig. 1.22 shows a radiograph of the knee region of a 6-year-old child. Primary and secondary centers of endochondral ossification or bone growth are well demonstrated and labeled.

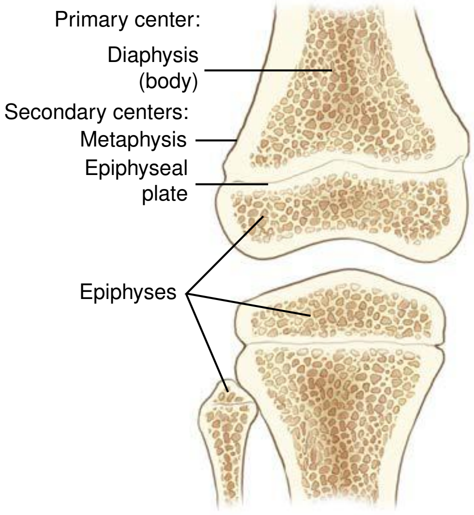


Fig. 1.21 Endochondral ossification.

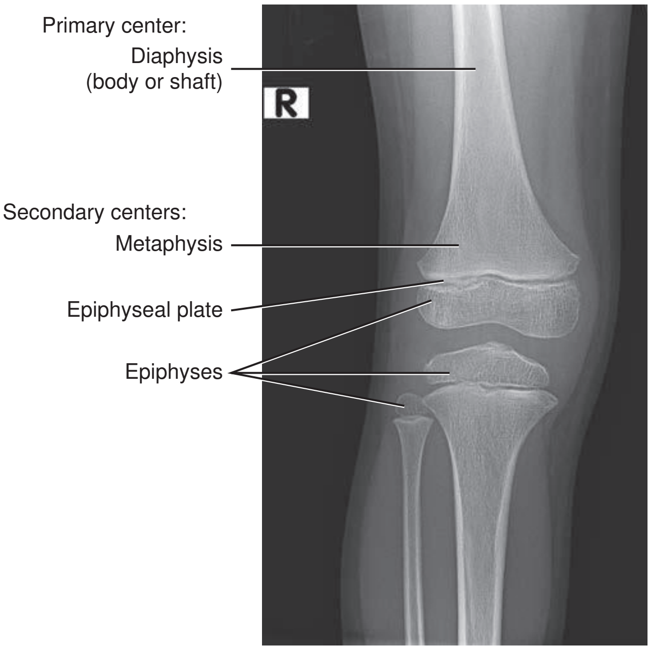


Fig. 1.22 Knee region (6-year-old child).

Arthrology (Joints)

The study of joints or articulations is called **arthrology.** It is important to understand that movement does not occur in all joints. The first two types of joints to be described are immovable joints and only slightly movable joints, which are held together by several fibrous layers, or cartilage. These joints are adapted for growth rather than for movement.

CLASSIFICATION OF JOINTS

Functional

Joints may be classified according to their function in relation to their mobility or lack of mobility as follows:

- **Synarthrosis** *(sin″-ar-thro′-sis)*—immovable joint
- **Amphiarthrosis** *(am″-fe-ar-thro′-sis)*—joint with limited movement
- **Diarthrosis** *(di″-ar-thro′-sis)*—freely movable joint

Structural

The primary classification system of joints, described in *Gray's Anatomy*[2] and used in this textbook, is a **structural classification** based on the **three types of tissue that separate the ends of bones** in the different joints. These three classifications by tissue type, along with their subclasses, are as follows:

1. Fibrous *(fi′-brus)* joints
   - Syndesmosis *(sin″-des-mo′-sis)*
   - Suture *(su′-tur)*
   - Gomphosis *(gom-fo′-sis)*
2. Cartilaginous *(kar″-ti-laj′-i-nus)* joints
   - Symphysis *(sim′-fi-sis)*
   - Synchondrosis *(sin″-kon-dro′-sis)*
3. Synovial *(si-no′-ve-al)* joints

Fibrous Joints

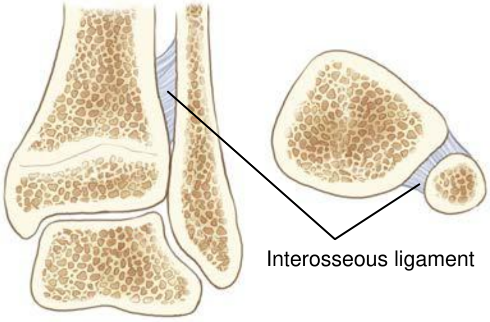
Fibrous joints lack a joint cavity. The adjoining bones, which are nearly in direct contact with each other, are held together by fibrous connective tissue. Three types of fibrous joints are syndesmoses, which are slightly movable; sutures, which are immovable; and gomphoses, a unique type of joint with only very limited movement (Fig. 1.23).

***Syndesmoses*[1]** Syndesmoses are fibrous types of articulations that are held together by interosseous ligaments and slender fibrous cords that allow slight movement at these joints. Some earlier references restricted the fibrous syndesmosis classification to the inferior tibiofibular joint. However, fibrous-type connections also may occur in other joints, such as the sacroiliac junction with its massive interosseous ligaments that in later life become almost totally fibrous articulations. The carpal and tarsal joints of the wrist and foot also include interosseous membranes that can be classified as syndesmosis-type joints that are only slightly movable, or amphiarthrodial.

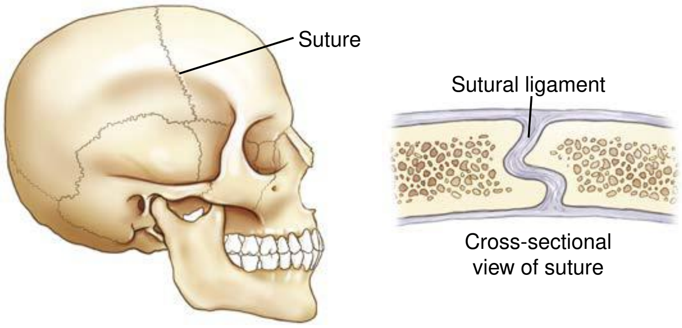
Sutures Sutures are found only between bones in the skull. These bones make contact with one another along interlocking or serrated edges and are held together by layers of fibrous tissue, or sutural ligaments. Movement is very limited at these articulations; in adults, these are considered **immovable,** or **synarthrodial, joints.**

Limited expansion- or compression-type movement at these sutures can occur in the infant skull (e.g., during the birth process). However, by adulthood, active bone deposition partially or completely obliterates these suture lines.

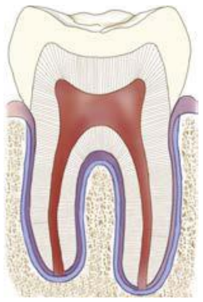
Gomphoses A **gomphosis** joint is the third unique type of fibrous joint, in which a conical process is inserted into a socket-like portion of bone. This joint or fibrous union—which, strictly speaking, does not occur between bones but between the roots of the teeth and the alveolar sockets of the mandible and the maxillae—is a specialized type of articulation that allows only very limited movement.



Distal tibiofibular joint
1. Syndesmosis–Amphiarthrodial (slightly movable)



Skull suture
2. Suture–Synarthrodial (immovable)



Roots of teeth
3. Gomphosis–Amphiarthrodial (only limited movement)

Fig. 1.23 Fibrous joints—three types.

Cartilaginous Joints

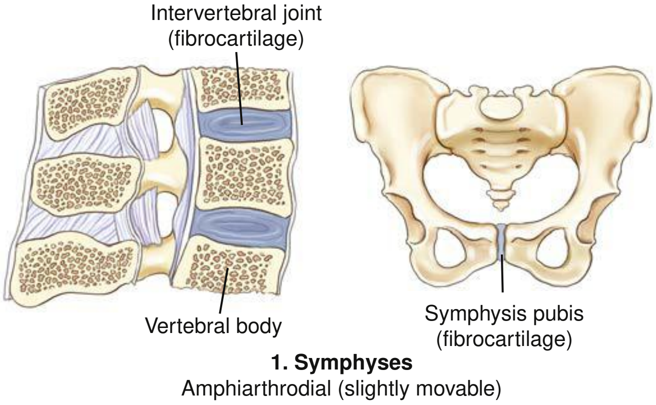
Cartilaginous joints also lack a joint cavity, and the articulating bones are held together tightly by cartilage. Similar to fibrous joints, cartilaginous joints allow little or no movement. These joints are synarthrodial or amphiarthrodial and are held together by two types of cartilage: symphyses and synchondroses (Fig. 1.24).

Symphyses The essential feature of a symphysis is the **presence of a broad**, **flattened disk of fibrocartilage** between two contiguous bony surfaces. These fibrocartilage disks form relatively thick pads that are capable of being compressed or displaced, allowing some movement of these bones, which makes these joints **amphiarthrodial** (slightly movable).

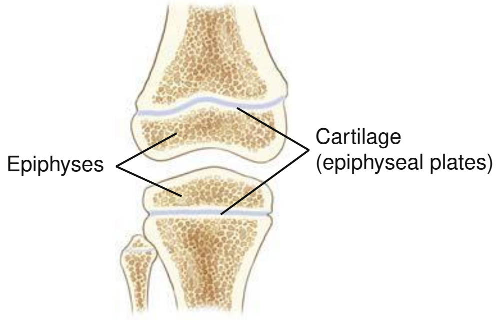
Examples of such symphyses are the intervertebral disks (between bodies of the vertebrae), between the manubrium (upper portion) and body of the sternum, and the symphysis pubis (between the two pubic bones of the pelvis).

Synchondroses A typical synchondrosis is a **temporary form of joint** wherein the connecting **hyaline cartilage** (which on long bones is called an *epiphyseal plate*) is converted into bone at adulthood. These temporary types of growth joints are considered **synarthrodial** or immovable.

Examples of such joints are the epiphyseal plates between the epiphyses and the metaphysis of long bones and at the three-part union of the pelvis, which forms a cup-shaped acetabulum for the hip joint.



1. Symphyses
Amphiarthrodial (slightly movable)



2. Synchondroses
Synarthrodial (immovable)

Fig. 1.24 Cartilaginous joints—two types.

Synovial Joints

Synovial joints are freely movable joints, most often found in the upper and lower limbs, which are characterized by a **fibrous capsule that contains synovial fluid** (Fig. 1.25). The ends of the bones that make up a synovial joint may make contact but are completely separate and contain a joint space or cavity, which allows for a wide range of movement at these joints. Synovial joints are generally **diarthrodial,** or freely movable. (Exceptions include the sacroiliac joints of the pelvis, which are amphiarthrodial, or slightly movable.)

The exposed ends of these bones contain thin protective coverings of **articular cartilage.** The **joint cavity,** which contains a viscous lubricating **synovial fluid,** is enclosed and surrounded by a **fibrous capsule** that is reinforced by strengthening **accessory ligaments.** These ligaments limit motion in undesirable directions. The inner surface of this fibrous capsule is thought to secrete the lubricating synovial fluid.

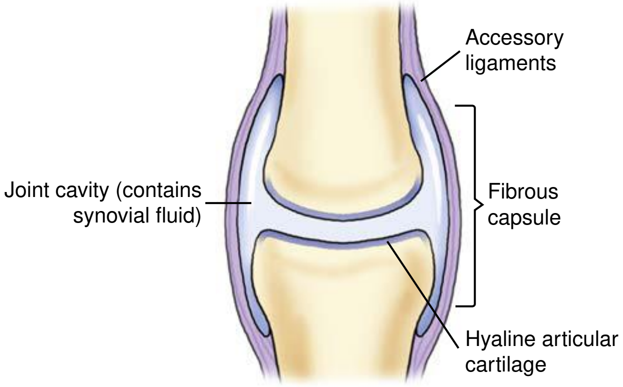


Fig. 1.25 Synovial joints—diarthrodial (freely movable).

Movement Types of Synovial Joints There are a considerable number and variety of synovial joints, and they are grouped according to the **seven types of movement** that they permit. These are listed in order from the least to the greatest permitted movement.

NOTE: The preferred name is listed first, followed by a synonym in parentheses. (This practice is followed throughout this textbook.)

Plane (gliding) joints This type of synovial joint permits the least movement, which, as the name implies, is a **sliding or gliding motion between the articulating surfaces.**

Examples of plane joints are the **intermetacarpal, carpometacarpal,** and **intercarpal** joints of the hand and wrist (Fig. 1.26). The right and left lateral **atlantoaxial joints** between C1 and C2 vertebrae are also classified as plane, or gliding, joints; they permit some rotational movement between these vertebrae, as is described in Chapter 8.

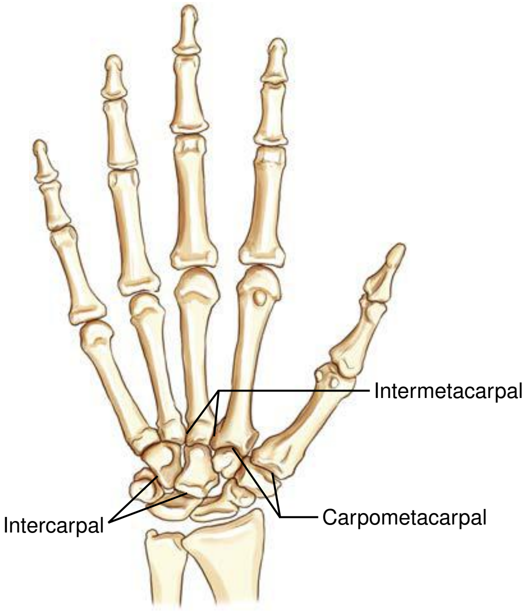


Fig. 1.26 Plane (gliding) joints.

Ginglymus (hinge) joints The articular surfaces of ginglymi, or ginglymus *(jin′-gli-mus)* joints, are molded to each other in such a way that they permit **flexion and extension movements** only. The articular fibrous capsule on this type of joint is thin on surfaces where bending takes place, but strong collateral ligaments firmly secure the bones at the lateral margins of the fibrous capsule.

Examples of ginglymi include the **interphalangeal joints** of fingers and toes and the **elbow joint** (Fig. 1.27).

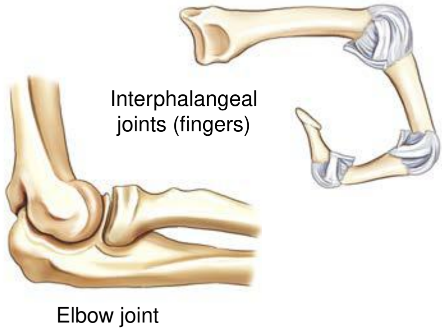


Fig. 1.27 Ginglymus (hinge) joints.

Pivot (trochoid) joints The pivot or trochoid *(tro′-koid)* joint is formed by a bony, pivot-like process that is surrounded by a ring of ligaments or a bony structure or both. This type of joint allows **rotational movement** around a single axis.

Examples of pivot joints are the **proximal** and **distal radioulnar joints** of the forearm, which demonstrate this pivot movement during rotation of the hand and wrist.

Another example is the joint **between the first and second cervical vertebrae.** The odontoid process (dens) of the axis (C2) forms the pivot, and the anterior arch of the atlas (C1), combined with ligaments, forms the ring (Fig. 1.28).

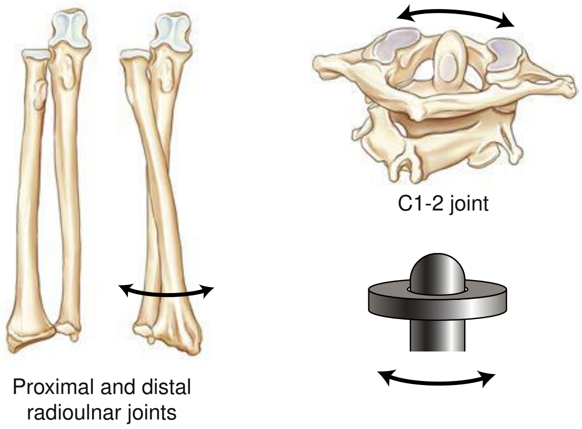


Fig. 1.28 Pivot (trochoid) joints.

Ellipsoid (condylar) joints In the ellipsoid *(e-lip′-soid)* joint, movement occurs primarily in one plane and is combined with a slight degree of rotation at an axis at right angles to the primary plane of movement. The rotational movement is limited by associated ligaments and tendons.

This type of joint allows primarily four directional movements: **flexion and extension** and **abduction and adduction. Circumduction** movement also occurs; this results from conelike sequential movements of flexion, abduction, extension, and adduction.

Examples of ellipsoidal joints include the metacarpophalangeal joints of the fingers, the radiocarpal (wrist joint), and the metatarsophalangeal joints of the toes (Fig. 1.29).

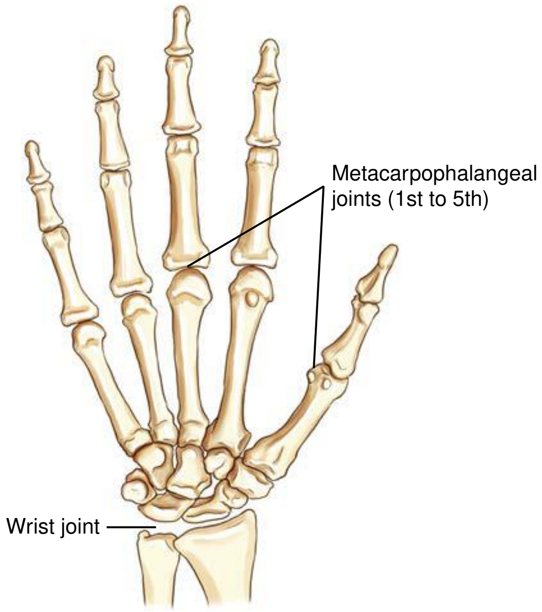


Fig. 1.29 Ellipsoid (condylar) joints.

Saddle (sellar) joints The term saddle, or *sellar (sel′-ar)*, describes this joint structure well in that the ends of the bones are shaped concave-convex and are positioned opposite each other (Fig. 1.30). (Two saddle-like structures fit into each other.)

Movements of this biaxial type of saddle joint are the same as for ellipsoidal joints—**flexion, extension, adduction, abduction,** and **circumduction.**

The best example of a true *saddle* joint is the **first carpometacarpal joint** of the thumb. Other sellar joints include the ankle and the calcaneocuboid joints. Although the ankle joint was classified as a ginglymus in earlier references, current references classify it as a saddle joint.[3]

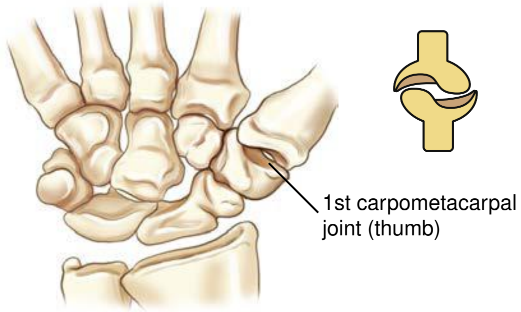


Fig. 1.30 Saddle (sellar) joints.

Ball-and-socket (spheroidal) joints The ball-and-socket or spheroidal *(sfe′-roid-el)* joint allows for the greatest freedom of motion. The distal bone (humerus) that makes up the joint is capable of motion around an almost indefinite number of axes, with one common center.

The greater the depth of the socket, the more limited is the movement. However, the deeper joint is stronger and more stable. For example, the hip joint is a much stronger and more stable joint than the shoulder joint, but the range of movement is more limited in the hip.

Movements of ball-and-socket joints include flexion, extension, abduction, adduction, circumduction, and medial and lateral rotation.

Two examples of ball-and-socket joints are the **hip joint** and the **shoulder joint** (Fig. 1.31).

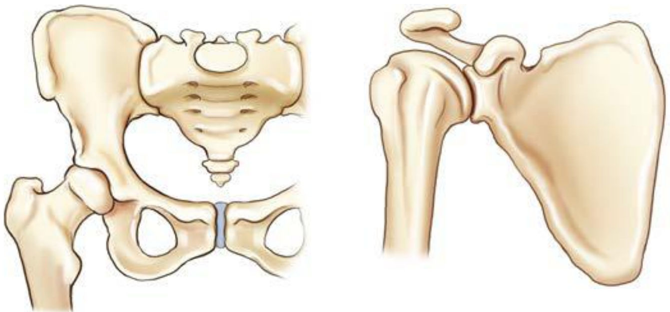


Fig. 1.31 Ball-and-socket (spheroidal) joints.

Bicondylar joints[3] Bicondylar joints usually provide movement in a single axis, such as flexion and extension. They can permit limited rotation. Bicondylar joints are formed by two convex condyles, which may be encased by a fibrous capsule.

Two examples of bicondylar joints are the knee (formerly classified as ginglymus) and the temporomandibular joint (TMJ) (Fig. 1.32).

See Table 1.3 for a summary of joint classification.

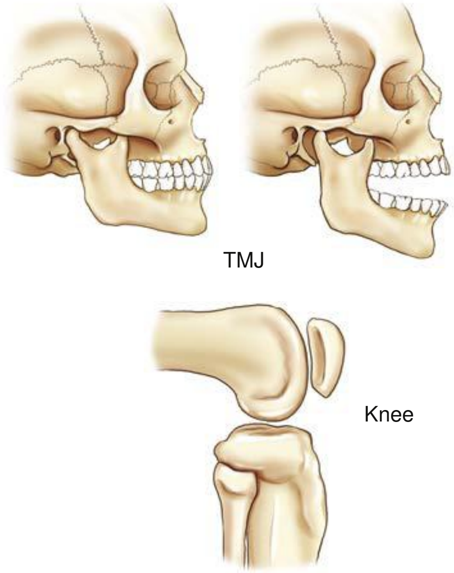


Fig. 1.32 Bicondylar joints.

TABLE 1.3 SUMMARY OF JOINT CLASSIFICATION

JOINT CLASSIFICATION	MOBILITY CLASSIFICATION	MOVEMENT TYPES	MOVEMENT DESCRIPTION	EXAMPLES
Fibrous Joints				
Syndesmoses	Amphiarthrodial (slightly movable)	—	—	Distal tibiofibular, sacroiliac, carpal, and tarsal joints
Sutures	Synarthrodial (immovable)	—	—	Skull sutures
Gomphoses	Very limited movement	—	—	Areas around roots of teeth
Cartilaginous Joints				
Symphyses	Amphiarthrodial (slightly movable)	—	—	Intervertebral disks Symphysis pubis
Synchondroses	Synarthrodial (immovable)	—	—	Epiphyseal plates of long bones and between the three parts of the pelvis
Synovial joints	Diarthrodial (freely movable) except for the sacroiliac joints (synovial joints with only very limited motion [amphiarthrodial])	Plane (gliding)	Sliding or gliding	Intermetacarpal, intercarpal, and carpometacarpal joints, C1 on C2 vertebrae
		Ginglymi (hinge)	Flexion and extension	Interphalangeal joints of fingers, toes, and elbow joints
		Pivot (trochoid)	Rotational	Proximal and distal radioulnar and between C1 and C2 vertebrae (atlantoaxial joint)
		Ellipsoid (condylar)	Flexion and extension Abduction and adduction Circumduction	Metacarpophalangeal and wrist joints
		Saddle (sellar)	Flexion and extension Abduction and adduction Circumduction	First carpometacarpal joint (thumb), ankle, and calcaneocuboid joints
		Ball and socket (spheroidal)	Flexion and extension Abduction and adduction Circumduction Medial and lateral rotation	Hip and shoulder joints
		Bicondylar	Movement primarily along one axis with some limited rotation	Knee and temporomandibular joints

NOTE: Arthrology is the study of joints. The nomenclature for joints described in this chapter will be used in subsequent chapters throughout the text.

Body Habitus

Body habitus is generally defined as the build, physique, and general shape of the human body. The size, dimensions, and shape of the patient's body affect the positioning of specific regions of the body such as the respiratory, gastrointestinal, and biliary systems.

Body habitus is classified into four general body styles:

1. **Sthenic:** Approximately **50%** of the population falls into this category. For the purpose of radiographic positioning, sthenic body styles are considered average in shape and internal organ location (Fig. 1.33).
2. **Hyposthenic:** A body style which is more slender than the sthenic body habitus. Approximately **35%** of the population is classified as hyposthenic (Fig. 1.34).
3. **Hypersthenic:** A body style which has a broad frame as compared to the sthenic body habitus. Approximately **5%** of the population is classified as hypersthenic (Fig. 1.35).
4. **Asthenic:** Approximately **10%** of the population is very thin or slender with a long and narrow body build. More slight in stature than the hyposthenic patient.

IMPACT OF BODY HABITUS ON RADIOGRAPHIC POSITIONING

The technologist must consider the patient's body habitus and alter centering and image receptor (IR) placement accordingly. This is especially true during adult chest radiography (described in Chapter 2). For the hyposthenic and asthenic patient, the image receptor is typically placed in **portrait** (lengthwise) alignment because the lungs are generally longer than those of the hypersthenic patient (Fig. 1.36). For the hypersthenic patient, the image receptor is typically placed in **landscape** (crosswise) alignment because the lungs are generally shorter in length and more broad in width than those of the hyposthenic or asthenic patient (Fig. 1.37). IR placement for the sthenic adult patient may be portrait or landscape, depending on the person's age, height, and even pathology. Other anatomic regions also are affected by body habitus. This will be discussed further in Chapter 12, Biliary Tract and Upper Gastrointestinal System.

Fig. 1.33 Sthenic body habitus.

Fig. 1.34 Hyposthenic body habitus.

Fig. 1.35 Hypersthenic body habitus.

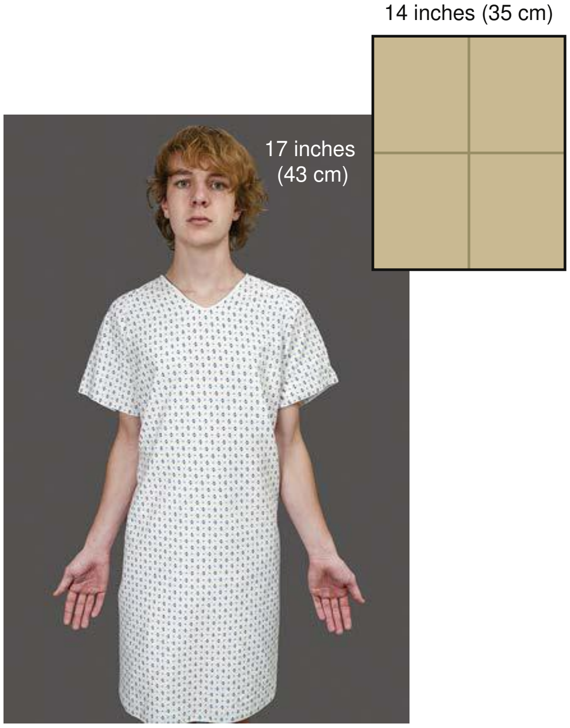


Fig. 1.36 Portrait alignment of image receptor.

Fig. 1.37 Landscape alignment of image receptor Ditto.

POSITIONING TERMINOLOGY

Radiographic positioning refers to the study of patient positioning performed for **radiographic demonstration or visualization of specific body parts on image receptors.** The radiologic technologist must clearly understand the correct use of positioning terminology. This section lists, describes, and illustrates the commonly used terms consistent with the positioning and projection terminology as approved and published by the American Registry of Radiologic Technologists (ARRT).[4]

Throughout this text, named positions (i.e., with the proper name of the person who first described a specific position or procedure) are referred to as **methods,** such as the Towne, Waters, and Caldwell methods. The ARRT concurs regarding the use of the named method in parentheses after the projection or position term. The description of radiographic positions by the proper name method is becoming less common.

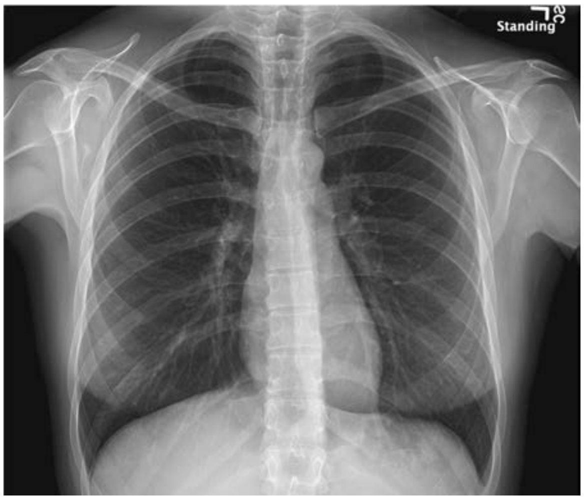


Fig. 1.38 Chest radiograph.

General Terms

Radiograph *(ra′-de-o-graf):* (1) An image of a patient's anatomic part(s), as produced by the action of x-rays on an image receptor (Fig. 1.38). If the radiograph is produced with the use of traditional film-screen (analog) technology, the image is captured and displayed on film; if the radiograph is produced via digital technology, the image is viewed and stored on display monitors. (2) The term *radiograph* refers to the recording medium *and* the image.

Radiography *(ra″-de-og′-rah-fe):* The process and procedures of producing a radiograph.

Image receptor (IR): The device that responds to the ionizing radiation to create the radiographic image after it exits the patient; refers to both analog (film-based) cassettes and digital acquisition devices.

Central ray (CR): Refers to the centermost portion of the x-ray beam emitted from the x-ray tube—the portion of the x-ray beam that has the least divergence.

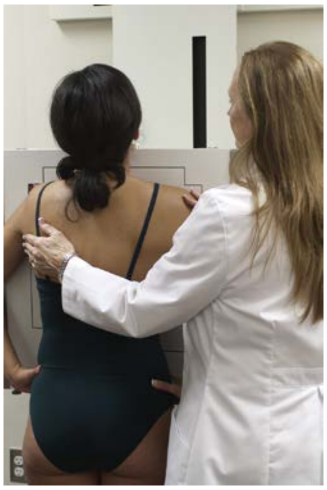


Fig. 1.39 Radiographic examination.

Radiographic Examination or Procedure A radiologic technologist is shown positioning a patient for a routine chest examination or procedure (Fig. 1.39). A radiographic examination involves five general functions:

1. Positioning of body part and alignment with the IR and CR
2. Application of radiation protection measures and devices
3. Selection of exposure factors (radiographic technique)
4. Instructions to the patient related to respiration (breathing) and initiation of the x-ray exposure
5. Processing of the IR (analog) [chemical processing] or digital processing systems

Fig. 1.40 Anatomic position.

Anatomic Position The *anatomic (an″-ah-tom′-ik) position* is a reference position that defines specific surfaces and planes of the body. It also defines anatomic directional terms such as anterior, posterior, medial, lateral, superior, and inferior regions of the body. The anatomic position is an upright position with arms abducted slightly (down), hands by sides with palms forward, and head and feet together and directed straight ahead (Fig. 1.40).

Viewing Radiographs A general rule in viewing radiographs is to display them so that the **patient is facing the viewer,** with the patient in the **anatomic position.**

Body Planes, Sections, and Lines (Fig. 1.41)

Positioning terms that describe CR angles or relationships between body parts often are related to **imaginary planes** that pass through the body in the **anatomic position.** The study of CT, MRI (magnetic resonance imaging), and sonography (diagnostic medical ultrasound) emphasizes sectional anatomy, which also involves the primary body planes and sections as described subsequently.

PLANE: STRAIGHT LINE SURFACE CONNECTING TWO POINTS

Four common planes used in medical imaging are the sagittal plane, coronal plane, horizontal (axial) plane, and oblique plane.

Sagittal Plane

A sagittal *(saj′-i-tal)* plane is any **longitudinal** plane that divides the body into **right and left parts.**

The **midsagittal plane,** sometimes called the **median plane,** is a midline sagittal plane that divides the body into **equal right and left parts.** It passes approximately through the sagittal suture of the skull. Any plane parallel to the midsagittal or median plane is called a **sagittal plane.**

Coronal Plane

A coronal *(ko-ro′-nal)* plane is any **longitudinal** plane that divides the body into **anterior and posterior parts.**

The **midcoronal plane** divides the body into approximately **equal anterior and posterior parts.** It is called a coronal plane because it passes approximately through the coronal suture of the skull. Any plane parallel to the midcoronal or frontal plane is called a **coronal plane.**

Horizontal (Axial) Plane

A horizontal (axial) plane is any **transverse** plane that passes through the body at **right angles to a longitudinal plane,** dividing the body into superior and inferior portions.

Oblique Plane

An oblique plane is a **longitudinal** or **transverse** plane that is at an angle or slant and is **not parallel** to the sagittal, coronal, or horizontal plane.

SECTIONAL IMAGE OF BODY PART

Longitudinal Sections—Sagittal, Coronal, and Oblique

These sections or images run **lengthwise** in the direction of the long axis of the body or any of its parts, regardless of the position of the body (erect or recumbent). Longitudinal sections or images may be taken in the **sagittal, coronal,** or **oblique plane.**

Transverse or Axial Sections (Cross-Sections)

Sectional images are at right angles along any point of the longitudinal axis of the body or its parts (Fig. 1.42)

Sagittal, Coronal, and Axial Images

CT, magnetic resonance imaging (MRI), and sonography images are obtained in these three common orientations or views. These common orientations are sagittal, coronal, and transverse (axial). (MRI sectional images are shown in Figs. 1.43 through 1.45.)

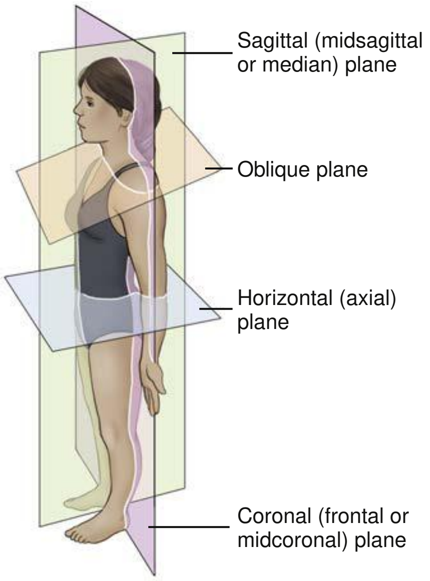
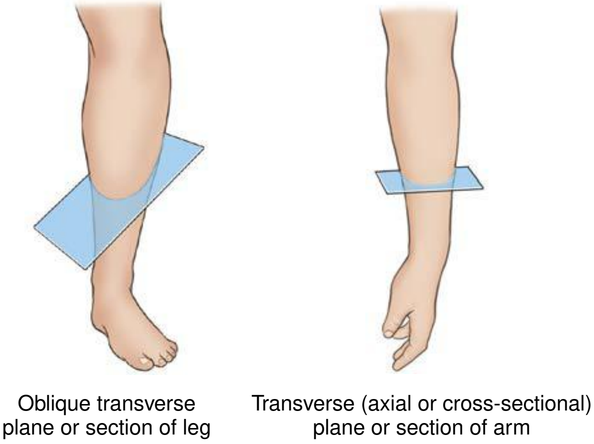


Fig. 1.41 Sagittal, coronal, oblique, and horizontal body planes.


Oblique transverse plane or section of leg

Transverse (axial or cross-sectional) plane or section of arm

Fig. 1.42 Transverse and oblique sections of body parts.

Fig. 1.43 Sagittal image.

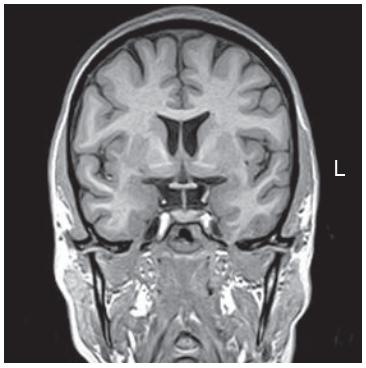


Fig. 1.44 Coronal image.

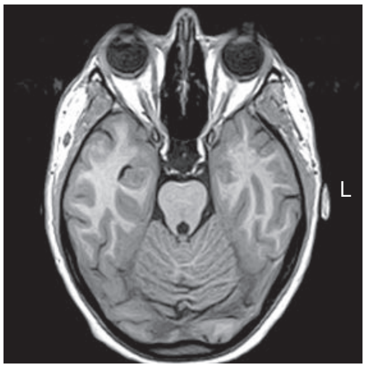


Fig. 1.45 Transverse (axial) image.

PLANES OF THE SKULL (FIG. 1.46)

Base Plane of Skull

This precise transverse plane is formed by connecting the lines from the infraorbital margins (inferior edge of bony orbits) to the superior margin of the external auditory meatus (EAM), the external opening of the ear. This sometimes is called the **Frankfort horizontal plane,**[1] as used in orthodontics and cranial topography to measure and locate specific cranial points or structures.

Occlusal Plane

This horizontal plane is formed by the biting surfaces of the upper and lower teeth with jaws closed (used as a reference plane of the head for cervical spine and skull radiography).

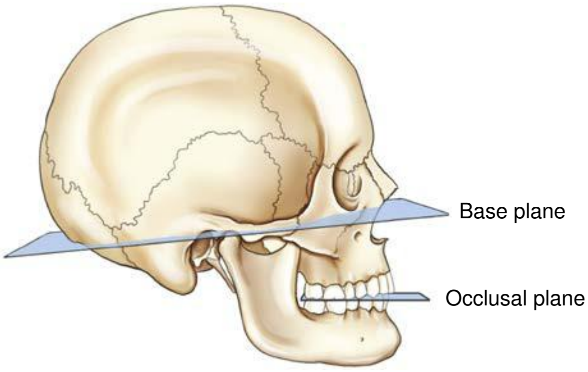


Fig. 1.46 Planes of skull.

Body Surfaces and Parts

TERMS FOR THE BACK AND FRONT PORTIONS OF THE BODY

Posterior or Dorsal (FIG. 1.47)

Posterior *(pos-te′-re-or)* or dorsal *(dor′-sal)* refers to the **back half** of the patient, or the part of the body seen when the person is viewed from the back; includes the bottoms of the feet and the backs of the hands as demonstrated in the anatomic position.

Anterior or Ventral

Anterior *(an-te′-re-or)* or ventral *(ven′-tral)* refers to the **front half** of the patient, or the part seen when viewed from the front; includes the tops of the feet and the fronts or palms of the hands in the anatomic position.

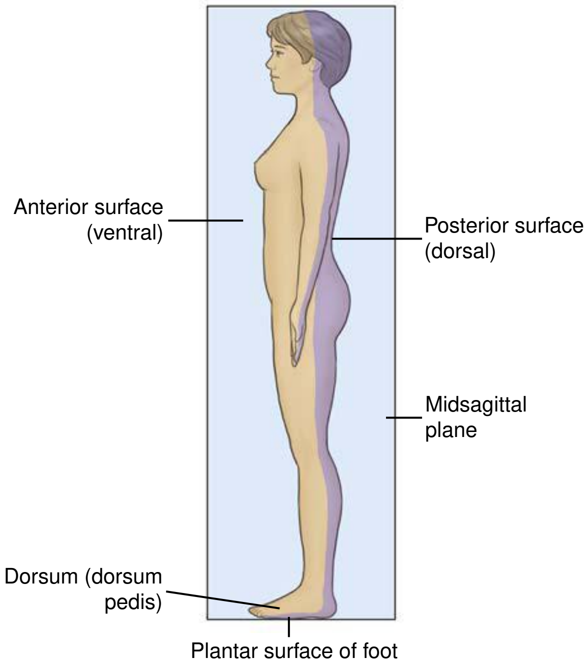


Fig. 1.47 Posterior vs. anterior.

TERMS FOR SURFACES OF THE HANDS AND FEET

Three terms are used in radiography to describe specific surfaces of the upper and lower limbs.

Plantar

Plantar *(plan′-tar)* refers to the **sole** or **posterior** surface of the foot.

Dorsal

Foot Dorsal *(dor′-sal)* refers to the **top** or **anterior** surface of the foot (dorsum pedis).

Hand Dorsal also refers to the **back** or **posterior** aspect of the hand (dorsum manus) (Fig. 1.48).

NOTE: The term **dorsum** (or **dorsal**) in general refers to the vertebral or posterior part of the body. However, when used in relationship with the foot, *dorsum* (dorsum pedis) specifically refers to the **upper surface,** or **anterior aspect,** of the foot opposite the sole, whereas for the hand (dorsum manus), it refers to the back or posterior surface opposite the palm.[1]

Palmar

Palmar *(pal′-mar)* refers to the **palm of the hand;** in the anatomic position, the same as the **anterior or ventral** surface of the hand.[1]

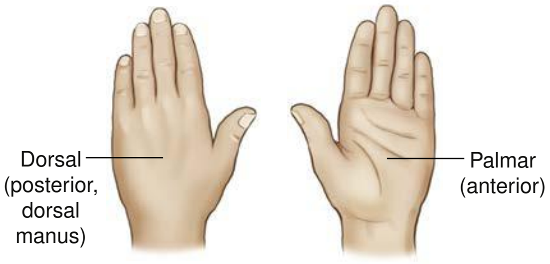


Fig. 1.48 Dorsal and palmar surfaces of hand.

Radiographic Projections

Projection is a positioning term that describes the **direction or path of the CR of the x-ray beam** as it passes through the patient, projecting an image onto the IR. Although the term ***position*** is used in the clinical setting, the term ***projection*** is considered to be the most accurate term for describing how the procedure is performed. Therefore, the term **projection** is used most frequently throughout this text.

Fig. 1.49 PA projection.

COMMON PROJECTION TERMS

Posteroanterior (PA) Projection

Posteroanterior *(pos″-ter-o-an-te′-re-or)* (PA) projection refers to a projection of the CR from **posterior to anterior.**

The term *posteroanterior* combines the two terms *posterior* and *anterior* into one word, abbreviated as PA. The CR enters at the posterior surface and exits at the anterior surface **(PA projection)** (Fig. 1.49).

This projection assumes a **true PA** without intentional rotation, which requires the CR to be perpendicular to the coronal body plane and parallel to the sagittal plane, unless some qualifying oblique or rotational term is used to indicate otherwise.

Fig. 1.50 AP projection.

Anteroposterior (AP) Projection

Anteroposterior *(an″-ter-o-pos-te′-re-or)* (AP) projection refers to a projection of the CR from **anterior to posterior,** the opposite of PA. *Anteroposterior* combines the two terms *anterior* and *posterior* into one word.

Anteroposterior describes the direction of travel of the CR, which enters at an anterior surface and exits at a posterior surface **(AP projection)** (Fig. 1.50).

The term assumes a **true AP** without rotation unless a qualifier term also is used, indicating it to be an oblique projection.

AP Oblique Projection

An AP projection of the upper or lower limb that is rotated is called *oblique.* This is not a true AP projection and **must also include a qualifying term** that indicates which way it is rotated, such as medial or lateral rotation (Fig. 1.51). (For an oblique projection of the whole body, see **oblique position** descriptions later in this chapter.) With an AP oblique projection, the CR enters the anterior surface and exits the posterior surface of the body or body part.

Fig. 1.51 AP oblique projection—medial rotation (from AP).

Fig. 1.52 PA oblique projection—lateral rotation (from PA).

PA Oblique Projection

A PA projection of the upper limb with lateral rotation (from PA) is shown in Fig. 1.52. (This is applicable to both upper and lower limbs.) This projection is described as a PA oblique. It **must also include a qualifying term** that indicates which way it is rotated. With a PA oblique projection, the CR enters the posterior surface and exits the anterior surface of the body or body part.

Mediolateral and Lateromedial Projections

A **lateral** projection is described by the **path of the CR.** Two examples are the **mediolateral** projection of the ankle (Fig. 1.53) and the **lateromedial** projection of the wrist (Fig. 1.54). The medial and lateral sides are determined with the patient in the anatomic position. In the case of the mediolateral ankle projection, the CR enters the medial aspect and exits the lateral aspect of the ankle.

Fig. 1.53 Mediolateral projection (ankle).

Fig. 1.54 Lateromedial projection (wrist).

Body Positions

In radiography, the term *position* is used in two ways, first as **general body positions,** as described next, and second as **specific body positions,** which are described in the pages that follow.

GENERAL BODY POSITIONS

The eight most commonly used general body positions in medical imaging are as follows:

1. **Supine** *(soo′-pine):* **Lying on back,** facing upward (Fig. 1.55)
2. **Prone** *(prohn):* **Lying on abdomen,** facing downward (head may be turned to one side) (Fig. 1.56)
3. **Erect** *(e-reckt′)* (upright): An **upright position,** to stand or sit erect
4. **Recumbent** *(re-kum′-bent)* (reclining): **Lying down in any position** (prone, supine, or on side)
    - **Dorsal recumbent:** Lying on back (supine)
    - **Ventral recumbent:** Lying face down (prone)
    - **Lateral recumbent:** Lying on side (right or left lateral)
5. **Trendelenburg**[5] *(tren-del′-en-berg)* position: A recumbent position with the body tilted with the **head lower than the feet** (Fig. 1.57)
6. **Fowler**[6] *(fow′-ler)* position: A recumbent position with the body tilted with the **head higher than the feet** (Fig. 1.58)
7. **Sims position** (semiprone position): A recumbent oblique position with the patient lying on the **left anterior side,** with the right knee and thigh flexed and the left arm extended down behind the back. A **modified Sims** position as used for insertion of the rectal tube for a barium enema is shown in Fig. 1.59 (demonstrated in Chapter 13).
8. **Lithotomy** *(li-thot′-o-me)* position: A **recumbent** (supine) position with knees and hip flexed and thighs abducted and rotated externally, supported by ankle supports (Fig. 1.60). This position is seen frequently in the surgical suite for certain urinary studies.

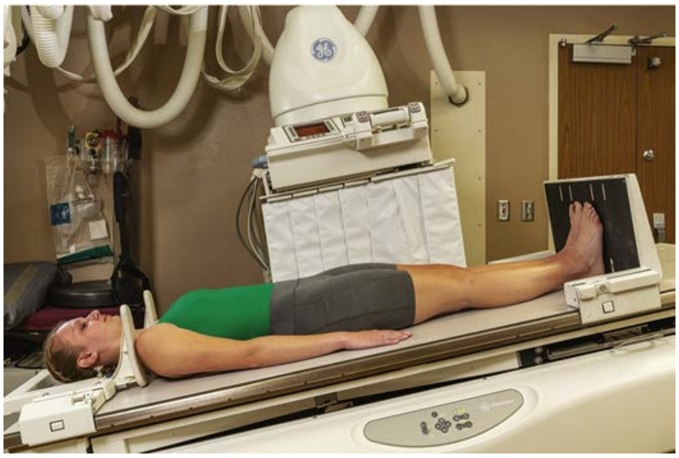


Fig. 1.57 Trendelenburg position—head lower than feet.


Fig. 1.58 Fowler position—feet lower than head.

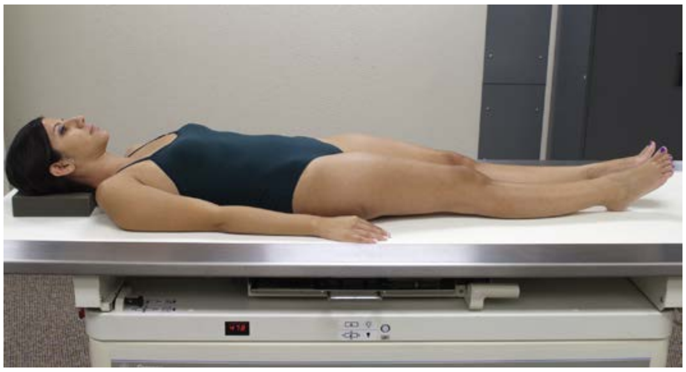


Fig. 1.55 Supine position.

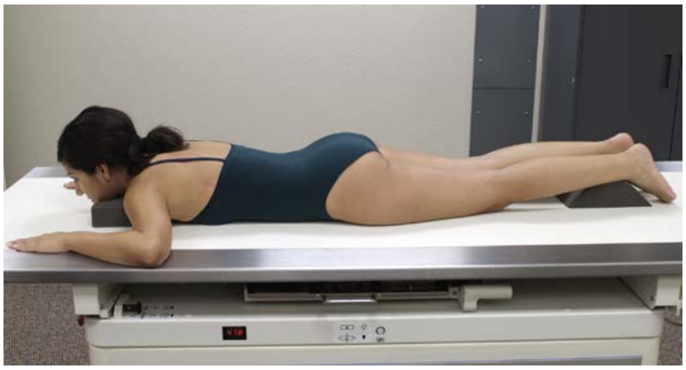


Fig. 1.56 Prone position.

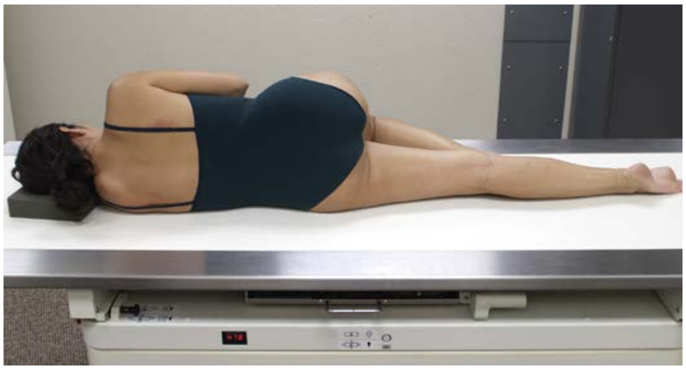


Fig. 1.59 Modified Sims position.


Fig. 1.60 Lithotomy position. (From Chitlik A: Safe positioning for robotic-assisted laparoscopic prostatectomy, *AORN J* 90[1]:39, 2011.)

SPECIFIC BODY POSITIONS

In addition to identifying general body positions, the term *position* is used in radiography to refer to a specific body position described by the body part closest to the IR (oblique and lateral) or by the surface on which the patient is lying (decubitus).

Lateral Position

Lateral *(lat′-er-al)* position refers to the side of, or a side view.

Specific lateral positions are described by the **side of the body closest to the IR** or the **body part from which the CR exits**. A **right lateral** position is shown with the right side of the body closest to the IR in the erect position (Fig. 1.61). Fig. 1.62 demonstrates a recumbent **left lateral** position.

A true lateral position is always 90°, or perpendicular, or at a right angle, to a true AP or PA projection. If it is not a true lateral, it is an oblique position.

Oblique Position[5]

Oblique *(ob-lek′,* or *ob-lik′)*[7] *(oh bleek′,* or *oh blike′)* position refers to an angled position in which neither the sagittal nor the coronal body plane is perpendicular or at a right angle to the IR.

Oblique body positions of the thorax, abdomen, or pelvis are described by the **side of the body closest to the IR** or the **body part from which the CR exits.**

Left and Right Posterior Oblique (LPO and RPO) Positions

LPO and RPO describe the specific oblique positions in which the **left or right posterior** aspect of the body is closest to the IR. A left posterior oblique (LPO) is demonstrated in both the erect (Fig. 1.63 and recumbent (Fig. 1.64) positions.

The CR exits from the left or right posterior aspect of the body.

NOTE: These also can be referred to as **AP oblique projections** because the CR enters an anterior surface and exits posteriorly. However, this **is not a complete description** and requires a specific position clarifier such as **LPO or RPO position.** Therefore, throughout this text, these body obliques are referred to as **positions** and not projections.

Obliques of upper and lower limbs are described correctly as AP and PA oblique but require the use of either **medial** or **lateral rotation** as a qualifier (see Figs. 1.51 and 1.52).

Right and Left Anterior Oblique (RAO and LAO) Positions

RAO and LAO refer to oblique positions in which the **right or left anterior** aspect of the body is closest to the IR and can be erect or recumbent general body positions. (A right anterior oblique [RAO] is shown in both examples (Figs. 1.65 and 1.66).

NOTE: These also can be described as **PA oblique projections** if a position clarifier is added, such as an RAO or LAO **position.**

It is *not* correct to use these oblique terms or the abbreviations LPO, RPO, RAO, or LAO as projections because they do not describe the direction or path of the CR; rather, these are **positions.**

Fig. 1.61 Erect R lateral position.

Fig. 1.62 Recumbent L lateral position.

Fig. 1.63 Erect LPO position.

Fig. 1.64 Recumbent LPO position.

Fig. 1.65 Erect RAO position.

Fig. 1.66 Recumbent RAO position.

Decubitus (Decub) Position

The word **decubitus** *(de-ku′bi-tus)* literally means to lie down, or the position assumed in lying down.

This body position, meaning to **lie on a horizontal surface,** is designated according to the **surface on which the body is resting.** This term describes a patient who is lying on one of the following body surfaces: **back** (dorsal), **front** (ventral), or **side** (right or left lateral).

In radiographic positioning, decubitus is *always* performed with the CR **horizontal.**

Decubitus positions are essential for detecting air-fluid levels or free air in a body cavity such as the chest or abdomen, where the air rises to the uppermost part of the body cavity. Decubitus positions are often performed if the patient cannot assume erect position.

Right or Left Lateral Decubitus Position—AP or PA Projection

In this position, the patient lies on the side, and the x-ray beam is directed horizontally from anterior to posterior (AP) (Fig. 1.67) or from posterior to anterior (PA) (Fig. 1.68).

The AP or PA projection is important as a qualifying term with decubitus positions to denote the direction of the CR.

This position is either a **left lateral decubitus** (see Fig. 1.67) or a **right lateral decubitus** (see Fig. 1.68).

NOTE: The decubitus position is identified according to the dependent side (side down) and the AP or PA projection indication. Example: Left lateral decubitus (PA projection) is with the patient lying on left side facing the image receptor. The CR enters the posterior side and exits the anterior side.

Dorsal Decubitus Position—Left or Right Lateral

In this position, the patient is **lying on the dorsal** (posterior) surface with the **x-ray beam directed horizontally,** exiting from the side closest to the IR (Fig. 1.69).

The position is named according to the surface on which the patient is lying (dorsal or ventral) and by the side closest to the IR (right or left).

Ventral Decubitus Position—Right or Left Lateral

In this position, the patient is lying on the ventral (anterior) surface with the x-ray beam directed horizontally, exiting from the side closest to the IR (Fig. 1.70).

Fig. 1.67 Left lateral decubitus position (AP projection).

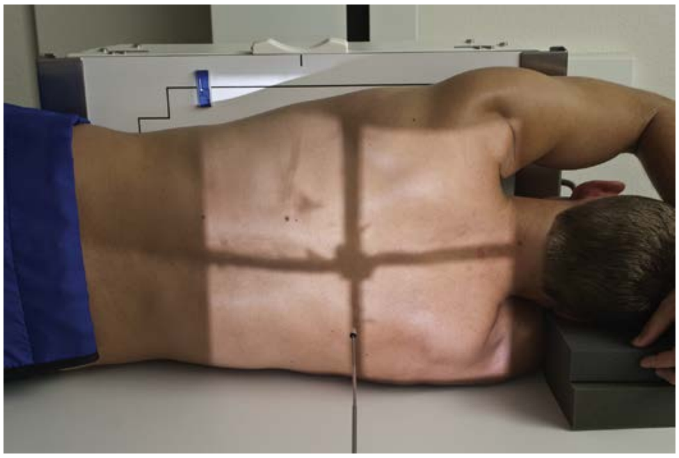


Fig. 1.68 Right lateral decubitus position (PA projection).

Fig. 1.69 Dorsal decubitus position (L lateral).

Fig. 1.70 Ventral decubitus position (R lateral).

Additional Special-Use Projection Terms

Following are some additional terms commonly used to describe projections. These terms, as shown by their definitions, also refer to the path or projection of the CR and are projections rather than positions.

Axial Projection

Axial (ak′-se-al) refers to the **long axis** of a structure or part (around which a rotating body turns or is arranged).

Special application—AP or PA axial: In radiographic positioning, the term *axial* is used to describe **any angle of the CR of 10° or more along the long axis of the body or body part.**[7] However, in a true sense, an axial projection would be directed along, or parallel to, the long axis of the body or part. The term *semiaxial,* or "partly" axial, more accurately describes any angle along the axis that is not truly perpendicular or parallel to the long axis. However, for the sake of consistency with other references, the term ***axial projection*** is used throughout this text to describe both axial and semiaxial projections, as defined earlier and as illustrated in Figs. 1.71 through 1.73.

Inferosuperior and Superoinferior Axial Projections **Inferosuperior** axial projections are frequently performed for the shoulder and hip, where the CR enters below or inferiorly and exits above or superiorly (see Fig. 1.73).

The opposite of this is the **superoinferior** axial projection, such as a special nasal bone projection (see Fig. 1.71).

Tangential Projection

Tangential (ta″-jen′-shal) means touching a curve or surface at only one point.

This is a special use of the term *projection* to describe the CR that skims a body part to project the anatomy into profile and free of superimposition of surrounding body structures.

Examples Following are two examples or applications of the term *tangential projection*:

- Tangential projection of zygomatic arch (Fig. 1.74)
- Tangential projection of patella (Fig. 1.75)

AP Axial Projection—Lordotic Position

This is a **specific AP axial chest projection** for demonstrating the apices of the lungs. It also is called the **AP lordotic position.** In this case, the long axis of the body rather than the CR is angled.

The term **lordotic** comes from **lordosis,** a term that denotes curvature of the cervical and lumbar spine (see Chapters 8 and 9). As the patient assumes this position (Fig. 1.76), the lumbar lordotic curvature is exaggerated, making this a descriptive term for this special chest projection.

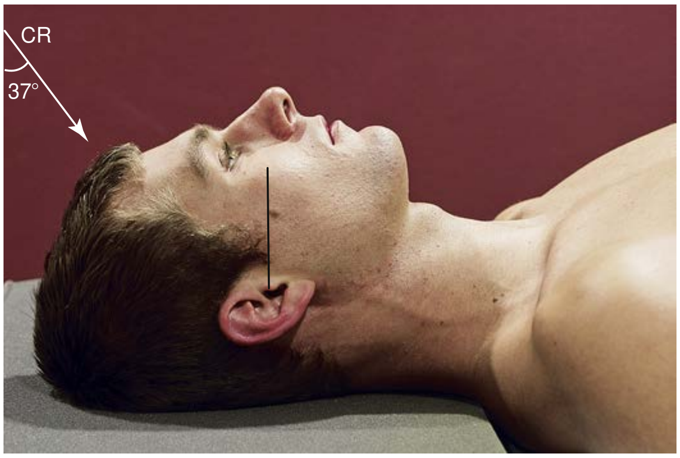


Fig. 1.72 AP axial (semiaxial) projection (CR 37° caudal).

Fig. 1.73 Inferosuperior axial projection.

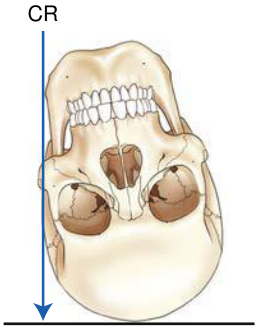


Fig. 1.74 Tangential projection (zygomatic arch).

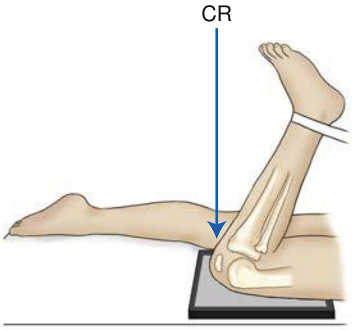


Fig. 1.75 Tangential projection (patella).

Fig. 1.71 Superoinferior (axial) projection.

Fig. 1.76 AP lordotic chest position.

Transthoracic Lateral Projection (Right Lateral Position)

This is a lateral projection through the thorax. It requires a qualifying positioning term (right or left lateral position) to indicate which shoulder is closest to the IR and is being examined (Fig. 1.77).

NOTE: This is a special adaptation of the projection term, indicating that the CR passes through the thorax even though it does not include an entrance or exit site. In practice, this is a common lateral shoulder projection and is referred to as a **right** or **left transthoracic lateral shoulder.**

Dorsoplantar and Plantodorsal Projections

These are secondary terms for AP or PA projections of the foot.

Dorsoplantar (DP) describes the path of the CR from the **dorsal** (anterior) surface to the **plantar** (posterior) surface of the foot (Fig. 1.78).

A special plantodorsal projection of the heel bone (calcaneus) is called an **axial plantodorsal projection** (PD) because the angled CR enters the plantar surface of the foot and exits the dorsal surface (Fig. 1.79).

NOTE: The term **dorsum** for the **foot** refers to the anterior surface, dorsum pedis (see Fig. 1.47).

Parietoacanthial and Acanthioparietal Projections

The CR enters at the cranial **parietal** bone and exits at the **acanthion** (junction of nose and upper lip) for the **parietoacanthial projection** (Fig. 1.80).

The opposite CR direction would describe the **acanthioparietal projection** (Fig. 1.81).

These are also known as **PA Waters** and **AP reverse Waters** methods and are used to visualize the facial bones.

Submentovertical (SMV) and Verticosubmental (VSM) Projections

These projections are used for the **skull** and **mandible.**

The CR enters below the chin, or mentum, and exits at the vertex or top of the skull for the **submentovertical (SMV) projection** (Fig. 1.82).

The less common, opposite projection of this would be the **verticosubmental (VSM) projection,** entering at the top of the skull and exiting below the mandible (not shown).

Fig. 1.79 Axial plantodorsal (PD) projection of calcaneus.

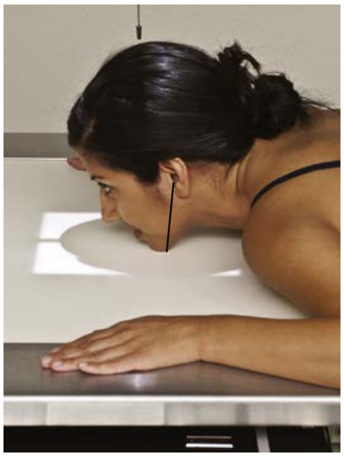


Fig. 1.80 Parietoacanthial projection (PA Waters position).

Fig. 1.81 Acanthioparietal projection.

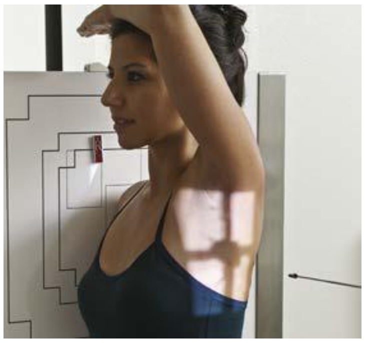


Fig. 1.77 Transthoracic lateral shoulder projection (R lateral shoulder position).

Fig. 1.78 AP or dorsoplantar (DP) projection of foot.

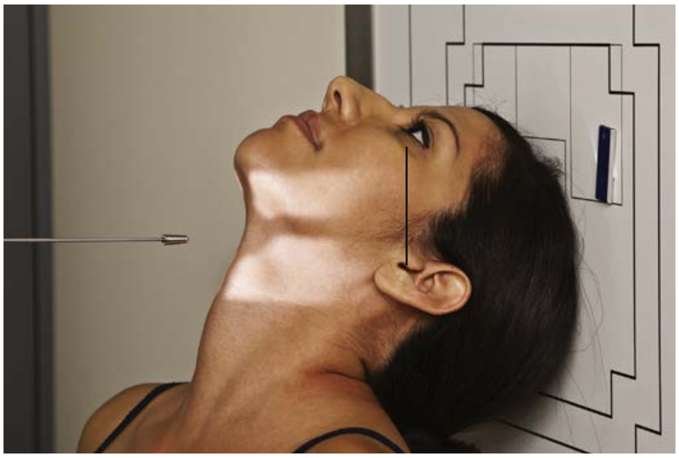


Fig. 1.82 Submentovertical (SMV) projection.

Relationship Terms

Following are paired positioning or anatomic terms that are used to describe relationships to parts of the body with opposite meanings.

Medial Versus Lateral

Medial *(me′-de-al)* versus lateral refers to **toward** versus **away from** the center, or median plane.

In the anatomic position, the medial aspect of any body part is the "inside" part closest to the median plane, and the lateral part is away from the center, or away from the median plane or midline of the body (Fig. 1.83).

Examples In the anatomic position, the thumb is on the lateral aspect of the hand. The lateral part of the abdomen and thorax is the part away from the median plane.

Proximal Versus Distal

Proximal *(prok′-si-mal)* is **near the source** or beginning, and **distal** *(dis′-tal)* is **away from.** In regard to the upper and lower limbs, proximal and distal would be the part closest to or away from the trunk, the source or beginning of that limb (see Fig. 1.83).

Examples The elbow is proximal to the wrist. The finger joint closest to the palm of the hand is called the *proximal interphalangeal (PIP) joint,* and the joint near the distal end of the finger is the *distal interphalangeal (DIP) joint* (see Chapter 4).

Cephalad Versus Caudad

Cephalad *(sef′-ah-lad)* means **toward** the head end of the body; **caudad** *(kaw′-dad)* means **away from** the head end of the body.

A **cephalad angle** is any angle toward the head end of the body (Fig. 1.84; also see Fig. 1.86). (*Cephalad,* or *cephalic,* literally means "head" or "toward the head.")

A **caudad angle** is any angle toward the feet or away from the head end (Fig. 1.85). (*Caudad* or *caudal* comes from *cauda,* literally meaning "tail.")

In human anatomy, cephalad and caudad also can be described as **superior** (toward the head) or **inferior** (toward the feet).

NOTE: As is shown in Figs. 1.84, 1.85, and 1.86, these terms are correctly used to describe the direction of the CR angle for axial projections along the entire length of the body, not just projections of the head.

Interior (Internal, Inside) Versus Exterior (External, Outer)

Interior is inside of something, nearer to the center, and exterior is situated on or near the outside.

The prefix **intra-** means **within** or **inside** (e.g., intravenous: inside a vein).

The prefix **inter-** means situated **between things** (e.g., intercostal: located between the ribs).

The prefix **exo-** means **outside** or **outward** (e.g., exocardial: something that develops or is situated outside the heart).

Superficial Versus Deep

Superficial is nearer the skin surface; deep is farther away.

Example The cross-sectional drawing in Fig. 1.87 shows that the humerus is deep compared with the skin of the arm, which is superficial.

Another example would be a superficial tumor or lesion, which is located near the surface, compared with a deep tumor or lesion, which is located deeper within the body or part.

Ipsilateral Versus Contralateral

Ipsilateral *(ip″-si-lat′-er-al)* is on the same side of the body or part; contralateral *(kon″-trah-lat′-er-al)* is on the opposite side.

Example The right thumb and the right great toe are ipsilateral; the right knee and the left hand are contralateral.

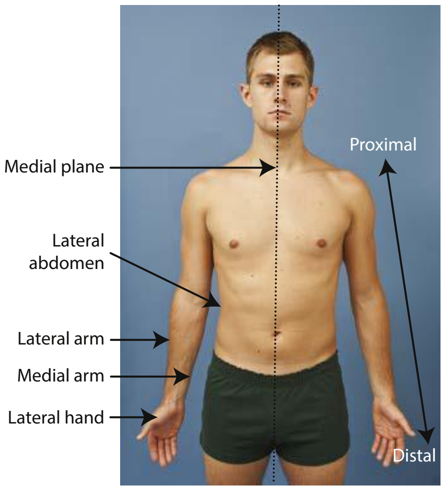


Fig. 1.83 Medial vs. lateral, proximal vs. distal.

Fig. 1.84 Cephalad CR angle (toward head).

Fig. 1.85 Caudad CR angle (away from head).

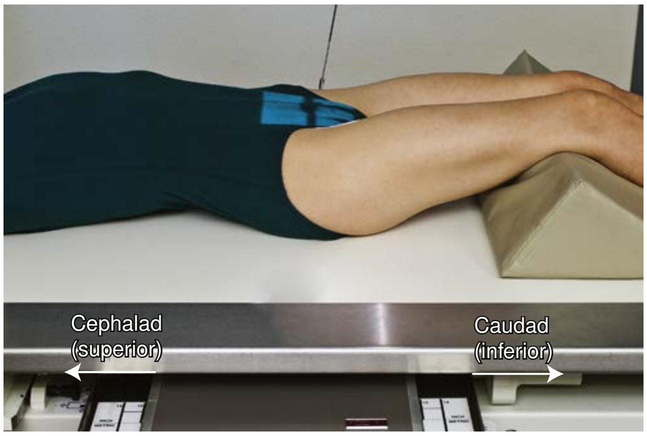


Fig. 1.86 Cephalic angle (AP axial projection of sacrum).

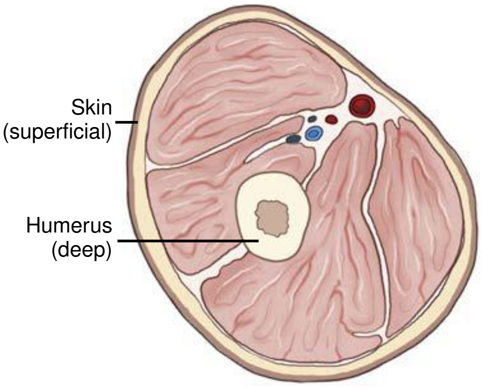


Fig. 1.87 Cross-section of arm.

Terms Related to Movement

The final group of positioning and related terms that every technologist should know relates to various movements. Most of these are listed as paired terms that describe movements in opposite directions.

Flexion Versus Extension

When a joint is flexed or extended, the **angle** between parts is **decreased** or **increased.**

Flexion decreases the angle of the joint (see examples of knee, elbow, and wrist flexions in Fig. 1.88).

Extension increases the angle as the body part moves from a flexed to a straightened position. This is true for the knee, elbow, and wrist joints, as is shown in Fig. 1.88.

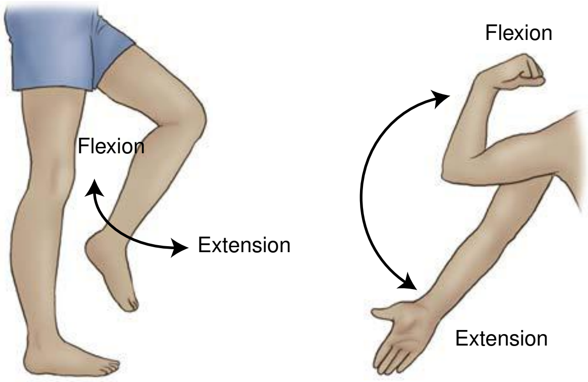


Fig. 1.88 Flexion vs. extension.

Hyperextension

Hyperextension is extending a joint beyond the straight or neutral position.

Abnormal Hyperextension

A hyperextended elbow or knee results when the joint is extended beyond the straightened or neutral position. This is not a natural movement for these two joints and results in injury or trauma.

Normal Flexion and Hyperextension of the Spine

Flexion is bending forward, and extension is returning to the straight or neutral position. A backward bending **beyond the neutral position is hyperextension.** In practice, however, the terms *flexion* and *extension* are commonly used for these two extreme flexion and hyperextension projections of the spine (Fig. 1.89).

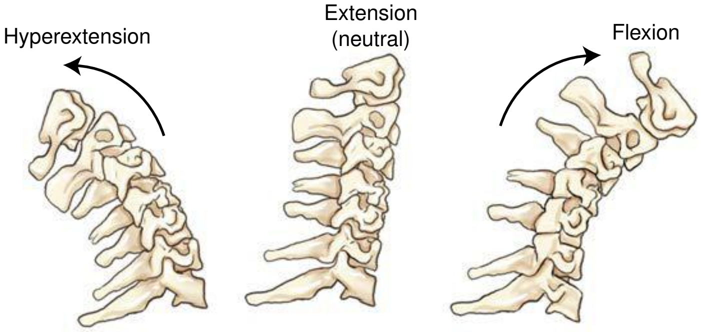


Fig. 1.89 Hyperextension, extension, and flexion of spine.

Normal Hyperextension of the Wrist

A second example of a special use of the term *hyperextension* concerns the wrist, where the carpal canal (tangential, inferosuperior) projection of the carpals is visualized by a special **hyperextended wrist movement** in which the wrist is extended beyond the neutral position. This specific wrist movement is also called **dorsiflexion** (backward or posterior flexion) (Fig. 1.90A).

Acute Flexion of the Wrist

An acute or full flexion of the wrist is required for a special tangential projection for a carpal bridge projection of the posterior aspect of the wrist (see Fig. 1.90B).

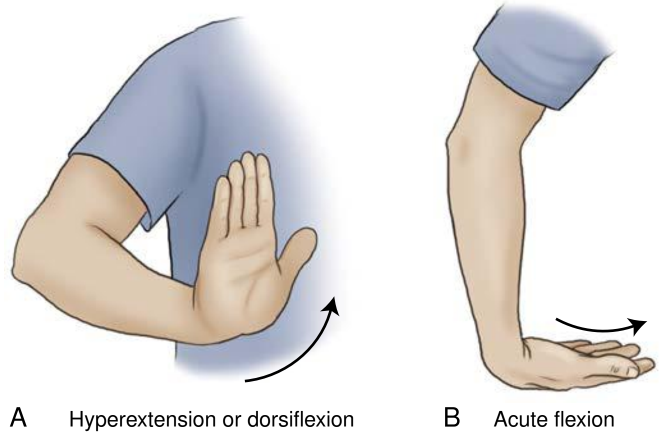


Fig. 1.90 Wrist extension and flexion movements. A, Hyperextension. B, Acute flexion.

Ulnar Deviation Versus Radial Deviation of the Wrist

Deviation literally means "to turn aside" or "to turn away from the standard or course."[8]

Ulnar deviation (Fig. 1.91A) is to turn or bend the hand and wrist from the natural position toward the ulnar side, and **radial deviation** (Fig. 1.91B) is toward the radial side of the wrist.

NOTE: Earlier editions of this textbook and other positioning references have defined these wrist movements as ulnar and radial flexion movements because they describe specific flexion movements toward either the ulna or the radius.[9] However, because practitioners in the medical community, including orthopedic physicians, commonly use the terms *ulnar* and *radial deviation* for these wrist movements, this text also has changed this terminology to *ulnar* and *radial deviation movements* to prevent confusion and to ensure consistency with other medical references.

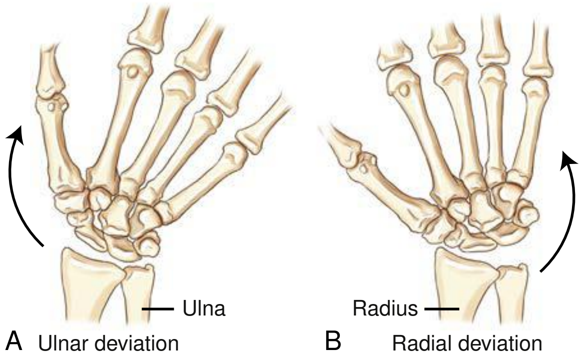


Fig. 1.91 Deviation wrist movements. A, Ulnar deviation. B, Radial deviation.

Dorsiflexion Versus Plantar Flexion of the Foot and Ankle

Dorsiflexion of the Foot This term means to **decrease the angle** (flex) between the dorsum (top of foot) and the lower leg, moving foot and toes upward (Fig. 1.92A).

Plantar Flexion of the Foot **Extending the ankle joint,** moving foot and toes downward from the normal position; flexing or decreasing the angle toward the plantar (posterior) surface of the foot (see Fig. 1.92B).

NOTE: See preceding page for dorsiflexion of the wrist (see Fig. 1.90A) compared with dorsiflexion of the foot (see Fig. 1.92A).

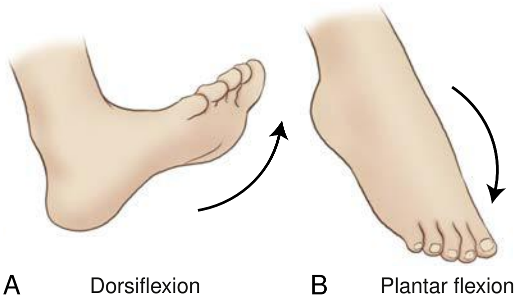


Fig. 1.92 Movements of ankle and foot. A, Dorsiflexion. B, Plantar flexion.

Eversion Versus Inversion

Eversion *(e-ver′-zhun)* is an **outward stress movement** of the foot at the ankle joint (Fig. 1.93).

Inversion *(in-ver′-zhun)* is **inward stress** movement of the foot as applied to the foot without rotation of the leg (Fig. 1.94).

The plantar surface (sole) of the foot is turned or rotated away from the median plane of the body (the sole faces in a more lateral direction) for eversion and toward the median plane for inversion.

The leg does not rotate, and stress is applied to the medial and lateral aspects of the ankle joint for evaluation of possible widening of the joint space (ankle mortise).

Fig. 1.93 Eversion (valgus stress).

Fig. 1.94 Inversion (varus stress).

Valgus Versus Varus[1]

Valgus *(val′-gus)* describes an abnormal position in which a part or limb is forced outward from the midline of the body. *Valgus* sometimes is used to describe **eversion stress** of the ankle joint.

Varus *(va′-rus)* describes an abnormal position in which a part or limb is forced inward toward the midline of the body. The term *varus stress* sometimes is used to describe **inversion stress** applied at the ankle joint.

NOTE: The terms *valgus* and *varus* are also used to describe the loss of normal alignment of bones due to fracture (see Chapter 15).

Medial (Internal) Rotation Versus Lateral (External) Rotation

Medial rotation is a rotation or turning of a body part with movement of the **anterior** aspect of the part **toward the inside,** or median, plane (Fig. 1.95A).

Lateral rotation is a rotation of an **anterior** body part **toward the outside,** or away from the median plane (Fig. 1.95B).

NOTE: In radiographic positioning, these terms describe movement of the **anterior** aspect of the part that is being rotated. In the forearm movements (see Fig. 1.95A and B), the anterior aspect of the forearm moves medially or internally on medial rotation and laterally or externally on lateral rotation. Another example is the medial and lateral oblique projections of the knee, in which the **anterior** part of the knee is rotated medially and laterally in **either the AP or PA** projections (see Chapter 6).

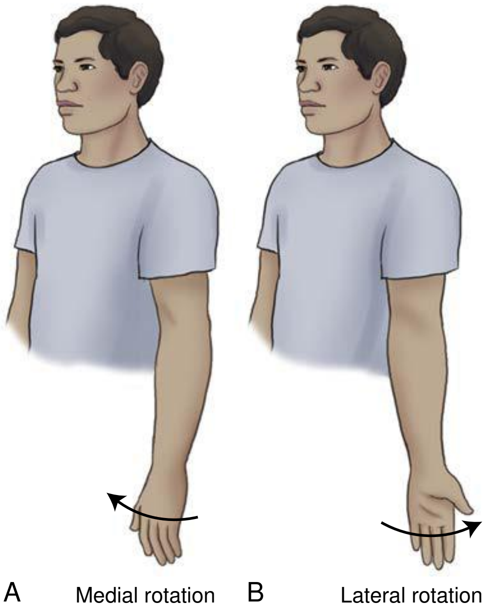


Fig. 1.95 Rotational movements of upper limb. A, Medial (internal) rotation. B, Lateral (external) rotation.

Abduction Versus Adduction

Abduction *(ab-duk′-shun)* is the lateral movement of the arm or leg **away** from the body.

Another application of this term is the abduction of the fingers or toes, which means spreading them apart (Fig. 1.96A).

Adduction *(ah-duk′-shun)* is a movement of the arm or leg **toward** the body, to draw toward a center or medial line (Fig. 1.96B).

Adduction of the fingers or toes means moving them together or toward each other.

Supination Versus Pronation

Supination *(su″-pi-na′-shun)* is a rotational movement of the hand into the anatomic position (palm up in supine position or forward in erect position) (Fig. 1.97A). This movement rotates the radius of the forearm laterally along its long axis.

Pronation *(pro-na′-shun)* is a rotation of the hand into the opposite of the anatomic position (palm down or back) (Fig. 1.97B).

NOTE: To help remember these terms, relate them to the body positions of supine and prone. *Supine* or *supination* means face up or palm up, and *prone* or *pronation* means face down or palm down.

Protraction Versus Retraction

Protraction *(pro-trak′-shun)* is a **movement forward** from a normal position (Fig. 1.98A).

Retraction *(re-trak′-shun)* is a **movement backward** or the condition of being drawn back (Fig. 1.98B).

Example Protraction is moving the jaw forward (sticking the chin out) or drawing the shoulders forward. Retraction is the opposite of this—that is, moving the jaw backward or squaring the shoulders, as in a military stance.

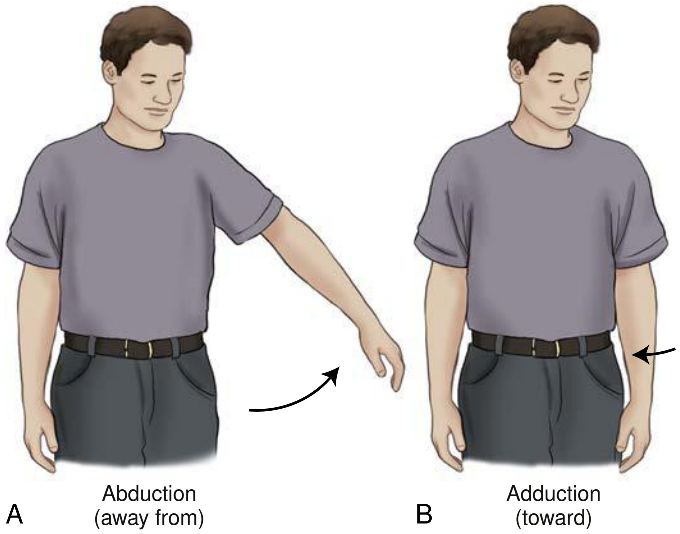


Fig. 1.96 Movements of upper limbs. A, Abduction. B, Adduction.

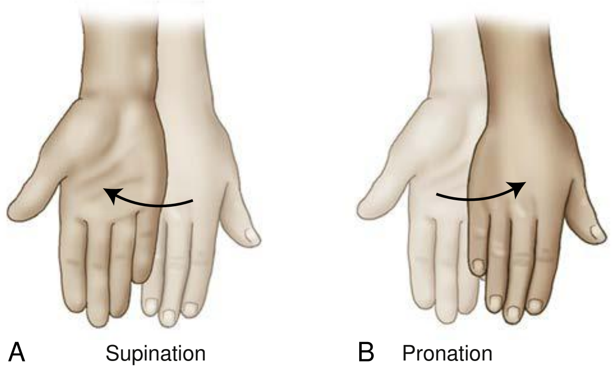


Fig. 1.97 Movements of hand. A, Supination. B, Pronation.

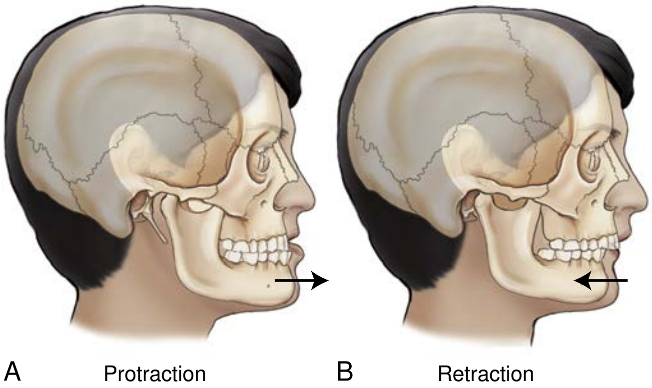


Fig. 1.98 Movements of mandible. A, Protraction. B, Retraction.

Elevation Versus Depression

Elevation is a **lifting, raising,** or **moving of a part superiorly** (Fig. 1.99A).

Depression is a **letting down, lowering,** or **moving of a part inferiorly** (Fig. 1.99B).

Example Shoulders are elevated when they are raised, as when shrugging the shoulders. Depressing the shoulders is lowering them.

Circumduction

Circumduction *(ser″-kum-duk′-shun)* means **to move around in the form of a circle** (Fig. 1.100). This term describes sequential movements of flexion, abduction, extension, and adduction, resulting in a cone-type movement at any joint where the four movements are possible (e.g., fingers, wrist, arm, leg).

Rotation Versus Tilt

Rotate is to turn or rotate a body part on its axis. In Fig. 1.101, the midsagittal plane of the entire body, including the head, is **rotated.**

Tilt is a slanting or tilting movement with respect to the long axis. Fig. 1.102 demonstrates no rotation of the head but a **tilting** (slanting) of the midsagittal plane of the head, which therefore is not parallel to the tabletop.

Understanding the difference between these two terms is important in cranial and facial bone positioning (see Chapter 11).

See Table 1.4 for a summary of positioning-related terminology.

Summary of Projections and Positions

The three terms **position, projection,** and **view** are sometimes confusing and may be used incorrectly in practice. These terms should be understood and used correctly (Table 1.5).

Position

Position is a term that is used to indicate the patient's general physical position, such as supine, prone, recumbent, erect, or Trendelenburg.

TABLE 1.4 **SUMMARY OF POSITIONING-RELATED TERMS**

Body Planes, Sections, and Lines	**Relationship Terms**
Longitudinal planes or sections	Medial vs. lateral
• Sagittal	Proximal vs. distal
• Coronal	Cephalad vs. caudad
• Oblique	Ipsilateral vs. contralateral
Transverse planes or sections	Internal vs. external
• Horizontal, axial, or cross-section	Superficial vs. deep
• Oblique	Lordosis vs. kyphosis (scoliosis)
Base plane	**Movement Terms**
Occlusal plane	Flexion vs. extension (acute flexion vs. hyperextension)
Infraorbitomeatal line (IOML)	
Body Surfaces	Ulnar vs. radial deviation
Posterior	Dorsiflexion vs. plantar flexion
Anterior	Eversion vs. inversion
Plantar	Valgus vs. varus
Dorsum	Medial vs. lateral rotation
Palmar	Abduction vs. adduction
	Supination vs. pronation
	Protraction vs. retraction
	Elevation vs. depression
	Tilt vs. rotation
	Circumduction
	Cephalad vs. caudad

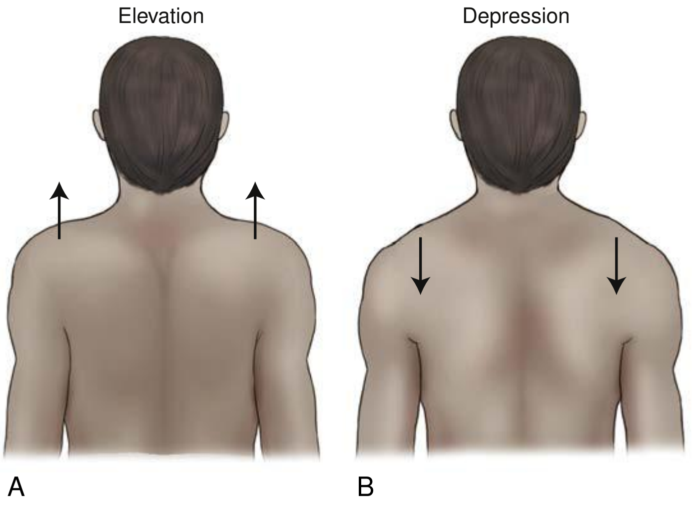


Fig. 1.99 Movements of shoulders. A, Elevation. B, Depression.

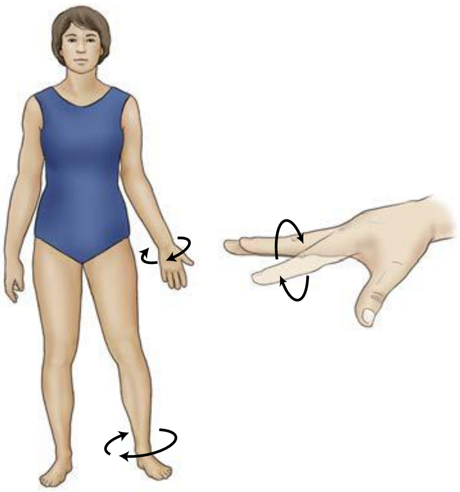


Fig. 1.100 Circumduction movements.

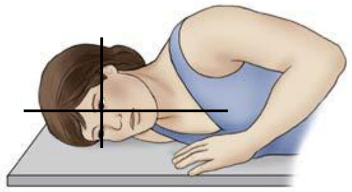


Fig. 1.101 Rotation—midsagittal plane rotated.

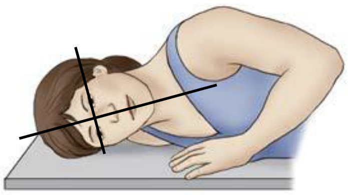


Fig. 1.102 Tilt—midsagittal plane of head tilted.

TABLE 1.5 **SUMMARY OF PROJECTIONS AND POSITIONS**

PROJECTIONS (PATH OF CR)	**GENERAL BODY POSITIONS**	**SPECIFIC BODY POSITIONS**
Posteroanterior (PA)	Anatomic	R or L lateral
Anteroposterior (AP)	Supine	Oblique
Mediolateral	Prone	Left posterior oblique (LPO)
Lateromedial	Erect (upright)	
AP or PA oblique	Recumbent	Right posterior oblique (RPO)
AP or PA axial	Trendelenburg	
Tangential	Sims	Left anterior oblique (LAO)
Transthoracic	Fowler	
Dorsoplantar (DP)	Lithotomy	Right anterior oblique (RAO)
Plantodorsal (PD)		
Inferosuperior axial		Decubitus
Superoinferior axial		Left lateral decubitus
Axiolateral		Right lateral decubitus
Submentovertex (SMV)		Ventral decubitus
Verticosubmental (VSM)		Dorsal decubitus
Parietoacanthial		Lordotic
Acanthioparietal		
Craniocaudal		

Position also is used to describe **specific body positions** by the anatomy closest to the IR, such as **lateral** and **oblique positions.**

The term *position* should be "restricted to discussion of the patient's physical position."[11]

Projection

Projection is a correct positioning term that describes or refers to the **path or direction of the central ray,** projecting an image onto an IR.

The term *projection* should be "restricted to discussion of the path of the central ray."[10]

View

View is *not* a correct positioning term in the United States.

View describes the anatomy or body part as seen by the IR or other recording medium, such as a fluoroscopic screen. In the United States, the term *view* should be **"restricted to discussion of a radiograph or image."**[10]

POSITIONING PRINCIPLES

Evaluation Criteria

The goal of every technologist should be to take not just a "passable" radiograph but rather an optimal one that can be evaluated by a **definable standard,** as described under **evaluation criteria** (Fig. 1.103).

An example of a three-part radiographic image evaluation as used in this text for a lateral forearm is shown on the right. The positioning photo and the resulting optimal radiograph (Figs. 1.104 and 1.105) are shown for this lateral forearm, as described in Chapter 4.

EVALUATION CRITERIA FORMAT

The technologist should review and compare radiographs using this standard to determine how close to an optimal image was achieved. A systematic method of learning how to critique radiographs is to break the evaluation down into these **three parts.**

1. **Anatomy demonstrated:** Describes precisely what anatomic parts and structures should be clearly visualized on that image (radiograph).
2. **Position:** Generally evaluates four issues: (1) placement of body part in relationship to the IR, (2) positioning factors that are important for the projection, (3) correct centering of anatomy, and (4) collimation.
3. **Exposure:** Describes how exposure factors or technique (kilovoltage [kVp], milliamperage [mA], and time [milliseconds]) can be evaluated for optimum exposure for that body part. **No motion** is a first priority, and a description of how the presence or absence of motion can be determined is listed. (Motion is included with exposure criteria because exposure time is the primary controlling factor for motion.)

Sample Lateral Forearm Evaluation Criteria

Anatomy Demonstrated: • Lateral projection of entire radius and ulna; proximal row of carpals, elbow, and distal end of humerus; and pertinent soft tissues such as fat pads and stripes of wrist and elbow joints.

Position: • Long axis of forearm aligned with long axis of IR. • Elbow flexed 90°. • No rotation from true lateral as evidenced by the following: • Head of the ulna should be superimposed over the radius. • Humeral epicondyles should be superimposed. • Radial head should superimpose the coronoid process with radial tuberosity seen in profile. • Collimation to **area of interest.**

Exposure: • Optimum density (brightness) and contrast with no motion will reveal sharp cortical margins and clear, bony trabecular markings and fat pads and stripes of the wrist and elbow joints.

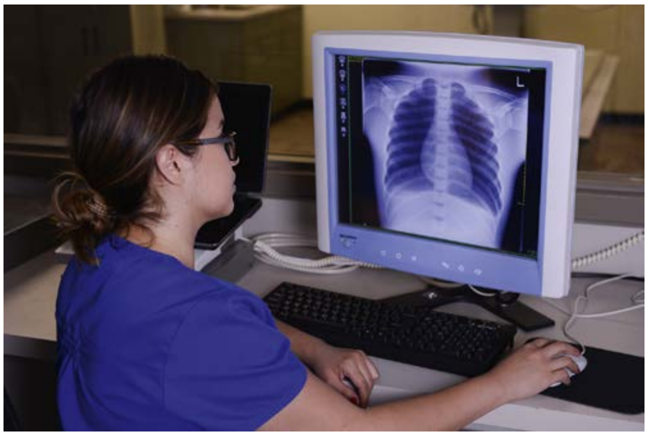


Fig. 1.103 Technologist viewing digital images on monitor.

Fig. 1.104 Accurate positioning for lateral forearm.

Fig. 1.105 Lateral forearm.

Image Markers and Patient Identification

A **minimum** of two types of markers should be imprinted on every radiographic image. These are (1) **patient identification and date** and (2) **anatomic side markers.**

PATIENT IDENTIFICATION AND DATE (FILM-SCREEN CASSETTE [ANALOG] SYSTEMS)

With analog (film) systems, patient information, which includes data such as name, date, case number, and institution, are photoflashed on the film in the space provided by a lead block in the film cassette (Fig. 1.106A). Each IR has a marker on the exterior indicating this area where the patient ID, including the date, should be placed. A general rule for most chest studies is to place the patient ID information at the top margin of the IR on chests. The patient ID marker is always placed where it is least likely to cover essential anatomy. The anatomic side markers are and should still be placed in a manner on the IR so that they are legible and esthetically correct (Fig. 1.106B). They must be within the collimation field so that they provide a permanent indicator of the correct side of the body or anatomic part.

Digital Systems

With photostimulable storage phosphor (PSP) cassette-based systems, often a bar code system imprints the patient information before or after exposure (Fig. 1.107). With digital imaging systems, patient identification is entered during registration and prior to exposure.

ANATOMIC SIDE MARKER

A right or left marker must also appear on every radiographic image correctly indicating the patient's right or left side or which limb is being radiographed, the right or the left. This may be provided as the word "Right" or "Left" or just the initials "R" or "L." This side marker preferably should be placed directly on the IR inside the lateral portion of the collimated border of the side being identified, with the placement such that the marker will not be superimposed over essential anatomy.

These radiopaque markers must be placed just within the collimation field so that they will be exposed by the x-ray beam and included on the image.

The two markers, the patient ID, and the anatomic side marker must be placed correctly on *all* radiographic images **including digitally produced images.** Generally, it is an unacceptable practice to write or annotate digitally this information on the image after it is processed because of legal and liability problems caused by potential mis-markings. A **radiograph taken without these two markers often has to be repeated,** which results in unnecessary radiation to the patient, making this a serious error. In the case of digital images, annotating the image to indicate side markers is an unacceptable practice. The exposure should be repeated to ensure the correct anatomy was imaged.

ADDITIONAL MARKERS OR IDENTIFICATION

Certain other markers or identifiers also may be used, such as **technologist initials,** which generally are placed on the R or L marker to identify the specific technologist responsible for the examination. Sometimes the examination room number is also included.

Time indicators are also commonly used; these note the minutes of elapsed time in a series, such as the 20-minute, 30-minute, 1-hour, and 2-hour series of radiographs taken in a small bowel series (SBS) procedure (see Chapter 13).

Another important marker on all decubitus positions is a decubitus marker or some type of indicator such as an **arrow identifying which side is up.** An **"upright"** or **"erect"** marker must also be used to identify erect chest or abdomen positions compared with recumbent, in addition to an arrow indicating which side is up.

Inspiration (INSP) and **expiration** (EXP) markers are used for special comparison PA projections of the chest. **Internal** (INT) and **external** (EXT) markers may be used for rotation projections, such as for the proximal humerus and shoulder. Sample markers are shown in Fig. 1.108.

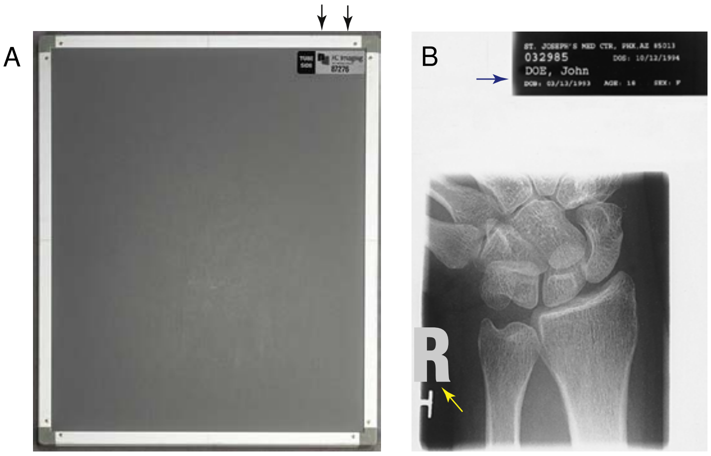


Fig. 1.106 A, Film cassette with patient information in block *(arrows)*. B, Radiograph (*blue arrow*, Patient identification information; *yellow arrow*, Anatomic side marker to indicate right wrist).

Fig. 1.107 PSP cassette with bar coding for patient information

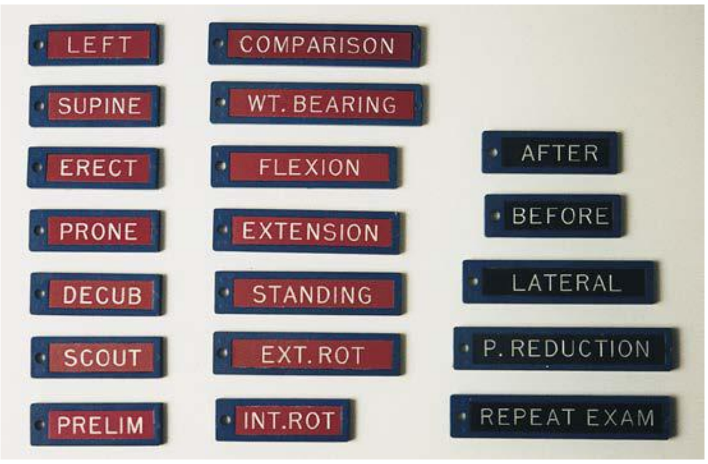


Fig. 1.108 Sample procedure markers.

Professional Ethics and Patient Care

The radiologic technologist is an important member of the health care team who is responsible in general for radiologic examination of patients. This includes being responsible for one's actions under a specific **code of ethics.**

Code of ethics describes the rules of acceptable conduct toward patients and other health care team members as well as personal actions and behaviors as defined within the profession. The ARRT code of ethics[11] is provided in Box 1.1. The **announce, communicate, and explain (ACE)** campaign of the American Society of Radiologic Technologists (ASRT)is an initiative to educate patients about the role of the radiologic technologist. ACE is an acronym to help you remember to share and gain important information with and from your patients (Box 1.2).

Patient Assessment and Clinical History[12]

Once in the radiology imaging suite, the patient will interact directly with the radiologic technologist. Key responsibilities of the technologist are to introduce yourself, ensure you are performing the correct procedure on the correct patient, ask questions and acquire clinical history pertinent to the procedure, and explain the imaging procedure briefly. This protocol must be followed for every patient and for every radiologic procedure. The ASRT recommends the following initial communication with the patient:

- **Introduce yourself:** By name and role as the radiologic technologist performing the procedure.
- **Patient identification by two means:** Ask patient their name and verify by reviewing the patient arm band, patient chart, and/or examination requisition.
- **Verification of procedure(s) ordered:** Make sure it is the correct procedure for the correct patient by examining the patient chart or examination requisition.
- **Acquire clinical history:** Interview patient to determine chief complaints, allergy history, symptoms, duration and frequency of symptoms.
- **Pregnancy status:** Ask females if there is any possibility they might be pregnant. If the response of the patient, is "yes," "maybe," or "I don't know," inform supervisor or physician before proceeding with procedure. Age range for this type of questioning is often determined by the medical facility.
- **Explain procedure**: Explain the radiologic procedure that will be performed. Use terms and language the patient can understand.
- **Provide opportunity for patient to ask questions:** Encourage patient to ask questions about the procedure or other concerns before beginning the procedure.

BOX 1.2 ACE CAMPAIGN

In addition to performing medical imaging procedures, radiologic technologists must also communicate with patients. It is important for patients to understand that radiologic technologists are highly qualified medical imaging professionals who are educated in patient positioning, radiation safety, radiation protection, and equipment protocols. Furthermore, patients should have an understanding of the medical imaging procedure they are undergoing.

To communicate these points to patients, the American Society of Radiologic Technologists (ASRT) recommends that medical imaging professionals use the ACE initiative. The easy-to-remember acronym reminds radiologic technologists to:

- **A**nnounce your name.
- **C**ommunicate your credentials.
- **E**xplain what you're going to do.

The ACE acronym provides medical imaging professionals with a unique and simple tool to educate patients about the radiologic technologist's role on the health care team.

BOX 1.1 AMERICAN REGISTRY OF RADIOLOGIC TECHNOLOGISTS CODE OF ETHICS

The Code of Ethics forms the first part of the *Standards of Ethics.* The Code of Ethics shall serve as a guide by which Certificate Holders and Candidates may evaluate their professional conduct as it relates to patients, healthcare consumers, employers, colleagues, and other members of the healthcare team. The Code of Ethics is intended to assist Certificate Holders and Candidates in maintaining a high level of ethical conduct and in providing for the protection, safety, and comfort of patients. The Code of Ethics is aspirational.

1. The radiologic technologist acts in a professional manner, responds to patient needs, and supports colleagues and associates in providing quality patient care.
2. The radiologic technologist acts to advance the principal objective of the profession to provide services to humanity with full respect for the dignity of mankind.
3. The radiologic technologist delivers patient care and service unrestricted by the concerns of personal attributes or the nature of the disease or illness, and without discrimination on the basis of sex, race, creed, religion, or socio-economic status.
4. The radiologic technologist practices technology founded upon theoretical knowledge and concepts, uses equipment and accessories consistent with the purposes for which they were designed, and employs procedures and techniques appropriately.
5. The radiologic technologist assesses situations; exercises care, discretion, and judgment; assumes responsibility for professional decisions; and acts in the best interest of the patient.
6. The radiologic technologist acts as an agent through observation and communication to obtain pertinent information for the physician to aid in the diagnosis and treatment of the patient and recognizes that interpretation and diagnosis are outside the scope of practice for the profession.
7. The radiologic technologist uses equipment and accessories, employs techniques and procedures, performs services in accordance with an accepted standard of practice, and demonstrates expertise in minimizing radiation exposure to the patient, self, and other members of the healthcare team.
8. The radiologic technologist practices ethical conduct appropriate to the profession and protects the patient's right to quality radiologic technology care.
9. The radiologic technologist respects confidences entrusted in the course of professional practice, respects the patient's right to privacy, and reveals confidential information only as required by law or to protect the welfare of the individual or the community.
10. The radiologic technologist continually strives to improve knowledge and skills by participating in continuing education and professional activities, sharing knowledge with colleagues, and investigating new aspects of professional practice.
11. The radiologic technologist refrains from the use of illegal drugs and/or any legally controlled substances which result in impairment of professional judgment and/or ability to practice radiologic technology with reasonable skill and safety to patients.

Essential Projections

ROUTINE PROJECTIONS

Certain basic projections are listed and described in this text for each radiographic examination or procedure commonly performed throughout the United States and Canada. Routine projections are defined as **projections commonly taken on patients who can cooperate fully.** This varies depending on radiologist and department preference and on geographic differences.

SPECIAL PROJECTIONS

In addition to routine projections, certain special projections are included for each examination or procedure described in this text. These are defined as **projections most commonly taken to demonstrate better specific anatomic parts or certain pathologic conditions or projections that may be necessary for patients who cannot cooperate fully.**

The authors recommend (on the basis of recent survey results) that all students learn and demonstrate proficiency in all essential projections as listed in this text. This includes all routine projections and all special projections as listed and described in each chapter. The following are examples of these routine projection and special projection boxes for Chapter 2. Becoming competent in these projections helps to ensure students are prepared to function as imaging technologists in any part of the United States.

General Principles for Determining Positioning Routines

Two general rules or principles are helpful for remembering and understanding the reasons certain minimum projections are performed for various radiographic examinations.

MINIMUM OF TWO PROJECTIONS (90° FROM EACH OTHER)

The first general rule in diagnostic radiology suggests that a **minimum of two projections** taken as near as possible to 90° from each other are required for most radiographic procedures. Exceptions include an AP mobile (portable) chest, a single AP abdomen (called a KUB—**k**idneys, **u**reter, and **b**ladder), and an AP of the pelvis, in which only one projection usually provides adequate information.

Three reasons for this general rule of a minimum of two projections are as follows:

1. Superimposition of anatomic structures
   Certain pathologic conditions (e.g., some fractures, small tumors) may not be visualized on one projection only.
2. Localization of lesions or foreign bodies
   A minimum of two projections, taken at 90° or as near as possible to right angles of each other, are essential in determining the location of any lesion or foreign body (Fig. 1.109).

Example

Foreign bodies embedded in tissues of the knee. Both AP/PA and lateral projections are necessary to determine the exact location of this "nail."

3. Determination of alignment of fractures
   All fractures require a minimum of two projections, taken at 90° or as near as possible to right angles of each other. This is both to fully visualize the fracture site and to determine alignment of the fractured parts following surgery (Figs. 1.110 and 1.111).

Chest
ROUTINE
- PA, p. XXX
- Lateral, p. XXX

Upper Airway
ROUTINE
- Lateral, p. XXX
- AP, p. XXX

Chest
SPECIAL
- AP supine or semierect, p. XXX
- Lateral decubitus, p. XXX
- AP lordotic, p. XXX
- Anterior oblique, p. XXX
- Posterior oblique, p. XXX

Fig. 1.109 AP and lateral projection for foreign body (nail through anterior knee).

Fig. 1.110 AP humerus projection for postoperative fracture alignment.

Fig. 1.111 Lateral humerus projection for postoperative fracture alignment.

MINIMUM OF THREE PROJECTIONS WHEN JOINTS ARE IN AREA OF INTEREST

This second general rule or principle suggests that all radiographic procedures of the skeletal system involving joints require a minimum of **three** projections rather than only two. These are **AP** or **PA, lateral,** and **oblique projections.**

The reason for this rule is that more information is needed than can be provided on only two projections. For example, with multiple surfaces and angles of the bones making up the joint, a small oblique chip fracture or other abnormality within the joint space may not be visualized on either frontal or lateral views but may be well demonstrated in the oblique position.

Following are examples of examinations that generally require three projections as routine (joint is in prime interest area):

- Fingers
- Toes
- Hand
- Wrist (Fig. 1.112)
- Elbow
- Ankle
- Foot
- Knee

Examples of examinations that require two projections as routine include the following:

- Forearm
- Humerus
- Femur
- Hips
- Tibia-fibula (Figs. 1.113 and 1.114)
- Chest

Exceptions to Rules

- Postreduction upper and lower limbs generally require only two projections for checking fracture alignment.
- **A pelvis study requires only a single AP projection unless a hip injury is suspected.**

Palpation of Topographic Positioning Landmarks

Radiographic positioning requires the location of specific structures or organs within the body, many of which are not visible to the eye from the exterior. Therefore, the technologist must rely on bony landmarks to indicate their location. These bony structures are referred to as **topographic landmarks.** Fig. 1.115 shows examples of topographic landmarks of the pelvis. (see Chapter 2, Chest, p. 70, and Chapter 3, Abdomen, p. 103, for topographic landmarks for chest, abdomen, and pelvis). Topographic landmarks can be located by a process referred to as *palpation*.

PALPATION

Palpation refers to the process of applying light pressure with the fingertips directly on the patient to locate positioning landmarks. **This must be done gently,** because the area being palpated may be painful or sensitive for the patient. Also, **the patient should always be informed of the purpose of this palpation before this process is begun, and patient permission should be obtained.**

NOTE: Palpation of certain landmarks, such as the ischial tuberosity and the symphysis pubis, may be embarrassing for the patient and **may not be permitted by institutional policy.** Technologists should use alternative landmarks as described in later chapters.

Fig. 1.112 Wrist—requires three projections.

Fig. 1.113 AP lower leg projection.

Fig. 1.114 Lateral lower leg projection (same patient as Fig. 1.113).

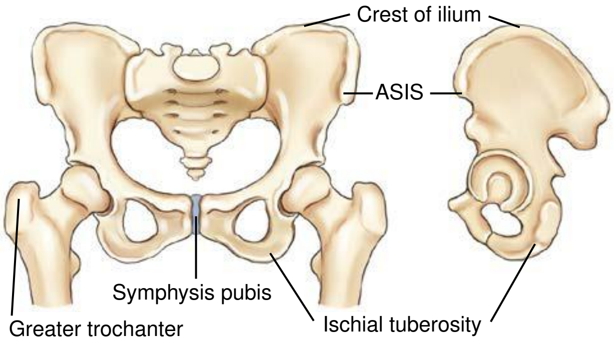


Fig. 1.115 Topographic landmarks of the pelvis.