Pediatric Spondylolysis and Spondylolisthesis

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Introduction

- Spondylolisthesis – slipping of one vertebra on another most commonly at L5-S1
- Spondylolysis – defect/fracture of the pars interarticularis also most frequent at L5 (Fig. 142.1)
- Spondylolisthesis: First described by Herineaux, an obstetrician, in 1782 – discovered spondyloptosis blocking the birth canal
  - Kilian – in 1852 – coined the term.
  - Neugebauer, in 1888, recognized the lytic type.
  - Robert, the 1800s – cadaver studies sequentially severing posterior ligamentous elements and pars to demonstrate how slipping occurs.
  - Descriptions based on anatomic dissections before radiography.

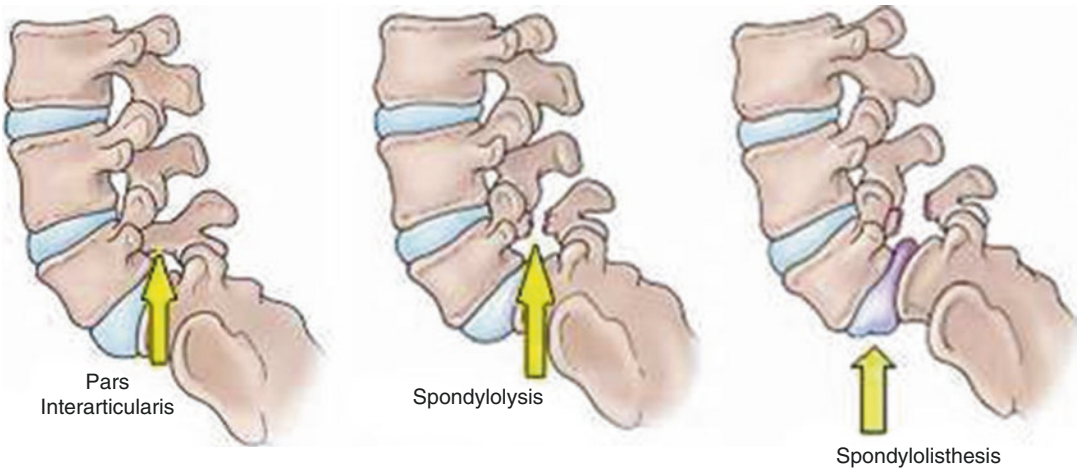

Fig. 142.1 Illustration of the status of the pars from intact to lysis to lysis with slip

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- Radiography allowed diagnosis on live patients and revealed different types and severity of slips necessitating a classification system.
- Newman and Wiltse – first comprehensive classification – (Table 142.1)
  - Weakness was not differentiating enough difference between dysplastic and lytic types – different natural history
- Marchetti and Bartolozzi classification (Table 142.2)
  - Two broad groups: developmental and acquired
  - Developmental type – high and low dysplasia – bad actor
    - Dysplasia of the components of the L-S junction
    - Underdeveloped facets, poor disc bond – hook-clasp concept of stability
    - Remodeling of sacral dome
    - Lysis of pars – not essential

Table 142.1 Newman – Wiltse classification

I	Dysplastic	A: facet with axial orientation B: facet with sagittal orientation
II	Isthmic	A: lysis B: elongation C: fracture
III	Degenerative	
IV	Post-traumatic	
V	Pathologic	
VI	Postsurgical	

Table 142.2 Marchetti-Bartolozzi classification

Developmental	Acquired
High dysplastic	Traumatic
With lysis	Acute fracture
With elongation	Stress fracture
	Postsurgical
	Direct
	Indirect
Low dysplastic	Pathologic
With lysis	Local
With elongation	Systemic
	Degenerative
	Primary
	Secondary

Etiology and Risk of Slippage

Developmental Type: Dysplasia of the Formation of the L-S Junction

- Abnormality allows gravity to displace the spine because of incompetent anatomic structures
- Displacement can be severe > spondyloptosis – L5 in front of the sacrum
- May be familial – potential genetic component

Acquired Type: Most Common (Lytic Type), Essential Component – Pars Defect

- Defect provides point of disconnection of the posterior elements of L5 with the sacrum and pelvis from the spine above.
- The spine can "rock" on the L5-S1 disc.
- Not a bad actor; maximal amount of slip not severe and reaches maximum in adolescence.

Risk Factors for Further Slip

- Patient characteristics – age, heredity, and pathology
- Classification – developmental vs acquired – different natural history
- Anatomy – integrity of the hook and clasp, disc bond, sacral doming, and slip angle
- Spinopelvic relationship – described by radiographic parameters as measured on standing lateral C-T-L radiographs that include the hip joints (Fig. 142.2)
- Pelvic incidence – specific for each individual – constant relationship
  - Sum of pelvic tilt and sacral slope
  - Should be within 10° of lumbar lordosis
- Patients with high PI and SS – "shear" force across L-S junction – set up for "unbalanced spine" described as + imbalance – lean forward with or without knee flexion
- Patients with low PI and SS – posterior compression at L-S junction, "nutcracker" – tend to be "balanced" (six types described)
- High slip angle – most important factor for further slip – basically a kyphotic relationship between L5 and S1 (Fig. 142.3)

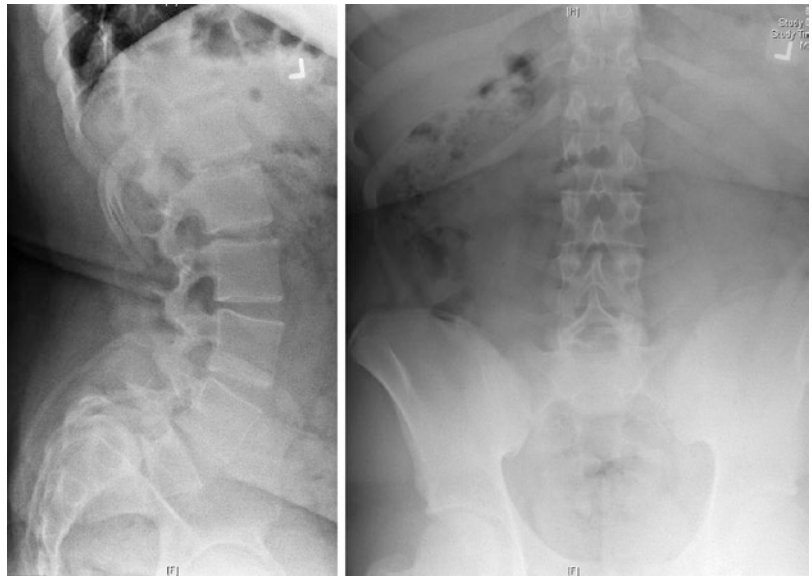

Fig. 142.2 Demonstration of a severe developmental spondylolisthesis with typical rounding of the top of the sacrum seen on the lateral and the axial view of the slipped L5 sometimes called the "Inverted Napoleon's Hat" sign

Presentation

- Presenting complaints – back pain +/– deformity; +/– history of recent injury; +/– history of leg pain
- Activities associated with repeated back hyperextension (gymnastics, FB, diving, etc), abnormality of gait
- Pain – activity related and usually without sciatica
- Physical exam – may appear normal, or + spinal imbalance, gait abnormality, tight hamstrings, limited ROM, abnormal stance (jump position), abnormal appearance of back (L-S step-off), and appearance of shortened trunk

Diagnosis

- Conventional radiography
- Standing long PA and lateral C-T-L plain radiographs to include the hips
- Standing spot lateral L-S spine to include the hips (Fig. 142.3)
- Oblique L-S spine images – usually unhelpful – needless radiation
- Measure spinopelvic parameters and amount of slip and assess global balance
  - Nuclear imaging – three-phase technetium bone scan with SPECT imaging
    - Assesses metabolic activity in pars
  - Advanced imaging – CT without contrast
    - Best to demonstrate the anatomy (unfortunately done recumbent, do standing if technology available)
    - MRI without contrast
    - Best to evaluate disc, nerve roots, and thecal sac
    - May demonstrate metabolic activity in the pars – signal change

Treatment

Spondylolysis

- Determine acuity – + bone scan – chance to heal pars
- If bone scan + LSO for at least 3–6 months evaluate healing on radiograph or CT > gradually wean from brace > PT for core strengthening > slowly resume activities
- If bone scan cold – treat symptomatically with or without LSO (no natural endpoint for bracing in this scenario), PT, NSAIDs, resume activities when symptoms resolved or tolerable
- If symptoms recur or never resolve consider:
  - Pars repair (best for lysis above L5) no more than G 1-associated slip
  - P-L fusion with instrumentation (Fig. 142.4)

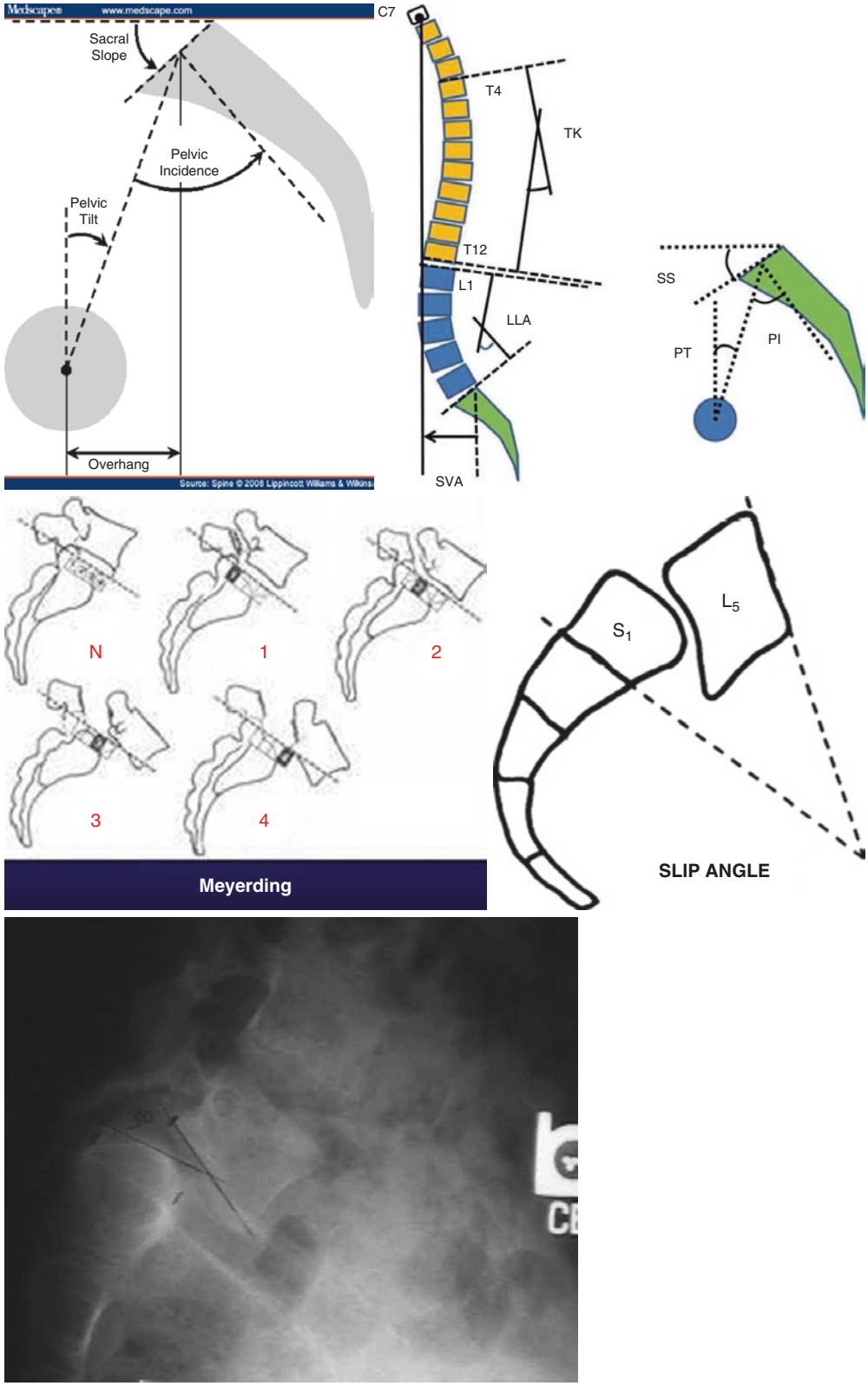

Fig. 142.3 Illustration of the various spino-pelvic parameters

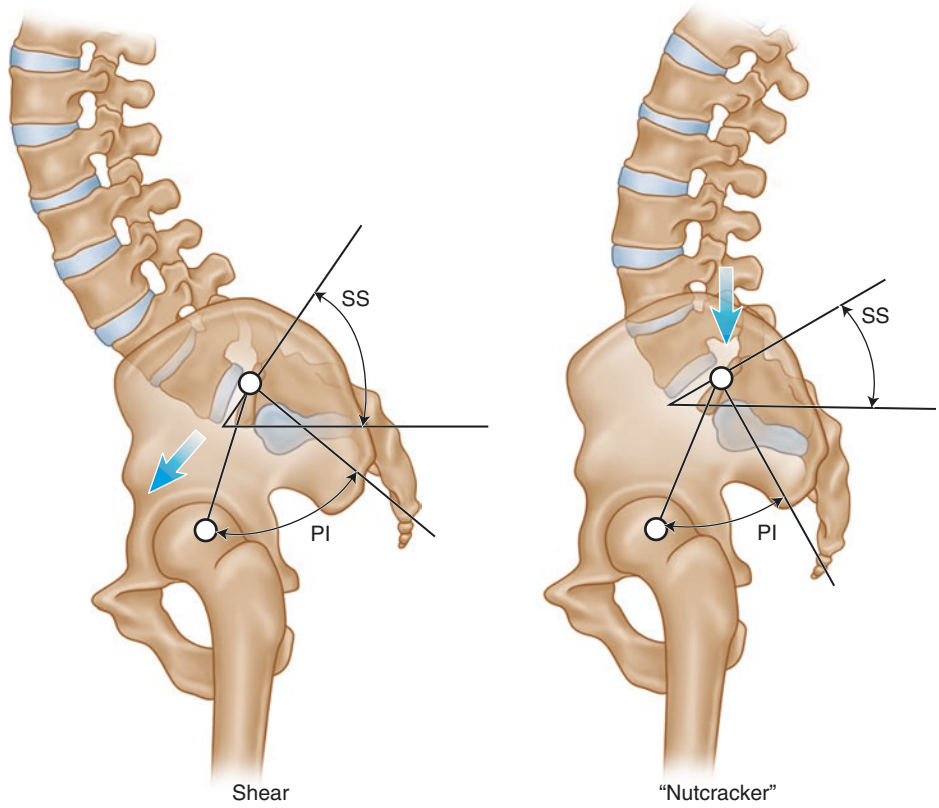

Fig. 142.4 Illustration of two sagittal alignments based on the pelvic incidence

Spondylolisthesis

- Nonoperative treatment (mainstay): activity modification, PT, and NSAIDs
  - May have asymptomatic periods interspersed with symptomatic ones
- Surgical treatment – P-L fusion in situ – gold standard
  - Traditionally no instrumentation but not now
  - Options: P-L fusion with instrumentation – when overall balance is good
    - May supplement usual construct with ASF. PLIF TLIF or transsacral bone graft and/or cage
    - Reduction – more complicated and neuro risky
      - Goal is to realign, not 100% reduction
      - Requires 360 fusion with instrumentation
    - Vertebrectomy (Gaines procedure)
    - For spondyloptosis – usually two stages (Figs. 142.5 and 142.6)
      - Technically very difficult and tedious
      - >50% risk of some neuro deficit postoperative
      - Completely realigns the spine
    - Neuromonitoring is essential for all options – cauda equina
    - Syndrome described after P-lL fusion in situ

Summary

- Spondylolysis and spondylolisthesis are diagnosis contradictions because symptoms in patients carrying these diagnoses can be so disparate. There seem to be few absolute indications for any kind of treatment, especially

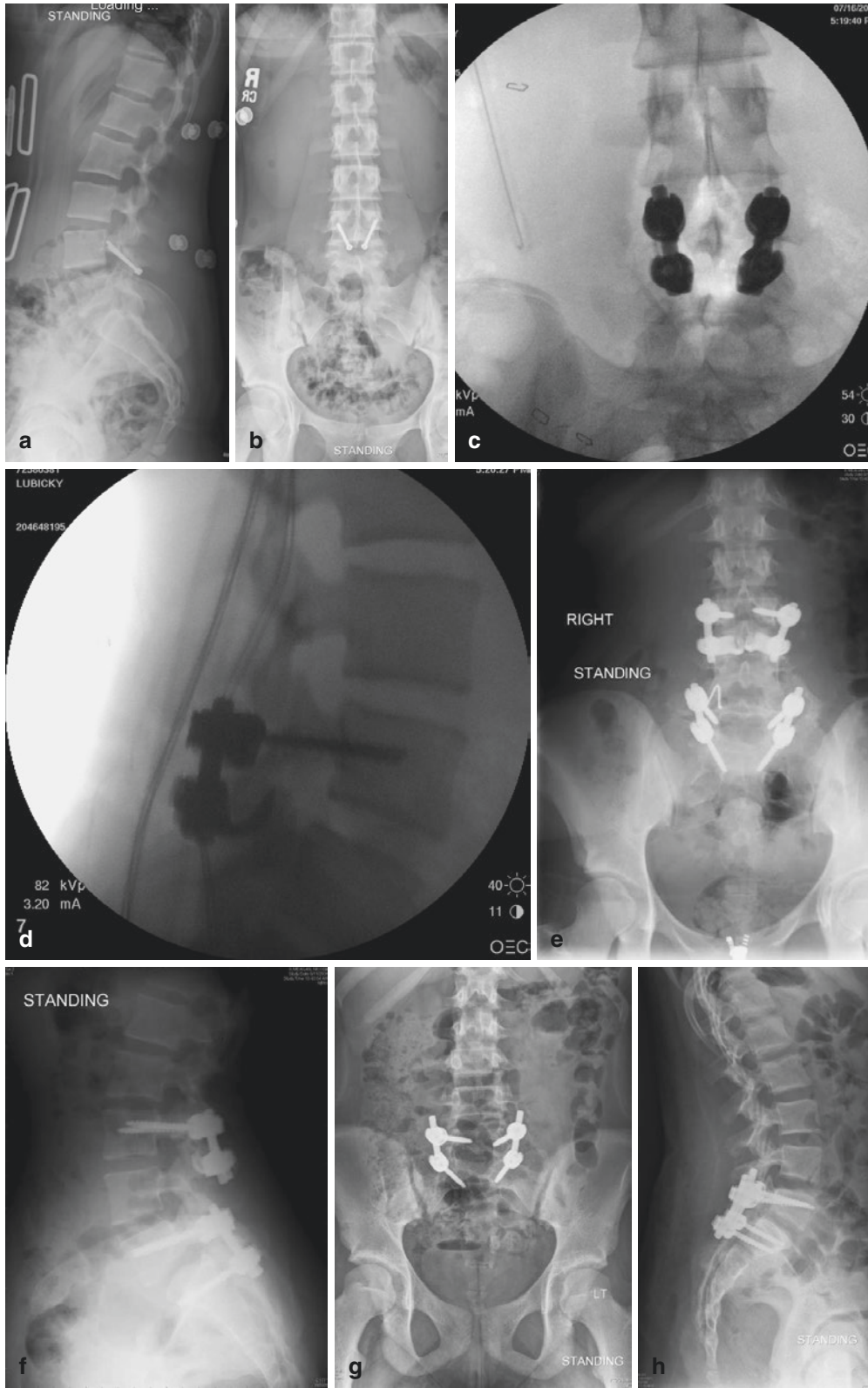

Fig. 142.5 (**a**, **b**) Buck pars repair. (**c**, **d**) pedicle screw/sublaminar hook repair. (**e**, **f**) 1 level pars reapir & L5-S1 PL fusion. (**g**, **h**) L5-S1 PL fusion

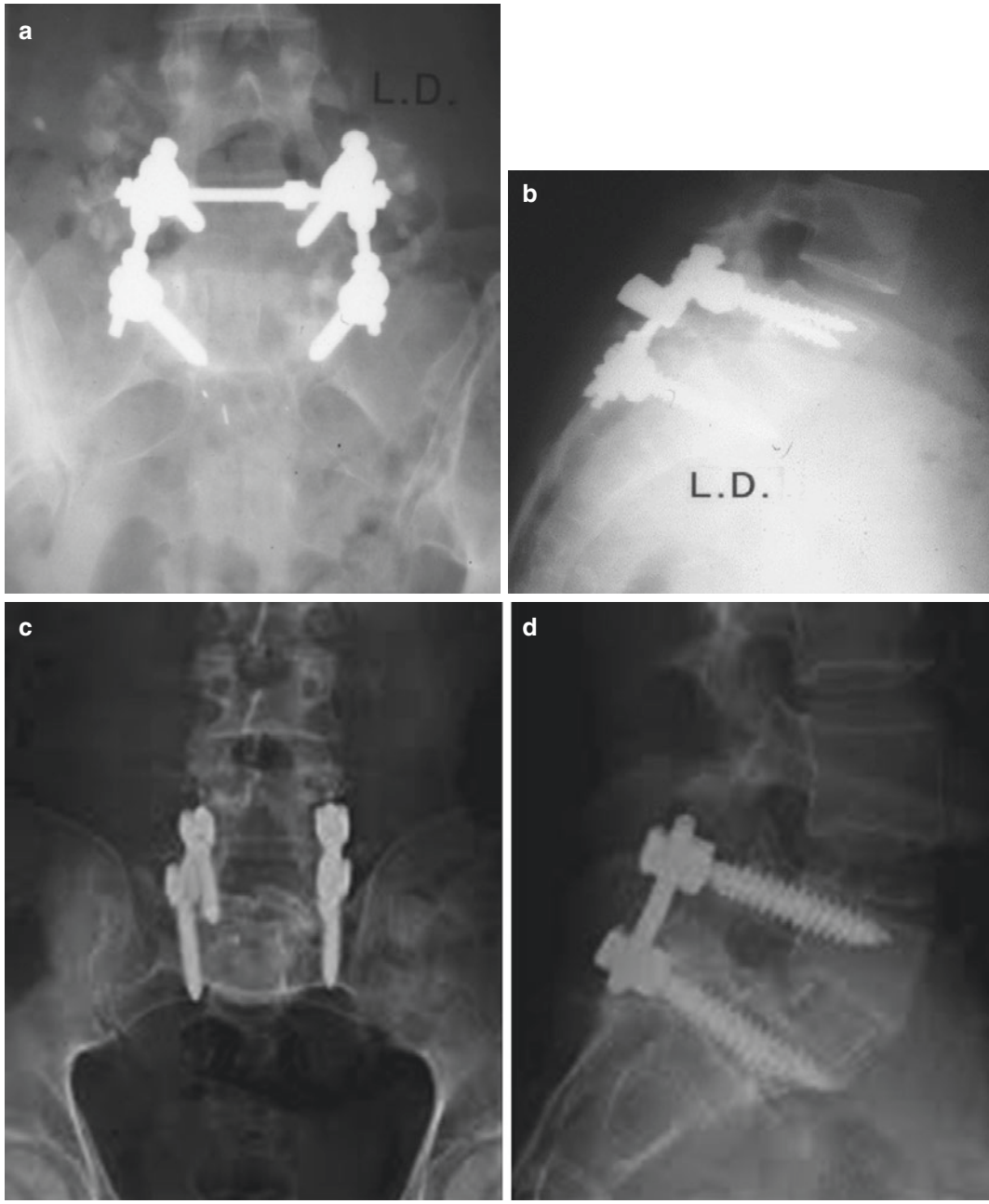

Fig. 142.6 (**a**–**f**) listhesis reductions using different implants a interbody structural supports. (**g**–**i**) spondyloptosis treated with Gaines procedure

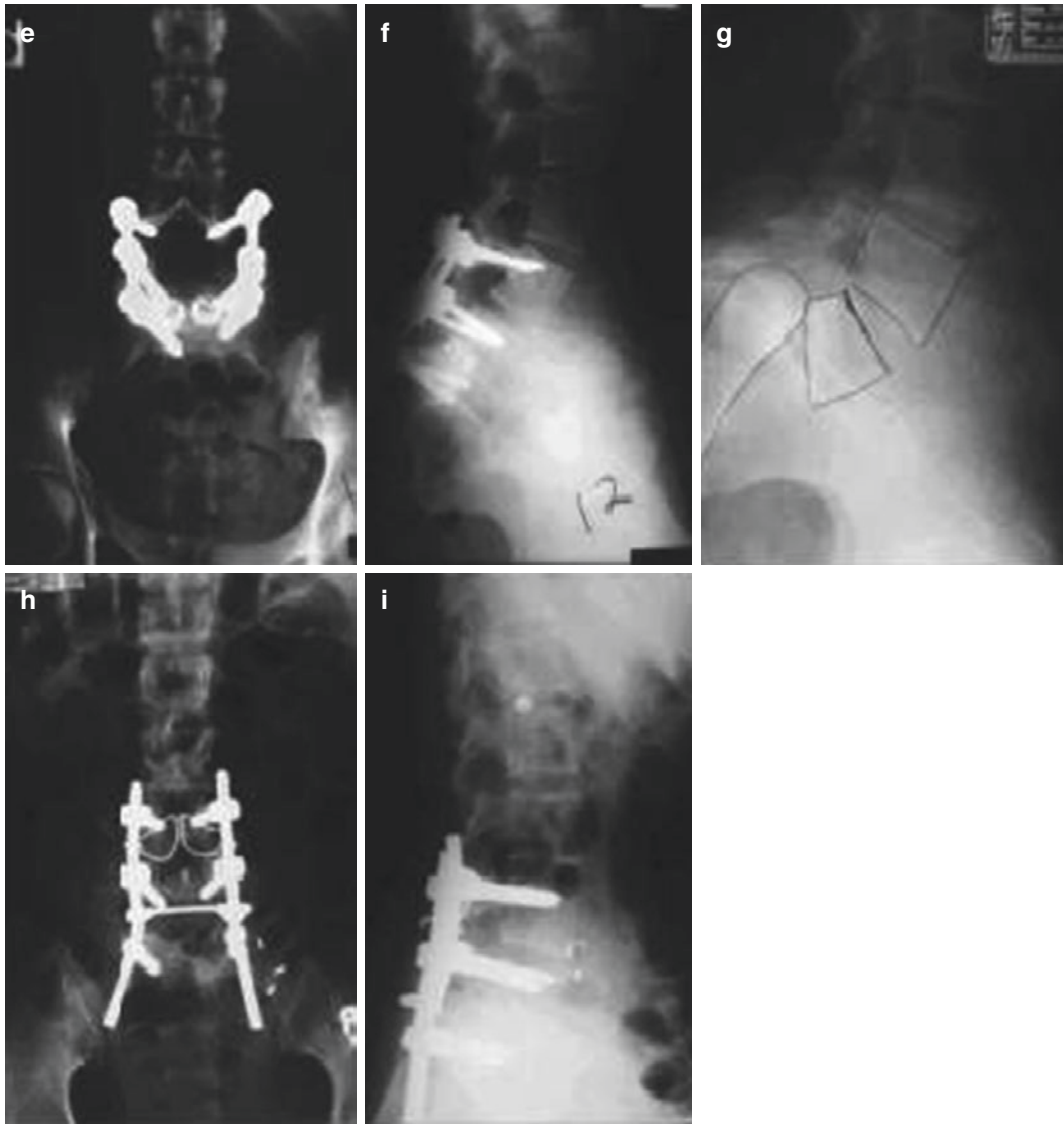

Fig. 142.6 (continued)

surgery. Neurologic deficit (uncommon) and severe deformity that interferes with function may qualify. Surgery for the relief of back pain is always problematic and often unreliable. An uneventful operation without complications evaluated by the usual radiographic may seem perfect. Yet the PRO may be poor. This and the fact that some patients with even severe slips may be asymptomatic is a treatment conundrum.

Reference

(Students are encouraged to peruse the extensive collection of classic papers included in the bibliographies of the following textbook chapters)

1. Shah SA, Shafa E. Scheuermann's Kyphosis. In: Heary RF, Albert TJ, editors. Spinal deformities: the essentials. 2nd edn. New York: Thieme Medical Publishers; 2014. p. 163–74.