Study Guide 2

This guide covers chapters 3 and 4. First you learn what a synovial joint is, how examiners feel joint play and end feel, what the pop of a joint really is, and how injured tissue heals and remodels. Then you learn what a manipulation is in physical terms: the grades, the force time curve, the barrier model, what the thrust does and does not do, and how to keep it safe. Work one chapter at a time, cover the steps of each worked case before you read them, and finish with the ten board style self-test items. The cram sheet at the end holds every number and rule.

WHAT THIS GUIDE COVERS

- Chapter 3 · synovial joint parts and lubrication, facet orientation and meniscoids, Wyke receptor types, joint play and the convex concave rule, close and loose packed positions, end feel and capsular patterns, cavitation, healing phases, tissue differences, immobilization and remodeling.
- Chapter 4 · manipulation versus mobilization, Maitland grades, technique families, the thrust profile, rate and impulse, the barrier model, mechanical and neurophysiological effects, clinical evidence, adverse events, contraindications and cervical artery screening.

CHAPTER 3

Joints, Cavitation and Tissue Response

Read it in full: **Chapter 3 in the textbook**. See it in motion: **Joints and Cavitation Walkthrough** and **Joints and Cavitation Lab**.

What to know

Joints are classified two ways. Structurally they are fibrous, cartilaginous (synchondrosis or symphysis, such as the disc) or synovial. Functionally they are synarthroses (immovable), amphiarthroses (slightly movable) or diarthroses (freely movable); nearly all diarthroses are synovial. Each motion segment has a cartilaginous joint in front (the disc) and two synovial facet joints behind.

A synovial joint is a sealed bearing. **Hyaline cartilage** (1 to 4 mm in small joints, up to about 6 mm in the knee) has no vessels, lymphatics or nerves. Chondrocytes sit in a matrix of type II collagen and proteoglycans, chiefly aggrecan, and cartilage is about 65 to 80% water. The capsule has an outer fibrous layer (mostly type I collagen) and an inner **synovial membrane**: type A synoviocytes clear debris, and type B synoviocytes secrete hyaluronan and lubricin. Normal synovial fluid is clear, scant (about 1 to 4 mL in a knee) and has fewer than about 200 white cells per microliter. Hyaluronan makes it shear thinning.

Cartilage on cartilage has a friction coefficient of about 0.001 to 0.01, lower than ice on ice. Three mechanisms share the work: **boundary** lubrication (lubricin and phospholipids on the surface), **fluid film** lubrication and **weeping** (hydrostatic) lubrication, where compression squeezes water out of the matrix. That same sponge action feeds the chondrocytes, so cartilage needs cyclic loading to stay healthy.

Facet joints are synovial **plane** joints holding about 1 to 1.5 mL of fluid in the lumbar spine. Their angle sets regional motion: about 45 degrees in the typical cervical spine, about 60 degrees and near the frontal plane in the thorax, near sagittal and curved in the lumbar spine. They contain **meniscoids**: connective tissue rims, adipose pads and fibroadipose meniscoids up to about 5 mm long. Each facet is supplied by medial branches of the dorsal rami from its level and the level above. Wyke's receptors: type I report static position, type II signal the onset of motion, type III fire near end range, and type IV are free nerve endings (nociceptors).

Osteokinematics is visible bone motion; **arthrokinematics** is roll, glide and spin between surfaces. **Joint play** (accessory motion) is passive motion a clinician can produce but the patient cannot. The **convex concave rule**: a convex surface moving on a fixed concave one rolls and glides in opposite directions (the humeral head rolls up and glides down in abduction); a concave surface moving on a fixed convex one rolls and glides the same way. The flat spinal facets do not follow the rule neatly.

The **close packed** position is the most congruent, with a taut capsule and minimal play (knee and elbow full extension; hip extension with abduction and internal rotation). The **loose packed** (resting) position has the most play and is where joint play is tested. Kaltenborn grades joint play 0 to 6: 0 ankylosed, 1 to 2 hypomobile, 3 normal, 4 to 5 hypermobile, 6 unstable. In the spine,

palpation for pain has fair to good agreement between examiners, but palpation for motion or position alone has poor to fair reliability, with kappa often below 0.4.

Cyriax's **end feels**: soft (tissue approximation), firm (capsular or ligamentous) and hard (bone to bone) can all be normal. Springy block (internal derangement), spasm (protective guarding), boggy (effusion) and **empty** (pain stops motion before any resistance; serious pathology) are abnormal. Ask what should stop the motion and whether it stopped where it should. The **capsular pattern** is the joint's typical proportional loss when the whole capsule is involved: glenohumeral loses external rotation, then abduction, then internal rotation; the knee loses flexion much more than extension; the cervical spine loses lateral flexion and rotation equally, then extension.

Cavitation is the sudden formation of a gas cavity in synovial fluid when sealed surfaces separate and pressure falls. The gas is mostly carbon dioxide, with nitrogen and oxygen. Unsworth (1971) linked the sound to bubble collapse and described a refractory period of about 20 minutes. Kawchuk's 2015 MRI study showed the cavity appearing at the crack and persisting, tying the sound to cavity formation; a 2018 model suggested rapid partial collapse. The pop is not a bone going back into place. Knuckle cracking has no clear link to arthritis.

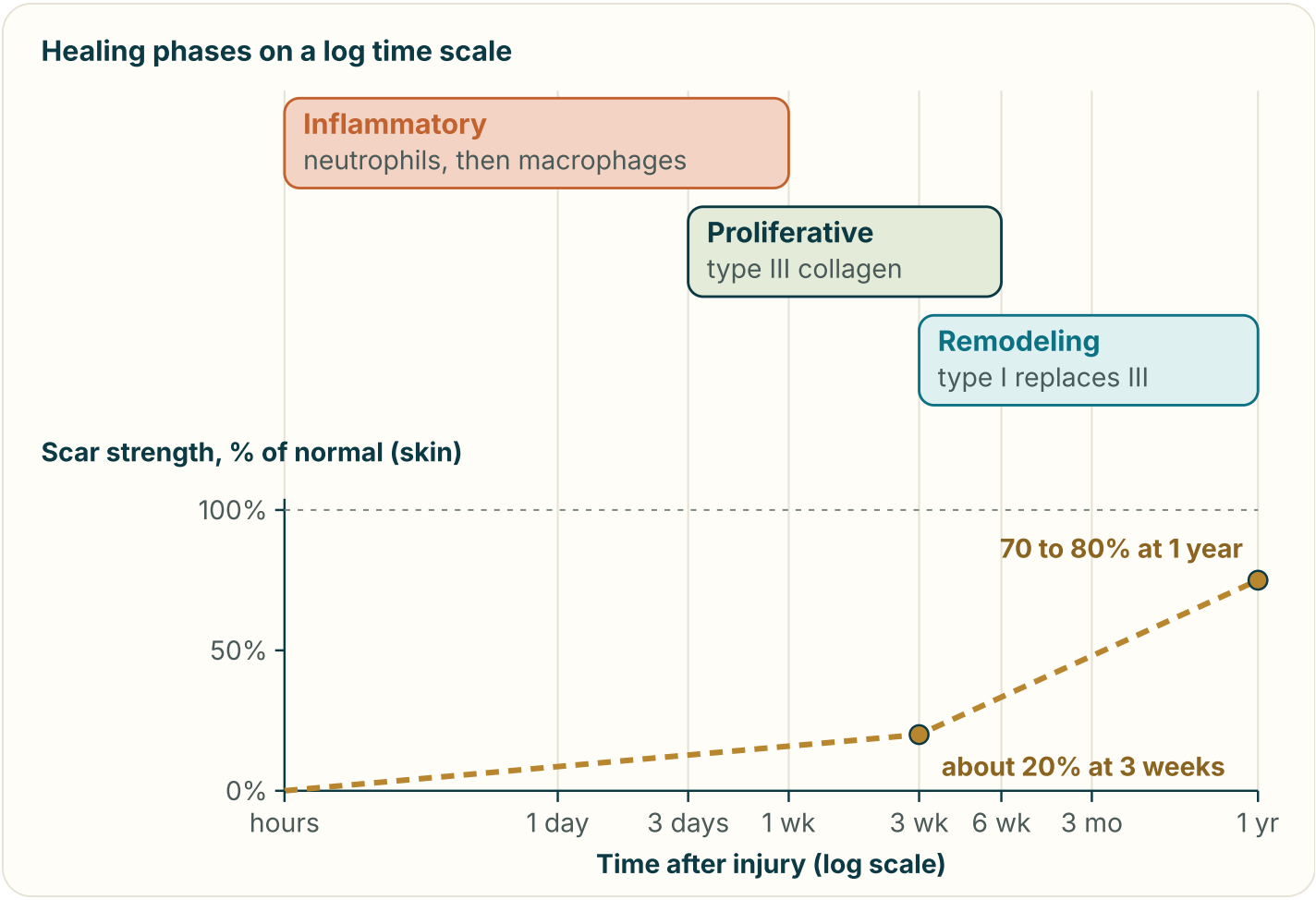
During spinal manipulation, cavitations often come from segments one or more levels away from the target, a single thrust often produces several, and outcomes are similar with or without an audible release. The pop is a byproduct, though it can shape a patient's expectations. Other joint sounds differ: a snapping tendon repeats with each movement, crepitus grinds through motion, and a click with locking suggests internal derangement.

Healing has three overlapping phases. **Inflammatory**: starts at injury, peaks at 1 to 3 days, largely settles by day 5 to 7; platelets (PDGF, TGF beta), neutrophils for the first 24 to 48 hours, then macrophages by 48 to 72 hours. **Proliferative**: about day 3 to 3 to 6 weeks; fibroblasts lay down **type III collagen**, granulation tissue forms and myofibroblasts contract the wound. **Remodeling**: about 3 weeks to 12 months or more; type I replaces type III and fibers align with stress. A skin scar is about 20% as strong at 3 weeks and 70 to 80% at a year.

Blood supply sets the pace. Muscle and bone heal well; bone truly regenerates with no scar (clinical union about 6 to 12 weeks in many adult fractures). Tendon and ligament heal slowly;

extra-articular ligaments such as the MCL heal better than intra-articular ones such as the ACL. Cartilage barely heals, and full thickness defects fill with weaker fibrocartilage. The disc is one of the poorest healers; a herniation often hurts less over time as macrophages resorb the fragment. Acute care advice moved from RICE to POLICE to PEACE and LOVE, with optimal loading replacing rest.

Tissues obey their loads: **Wolff's law** for bone, **Davis's law** for soft tissue, through **mechanotransduction**. Immobilization drains cartilage of proteoglycans, shortens and cross links the capsule, lets fibrofatty tissue form adhesions, weakens ligaments at their insertions, wastes muscle fastest in the first one to two weeks and thins weight bearing bone by about 1 to 2% a month. Loss is fast and recovery is slow. Rat studies show facet adhesions grow with immobilization time, but adhesions in human stiff segments, and their release by manipulation, are not proven. Creep and stress relaxation explain short term gains from a sustained stretch; lasting change needs remodeling over weeks.



Phases overlap, and strength lags behind. Inflammation settles within about a week, type III collagen fills the gap over weeks, and type I remodeling runs for a year or more. A skin scar is only about 20% as strong at 3 weeks and 70 to 80% at a year, long after pain fades.

LOCK THESE IN

- Cartilage: avascular, aneural, type II collagen and aggrecan, about 65 to 80% water, fed by cyclic loading.
- Type A synoviocytes clear debris; type B make hyaluronan and lubricin.
- Convex on concave: roll and glide opposite. Concave on convex: same direction.
- Close packed: most congruent, least play. Loose packed: most play, where joint play is tested.
- Empty end feel is never normal; a hard end feel is normal at elbow extension.
- Cavitation: gas forms as surfaces separate; refractory period about 20 minutes; not a bone moving into place.
- Healing: inflammatory (neutrophils then macrophages), proliferative (type III), remodeling (type I).
- Immobilization: fast loss, slow recovery. Wolff's law for bone, Davis's law for soft tissue.

End feels at a glance

End feel	What you feel	Normal example	When abnormal
Soft	Gradual squeezing stop	Knee or elbow flexion	Early stop from soft swelling
Firm	Leathery, slightly springy	Shoulder external rotation	Early firm stop: capsular tightness
Hard	Abrupt, unyielding	Elbow extension	Early hard stop: osteophyte, bony block
Springy block	Rebound before the expected end	None	Internal derangement (torn meniscus)
Spasm	Sudden muscular stop with pain	None	Guarding: acute injury, fracture, instability
Boggy	Soft, mushy stop	None	Effusion or marked swelling
Empty	Pain stops motion before resistance	None	Serious pathology: abscess, fracture, tumor

Healing by phase and by tissue

Item	Key facts	Remember
Inflammatory phase	Peaks 1 to 3 days, settles by day 5 to 7; neutrophils, then macrophages	No new collagen yet
Proliferative phase	About day 3 to 3 to 6 weeks; fibroblasts, granulation tissue	Type III: three for early
Remodeling phase	About 3 weeks to a year or more; fibers align with stress	Type I: one for the long run
Muscle	Rich supply; satellite cells regenerate	Mild strains 1 to 3 weeks
Ligament	Modest supply; longer, weaker scar	MCL heals better than ACL
Cartilage	No supply	Partial defects barely heal
Disc	Outer annulus and endplate margins only	Herniated fragments can resorb
Bone	Rich supply; regenerates without scar	Union about 6 to 12 weeks

Worked cases

WORKED CASE 1 · CHOOSING A MOBILIZATION DIRECTION

A patient cannot fully abduct the shoulder, and joint play testing shows a stiff glide. Using the convex concave rule, which glide should the clinician restore, and where should it be tested?

STEP 1 · IDENTIFY THE MOVING SURFACE

In abduction the convex humeral head moves on the fixed, concave glenoid.

STEP 2 · APPLY THE RULE

Convex on concave means roll and glide go in opposite directions. The head rolls up, so it must glide **down** (inferiorly).

STEP 3 · PICK THE TECHNIQUE

An inferior glide of the humeral head is the logical accessory motion to restore.

STEP 4 · PICK THE POSITION

Test and start in the loose packed position, about 55 degrees of abduction with slight horizontal adduction, where play is greatest.

KEEP THE CAVEAT

The rule is a starting point. Real joints are not perfect spheres, and the flat spinal facets do not follow it neatly.

WORKED CASE 2 · READING TWO END FEELS

During passive knee flexion an examiner feels a gradual squeezing stop at full range. At another visit a patient with hip pain stops passive motion because of severe pain before the examiner feels any tissue resistance. Interpret each.

STEP 1 · ASK WHAT SHOULD STOP THE KNEE

At full knee flexion the calf meets the thigh, so a soft (tissue approximation) end feel is expected.

STEP 2 · JUDGE IT

It came at the expected point, so it is a **normal soft** end feel.

STEP 3 · LOOK AT THE HIP

Motion stopped by pain with no resistance felt is an **empty** end feel, which is never normal.

STEP 4 · DECIDE THE ACTION

Empty end feel raises concern for serious pathology such as acute bursitis, abscess, fracture or tumor, so it calls for careful evaluation before any manual treatment.

WORKED CASE 3 · DATING A HEALING ANKLE SPRAIN

A patient sprained an ankle ten days ago. Which phase dominates, what collagen is being laid down, and what kind of activity helps? When will the ligament reach its final strength?

STEP 1 · PLACE DAY TEN

The inflammatory phase has largely settled by day 5 to 7. The proliferative phase runs from about day 3 to 3 to 6 weeks, so it dominates now.

STEP 2 · NAME THE COLLAGEN

Fibroblasts are laying down **type III collagen** in a fragile, disorganized scar that is gaining strength quickly.

STEP 3 · CHOOSE THE LOAD

Gentle, progressive loading and protected motion help align new collagen with lines of stress without overloading it.

STEP 4 · LOOK AHEAD

Remodeling to type I collagen continues for a year or more, and a healed ligament is often longer and weaker than the original. Pain fading early does not mean full strength.

TRAPS PEOPLE FALL INTO

- **Calling a hard end feel abnormal.** It is normal at elbow extension. Judge whether it fits the joint and comes at the right point.
- **Testing joint play in the close packed position.** Close packing tightens the capsule and leaves almost no play. Use the resting position.
- **Explaining the pop as a bone going back in.** The refractory period shows a fluid and gas event. Imaging shows a gas cavity, not a change in bone position.
- **Treating the audible release as the goal.** Outcomes are similar with or without it, and it often comes from a neighboring segment.
- **Mixing up collagen types.** Type III is early repair. Type I replaces it during remodeling. Cartilage is type II.
- **Thinking rest is always safest.** Tissues lose strength fast and regain it slowly. Short protection, then graded loading, is usually better.
- **Trusting motion palpation alone.** Palpation for motion or position has poor to fair reliability. Palpation for pain is better.
- **Calling adhesions the proven cause of fixation.** Adhesions are shown in rats. In people they are a plausible, partly supported mechanism.

Chapter 3 self-test · ten items

1. A lab slide shows fibroblast like lining cells making the lubricants of a facet joint. What are they?

A. Type B synoviocytes
B. Deep chondrocytes
C. Myofibroblasts
D. Type A synoviocytes

A. Type B synoviocytes Type B synoviocytes are fibroblast like and secrete hyaluronan and lubricin. Type A synoviocytes are macrophage like and clear debris.

2. A patient's wrist was in a cast for six weeks. Why did the articular cartilage thin and soften?

A. Excess lubricin production by the synovium
B. A sharp rise in type I collagen in the matrix
C. Ingrowth of new blood vessels into the cartilage matrix
D. Loss of the cyclic loading that pumps nutrients in

D. Loss of the cyclic loading that pumps nutrients in Chondrocytes have no blood supply. Compression and release pump fluid in and out, so without cyclic loading the matrix loses proteoglycans and water.

3. A concave tibial plateau extends on the fixed femoral condyles in open chain knee extension. Which way do roll and glide go?

A. Both posteriorly, in the same direction
B. Roll posterior and glide anterior
C. Both anteriorly, in the same direction
D. Roll anterior and glide posterior

C. Both anteriorly, in the same direction When a concave surface moves on a fixed convex one, roll and glide go the same way. The tibia rolls and glides anteriorly.

4. In which position is joint play greatest and easiest to assess?

A. The close packed position
B. The loose packed position
C. The capsular pattern position
D. Full end range extension

B. The loose packed position In the resting position the capsule is most lax and accessory motion is greatest. Close packing makes the surfaces congruent and the capsule taut.

5. A patient with a painful knee shows a rebound feel before the expected end of extension. What does this end feel suggest?

A. Capsular tightness from an adhesive capsulitis
B. A normal tissue approximation at full range
C. A normal bony block at the end of range
D. An internal derangement such as a torn meniscus

D. An internal derangement such as a torn meniscus A springy block is a rebound before the expected end. It suggests an internal derangement, classically a torn meniscus caught in the joint.

6. A patient has lost glenohumeral motion with external rotation most limited, then abduction, then internal rotation. How is this best described?

A. A noncapsular pattern from a ligament
B. A capsular pattern of the shoulder
C. An empty end feel at the shoulder
D. A close packed restriction of the shoulder

B. A capsular pattern of the shoulder External rotation, then abduction, then internal rotation is the glenohumeral capsular pattern, seen when the whole capsule is inflamed or contracted, as in adhesive capsulitis.

7. A patient cracks a finger joint and tries again at once with no sound. What explains this?

A. The cartilage surfaces have locked together
B. The bone has already been set back in place
C. The gas cavity must redissolve first
D. The tendon has stopped snapping over the bone

C. The gas cavity must redissolve first After cavitation there is a refractory period of about 20 minutes while the gas slowly redissolves. The timing points to a fluid and gas event, not a positional one.

8. High frame rate MRI was used to film finger joints being pulled until they cracked. What did it reveal?

A. The cavity appeared at the crack and remained after
B. The bubble collapsed fully at the moment of the crack
C. A tendon snapped over bone at the moment of the crack
D. No gas was present in the joint after the crack

A. The cavity appeared at the crack and remained after High frame rate MRI showed the cavity forming at the instant of the crack and persisting, linking the sound to cavity formation rather than complete collapse.

9. Why does a torn medial collateral ligament usually heal well without surgery while a partial thickness cartilage defect barely heals?

A. The MCL is intra-articular, bathed in synovial fluid
B. Cartilage is made of type I collagen that cannot remodel
C. The MCL heals by true regeneration like bone does
D. The MCL has a blood supply and cartilage has none

D. The MCL has a blood supply and cartilage has none The MCL is extra-articular with a blood supply that brings repair cells. Avascular cartilage gets no clot or repair cells unless a defect reaches bone.

10. Four days after a hamstring strain, which cell type has largely taken over from neutrophils?

A. Macrophages
B. Chondrocytes
C. Osteoblasts
D. Synoviocytes

A. Macrophages Neutrophils dominate the first 24 to 48 hours. Macrophages take over by about 48 to 72 hours, clear dead tissue and release signals that switch the area toward repair.

CHAPTER 4

Manipulation and Mobilization Mechanics

Read it in full: **Chapter 4 in the textbook**. See it in motion: **Manipulation and Mobilization Walkthrough** and **Manipulation and Mobilization Lab**.

What to know

Both manipulation and mobilization are passive. **Manipulation** (spinal manipulative therapy, an adjustment in chiropractic, an HVLA thrust) is a quick, short impulse at or near the end of passive range that the patient cannot stop once it begins. It is often, but not always, accompanied by cavitation. **Mobilization** is slower, rhythmic or sustained (about 1 to 3 oscillations per second), small or large, and the patient can stop it at any time. Chiropractic schools differ on what a subluxation means; for mechanics, an adjustment is an HVLA thrust and the research on manipulation applies to it.

The **Maitland grades** place techniques on the range. Grade I: small, at the start of range, before resistance (pain relief). Grade II: large, within range, up to but not into resistance. Grade III: large, from mid range into resistance (gain range). Grade IV: small, at the limit, into resistance. Grade V: very small and fast, beyond the passive limit into the paraphysiological space: the manipulative thrust. Grade IV and grade V work in nearly the same part of the range; the difference is velocity and whether the patient can stop it.

Technique families: **diversified** manual HVLA (the most widely taught chiropractic technique), Gonstead and other listing based systems, drop table (Thompson), **flexion distraction** (Cox, a slow mobilization style approach often used for disc related low back pain), instrument assisted (Activator, very fast and low amplitude), low force and reflex techniques, **mobilization with movement** (Mulligan, SNAGs in the spine, must be pain free) and osteopathic muscle energy. A technique can be specific (short lever) or nonspecific (long lever), and direct (into the restriction) or indirect (toward ease).

A thrust has three phases on a force time curve: **preload** (take up slack toward the end of passive range), **thrust** (a steep rise to peak force, about 100 to 200 ms in the spine) and **resolution**. A brief countermovement dip may appear before the thrust. Approximate peak forces: cervical about 100 to 150 N, thoracic about 250 to 550 N, lumbar or sacroiliac side posture about 200 to 500 N. Instruments reach their peak in under about 5 ms. Grade III to IV mobilization commonly uses about 50 to 150 N per oscillation. 100 N is about the weight of a 10 kg mass.

Force at the hand is not force at the joint. Skin, fat and muscle absorb part of it, and the rest is shared across several segments, the ribs and the pelvis. Target displacement is a few millimeters and a few degrees, and adjacent vertebrae move almost as much. Manipulation is less segment specific than it feels.

The defining feature is speed, not force. **Rate of force application** is force divided by time to peak (N/s): 400 N in 100 ms is 4,000 N/s. **Impulse** is force times time, the area under the curve (N·s); a large brief force can match a small long one. A fast thrust peaks before the stretch reflex builds a full guarding contraction. Animal recordings show spindle discharge is greatest at thrust durations around 75 to 150 ms. Remember: fast, not forceful. Peak forces are like lifting a bag of groceries.

The **barrier model** (Sandoz, 1976, plus osteopathic terms) runs from neutral outward: the neutral zone; active range ending at the **physiological barrier**; passive end play ending at the **elastic barrier** (where end feel is judged and grades III to IV act); the narrow **paraphysiological space** entered only by a thrust, often with cavitation; and the **anatomical barrier**, beyond which tissue is injured. In a stiff or painful joint a **restrictive barrier** stops motion early. Osteopathic language

describes ease (moves freely) and bind (early resistance). Memory aid: Patients Earn Paraphysiological Access.

The model is a drawing, not a measured map. Barriers are perceived along a smooth resistance curve, cavitation does not prove entry into a special space, the extra motion is small and short lived, and many joints that feel restricted move further under anesthesia. So a restrictive barrier is often neurological, which supports the idea that manual therapy works partly by changing nervous system output.

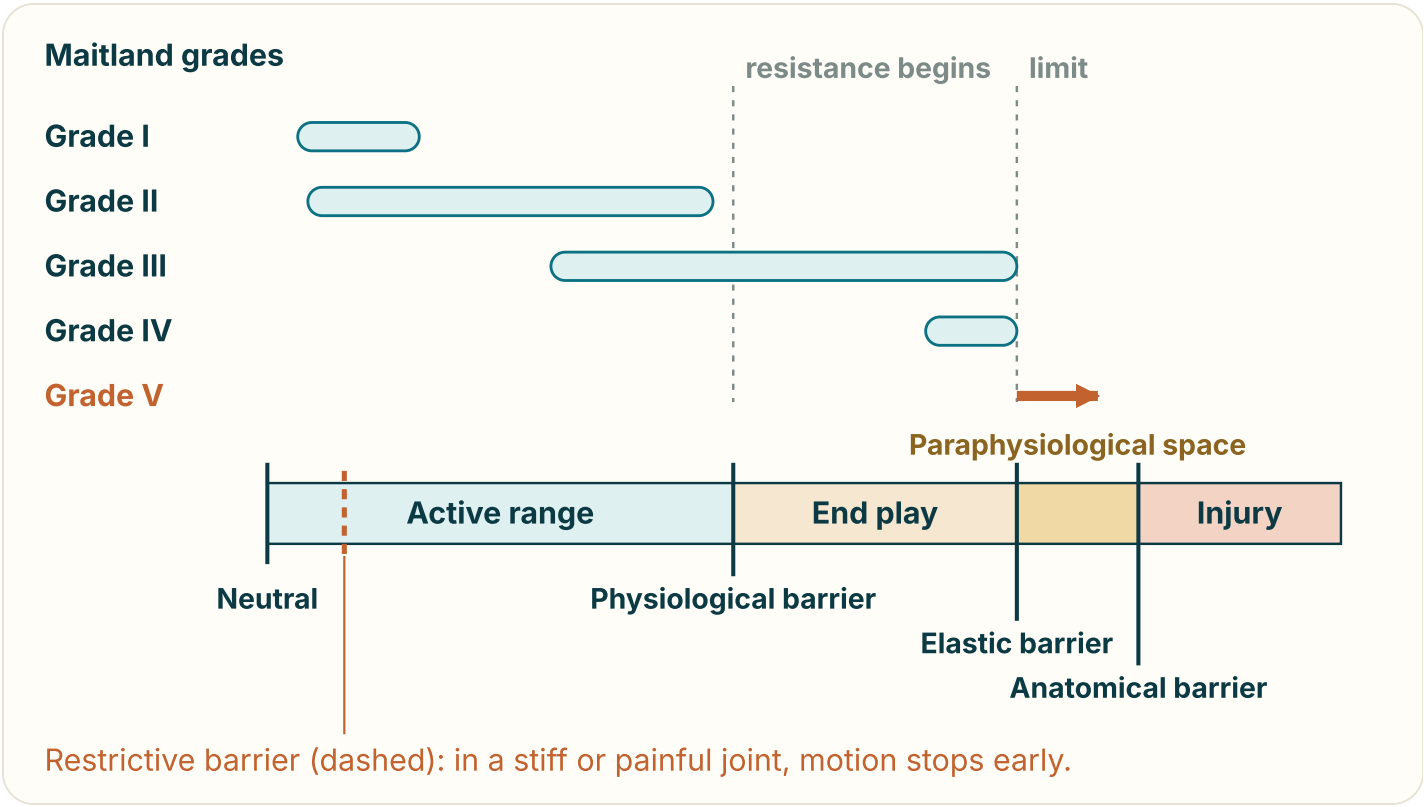
Mechanical effects: MRI shows side posture positioning gaps the upper facet joints and a thrust gaps them further, by about a millimeter, for an unknown time. Meniscoid release is anatomically plausible but not shown in patients. Adhesion release is shown only in animal models. Segmental stiffness drops after manipulation in some patients, and those whose stiffness drops most tend to improve most. **Vertebral repositioning is not supported** by imaging, and language implying misalignment can raise fear and dependence.

Neurophysiological effects (the Bialosky model of peripheral, spinal and supraspinal levels, shaped by expectation): a sensory barrage from spindles, tendon organs and joint receptors; dorsal horn inhibition and reduced **temporal summation**; brief reflex bursts; reduced motoneuron excitability on the **H-reflex**, usually for under a minute; small local and remote **hypoalgesia** (raised pressure pain thresholds) lasting minutes to hours; and sympathetic excitation, mainly with cervical techniques. Expectation and context consistently influence outcomes, and sham manipulation often helps too.

Clinical evidence: for low back pain, small to moderate short term improvements similar to exercise and appropriate medication, and several guidelines list manipulation as one option alongside staying active. For neck pain, short term benefit, especially with exercise. For cervicogenic headache, limited evidence; less for migraine and tension type headache. For asthma, high blood pressure, infant colic, otitis media and painful menstruation, well designed trials have **not** shown benefit, and claims of boosting immunity or treating organ disease are not supported.

Safety: about 30 to 60% of patients report a mild reaction (local soreness, stiffness, headache, tiredness), starting within 24 hours and resolving in 24 to 72 hours; mild reactions are also

common after sham and exercise. Serious events are rare: cervical artery dissection with stroke, cauda equina syndrome, worsening herniation, fracture and epidural hematoma. Population studies found vertebrobasilar stroke patients were as likely to have seen a primary care physician as a chiropractor beforehand, suggesting much of the link is people seeking care for an early dissection. Positional premanipulative tests have poor sensitivity; screen instead for the five Ds (dizziness, diplopia, dysarthria, dysphagia, drop attacks), three Ns (nausea, numbness, nystagmus) and ataxia, plus a new, unusual headache and Horner syndrome.



Where each technique acts. Grades I and II stay short of resistance, III and IV work into it, and the grade V thrust passes the elastic barrier into the narrow paraphysiological space but never to the anatomical barrier.

LOCK THESE IN

- Manipulation: HVLA, end of passive range, patient cannot stop it. Mobilization: slow, patient can stop it.
- Maitland I and II stay short of resistance (pain); III and IV go into resistance (range); V is the thrust.
- Thrust phases: preload, thrust (about 100 to 200 ms), resolution.
- Rate = force ÷ time to peak (N/s). Impulse = force × time (N·s).
- Barriers outward: physiological, elastic, paraphysiological space, anatomical. Restrictive barrier comes early.
- Supported: small gapping, brief neurophysiological effects. Not supported: lasting repositioning.
- Mild reactions in about 30 to 60%, resolve in 24 to 72 hours.
- Five Ds, three Ns and ataxia: refer urgently, do not manipulate.

Maitland grades and thrust numbers

Item	Value or description	Purpose or note
Grade I	Small amplitude, start of range, before resistance	Pain relief in an irritable joint
Grade II	Large amplitude, within range, up to resistance	Pain relief, gentle movement
Grade III	Large amplitude, mid range into resistance	Increase range
Grade IV	Small amplitude, at the limit, into resistance	Increase range in a less irritable joint
Grade V	Very small, high velocity, past the passive limit	Manipulation (thrust)
Cervical HVLA	Peak about 100 to 150 N; preload often under 50 N	About 50 to 150 ms
Thoracic HVLA	Peak about 250 to 550 N; preload about 100 to 250 N	About 100 to 200 ms
Lumbar or SI side posture	Peak about 200 to 500 N; preload about 50 to 200 N	About 100 to 200 ms
Spring instrument	Up to a few hundred N at the tip	Under about 5 ms

Contraindications to HVLA at the region

Category	Absolute	Relative (modify or choose another technique)
Bone	Acute fracture, tumor or metastasis, osteomyelitis, severe osteoporosis	Osteopenia, long term corticosteroids, healed fracture
Joint and ligament	Instability (atlantoaxial in RA or Down syndrome), acute dislocation	Hypermobility, spondylolisthesis, prior fusion at or next to the level
Neurological	Cauda equina syndrome, cord compression, rapidly progressing deficit	Radiculopathy with stable deficits
Vascular	Suspected cervical artery dissection, aortic aneurysm near the area	Anticoagulants or bleeding disorders, vascular risk factors
Inflammatory and infectious	Acute arthritis flare at the region, discitis, epidural abscess	Arthritis in remission, ankylosing spondylitis with fused segments
Other	Patient refusal, no diagnosis that justifies treatment	Pregnancy, pain that prevents relaxation, high anxiety

Worked cases

WORKED CASE 1 · RATE OF FORCE AND IMPULSE

A thoracic thrust starts from a 150 N preload and rises to a 450 N peak in 150 ms. A second technique must deliver an impulse of 20 N·s. Find the rate of force application of the first thrust, and the average force needed if the second impulse is delivered in 100 ms or in 400 ms.

STEP 1 · FIND THE RISE

The force climbs from 150 N to 450 N, a rise of 300 N.

STEP 2 · DIVIDE BY THE TIME TO PEAK

300 N ÷ 0.150 s = **2,000 N/s**.

STEP 3 · REARRANGE IMPULSE

Impulse = force × time, so average force = impulse ÷ time.

STEP 4 · SOLVE BOTH TIMES

20 ÷ 0.1 = **200 N** in 100 ms; 20 ÷ 0.4 = **50 N** in 400 ms.

WHAT IT SHOWS

The same impulse delivered faster needs a higher force. The shorter thrust also sits in the 75 to 150 ms range where spindle discharge is greatest in animal studies.

WORKED CASE 2 · GRADING TWO TECHNIQUES

One clinician applies slow, large oscillations to a lumbar segment that move into resistance near end range. A colleague applies a quick, tiny thrust at the same point. Name each, and say which the patient could stop.

STEP 1 · DESCRIBE THE FIRST

Large amplitude, low velocity, from mid range into resistance: a **grade III mobilization**.

STEP 2 · DESCRIBE THE SECOND

Small amplitude, high velocity, just past the passive limit: a **grade V manipulation** (HVLA thrust).

STEP 3 · COMPARE CONTROL

The patient can stop the mobilization at any time. Once the thrust begins, the patient cannot stop it.

STEP 4 · PLACE IT ON THE BARRIER MODEL

Grade III acts up to the elastic barrier; the thrust enters the paraphysiological space but never reaches the anatomical barrier.

WORKED CASE 3 · WALKING THE SAFETY PATHWAY

A 72 year old woman on long term prednisone has new mid back pain after lifting groceries. Walk through the safety pathway before choosing care.

STEP 1 · SCREEN FOR RED FLAGS

Age over 70 and long term corticosteroid use raise concern for osteoporosis and a vertebral compression fracture.

STEP 2 · DECIDE ON REFERRAL

A suspected fracture needs evaluation (and imaging where indicated) before any manual care.

STEP 3 · CHECK CONTRAINDICATIONS TO THRUST

Long term corticosteroid use is a relative contraindication and severe osteoporosis or acute fracture is absolute, so forceful thoracic HVLA should be avoided.

STEP 4 · CHOOSE THE DOSE

If fracture is excluded, gentle mobilization, soft tissue care and exercise are safer options, with informed consent and reassessment after each visit.

TRAPS PEOPLE FALL INTO

- **Defining manipulation by force.** It is defined by speed and small amplitude at the end of range. Peak forces are similar to lifting groceries.
- **Saying the thrust repositions a vertebra.** Imaging shows no lasting change in position. Displacements are tiny and shared across segments.
- **Believing a specific thrust moves one segment.** Neighboring vertebrae move almost as much as the target and often cavitate.
- **Treating a negative positional test as clearance.** Premanipulative positional tests have poor sensitivity and are not a reliable screen on their own.
- **Reading the stroke association as proof of cause.** Equal association with primary care visits suggests people seek care for an early dissection already underway.
- **Claiming benefit for nonmusculoskeletal disease.** Trials for asthma, hypertension, colic, otitis media and dysmenorrhea have not shown benefit.
- **Treating every reaction as caused by the thrust.** Mild reactions are common after sham and exercise too.
- **Confusing absolute and relative.** Osteopenia is relative; severe osteoporosis or acute fracture is absolute for HVLA at that region.

Chapter 4 self-test · ten items

1. A clinician applies small oscillations at the limit of a stiff, minimally irritable lumbar segment, into resistance. Which Maitland grade is this?

A. Grade V
B. Grade II
C. Grade I
D. Grade IV

D. Grade IV Grade IV is small amplitude at the limit of range, into resistance. Grade V is the thrust beyond the passive limit, and grades I and II stay short of resistance.

2. Both a grade IV mobilization and a grade V thrust act near the limit of range. What sets the thrust apart?

A. High velocity that the patient cannot stop
B. A peak force that is always above 1,000 N
C. A larger amplitude through the whole range
D. A starting point near the beginning of range

A. High velocity that the patient cannot stop Both act near the limit of passive range. Manipulation is a high velocity thrust the patient cannot stop; mobilization is slow and stoppable.

3. Which technique uses slow, rhythmic flexion and traction on a moving table and is often used for disc related low back pain?

A. Diversified HVLA
B. Muscle energy
C. Flexion distraction
D. Instrument assisted

C. Flexion distraction Flexion distraction (Cox) is a mobilization style approach using a moving table. Diversified is manual HVLA, and instrument techniques use a very fast spring impulse.

4. A lumbar thrust climbs from a 100 N preload to a 400 N peak in 150 ms. What is its rate of force application?

A. 200 N/s
B. 2,000 N/s
C. 20,000 N/s
D. 20 N/s

B. 2,000 N/s Rate is the rise in force divided by time to peak: (400 − 100) N ÷ 0.15 s = 2,000 N/s.

5. Why does a fast thrust meet less protective muscle guarding than a slow push?

A. It stretches only the skin, not the muscle
B. It delivers more total impulse than a push
C. It peaks before reflex guarding can build
D. It bypasses the muscle spindles entirely

C. It peaks before reflex guarding can build A protective contraction takes tens of milliseconds to begin and longer to build, so a thrust of about a tenth of a second reaches its peak first.

6. In the barrier model, which zone can be entered only by a sudden thrust?

A. The active range of motion
B. The paraphysiological space
C. The end play zone of the joint
D. The neutral zone of the joint

B. The paraphysiological space Sandoz described the paraphysiological space just beyond the elastic barrier, entered only by a thrust, often with cavitation. Beyond it lies the anatomical barrier.

7. Under anesthesia, a joint that felt restricted in the clinic moves much further. What does this suggest?

A. The anatomical barrier had moved outward
B. Adhesions were broken by the anesthetic
C. The joint capsule had fully remodeled overnight
D. Guarding contributed much of the restriction

D. Guarding contributed much of the restriction Much of a restrictive barrier in a painful patient comes from muscle activity and protective nervous system output, which anesthesia removes.

8. Which proposed effect of manipulation is not supported by imaging?

A. Lasting vertebral repositioning
B. Raised pressure pain thresholds
C. Reduced segmental stiffness
D. Facet gapping on side posture

A. Lasting vertebral repositioning MRI shows small gapping, stiffness drops in some patients and hypoalgesia is consistent. No imaging shows a lasting change in vertebral position.

9. A patient reports neck soreness and a mild headache the morning after a first cervical treatment. What is the best interpretation?

A. An absolute contraindication to any further manual care
B. A sign of cervical artery dissection needing urgent care
C. Proof that the thrust was delivered at the wrong level
D. A common mild reaction that usually settles in 1 to 3 days

D. A common mild reaction that usually settles in 1 to 3 days About 30 to 60% of patients report a mild reaction that begins within 24 hours and resolves within 24 to 72 hours. Neurological features such as the five Ds would change the picture.

10. A 38 year old has sudden severe neck pain and, since this morning, double vision and slurred speech. What should the clinician do?

A. Use a lateral flexion setup instead of rotation
B. Mobilize gently and recheck in a week
C. Do not manipulate; arrange emergency evaluation
D. Perform a positional test before deciding

C. Do not manipulate; arrange emergency evaluation Diplopia and dysarthria are among the five Ds of brainstem ischemia. With sudden neck pain they raise concern for cervical artery dissection and stroke.

ONE PAGE

Cram sheet

Everything from chapters 3 and 4 in one place. Cover the right column and see if you can rebuild each row.

Numbers to know

Item	Value	Note
Cartilage	1 to 4 mm (up to about 6 mm in the knee); 65 to 80% water	Avascular, aneural
Friction	Coefficient about 0.001 to 0.01	Lower than ice on ice
Synovial fluid	Knee about 1 to 4 mL; under about 200 white cells per µL	Lumbar facet about 1 to 1.5 mL
Meniscoids	Fibroadipose folds up to about 5 mm	Rims, fat pads, fibroadipose types
Kaltenborn grades	0 ankylosed; 1 to 2 hypo; 3 normal; 4 to 5 hyper; 6 unstable	Joint play scale
Palpation reliability	Motion and position kappa often below 0.4	Pain provocation fair to good
Refractory period	About 20 to 30 minutes	Gas redissolves
Inflammatory phase	Peaks 1 to 3 days; settles by day 5 to 7	Neutrophils 24 to 48 h; macrophages by 48 to 72 h
Proliferative phase	About day 3 to 3 to 6 weeks	Type III collagen
Remodeling phase	About 3 weeks to 12 months or more	Type I collagen
Skin scar strength	About 20% at 3 weeks; 70 to 80% at a year	Rarely full strength
Bone loss in disuse	About 1 to 2% per month	Bed rest or spaceflight
Thrust duration	About 100 to 200 ms in the spine	Instrument under about 5 ms
Peak force	Cervical 100 to 150 N; thoracic 250 to 550 N; lumbar 200 to 500 N	Mobilization 50 to 150 N
Spindle peak response	Thrusts of about 75 to 150 ms	Animal recordings
Mild reactions	About 30 to 60% of patients	Start within 24 h, resolve in 24 to 72 h

Equations and scales

Name	Rule	Units or note
Rate of force application	(Peak force − preload) ÷ time to peak	N/s
Impulse	Force × time (area under the curve)	N·s
Average force from impulse	Impulse ÷ time	N
Weight	100 N is about 10 kg	N
Maitland I to V	I small early; II large to resistance; III large into resistance; IV small at limit; V thrust	Grades of range
Barrier order	Physiological, elastic, paraphysiological space, anatomical	Restrictive comes early
Convex concave rule	Convex moves: opposite. Concave moves: same.	Roll and glide

Rules that are not equations

Topic	The rule
End feel	Ask what should stop the motion and whether it stopped where it should. Empty is never normal.
Capsular pattern	Shoulder: ER, then ABD, then IR. Knee: flexion much more than extension. Neck: side bend and rotation, then extension.
Cavitation	A gas cavity forms as sealed surfaces separate; it is not a bone going back into place.
Healing	Blood supply sets the pace: muscle and bone well, ligament and tendon slowly, cartilage and disc poorly.
Immobilization	Loss is fast, recovery is slow; keep it short and partial.
Mechanisms	Gapping and stiffness change shown; meniscoid and adhesion release unproven; repositioning not supported.
Evidence	Small to moderate short term benefit for low back and neck pain; no benefit shown for nonmusculoskeletal conditions.
Safety	Red flags: refer. Contraindication to thrust: gentler technique. Then consent, dose and reassess.
Screening	Five Ds, three Ns and ataxia; positional tests are not a reliable screen.

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