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Appendix A: Medline search strings

Search 1 (24 November 2018):

(Back[Mesh] OR "lumbar vertebrae"[Mesh] OR lumbosacral [Tiab] OR lumbar [Tiab] OR intervertebral[Tiab]) **AND** ("spinal fusion" [Mesh] OR "spinal fusion"[Tiab] OR "spine surgery"[Tiab] OR "spine procedure"[Tiab] OR "spine procedures"[Tiab] OR "lumbar surgery"[Tiab] OR "lumbar spinal fusion"[Tiab] OR "spine fusion"[Tiab] OR spondylodesis[Tiab] OR "spinal arthrodesis"[Tiab] OR "posterolateral fusion"[Tiab] OR"posterior lumbar fusion"[Tiab] OR "posterior fusion"[Tiab] OR "posterior spinal fusion"[Tiab] OR "posterolateral lumbar spine fusion"[Tiab] OR "posterior spine fusion"[Tiab] OR "posterolateral spine fusion"[Tiab] OR "interbody fusion"[Tiab] OR "anterior spinal fusion"[Tiab] OR "anterior spine fusion"[Tiab] OR "anterior interbody fusion"[Tiab] OR "anterior lumbar interbody fusion"[Tiab] OR "transforaminal lumbar interbody fusion"[Tiab] OR "transforaminal interbody fusion"[Tiab] OR "lateral lumbar interbody fusion"[Tiab] OR "lateral interbody fusion"[Tiab] OR "posterior interbody fusion"[Tiab] OR "posterior lumbar interbody fusion"[Tiab] OR "extreme lateral interbody fusion"[Tiab] OR "extreme lateral lumbar interbody fusion"[Tiab] OR ALIF [Tiab] OR TLIF[Tiab] OR LLIF[Tiab] OR PLIF[Tiab] OR XLIF[Tiab]) **AND** (Radiculopathies[Tiab] OR Radiculopathy[Tiab] OR "Nerve root"[Tiab] OR radiculitis[Tiab] OR radiculitides[Tiab] OR radiating[Tiab] OR Radicular[Tiab] OR "spinal stenosis"[Mesh] OR "spinal stenosis"[Tiab] OR stenosis[Tiab] OR spondylolisthesis[Mesh] OR spondylolisthesis[Tiab] OR "low back pain"[Mesh] OR "low back pain"[Tiab] OR "back pain"[Tiab] OR sciatica[Mesh] OR sciatica[Tiab] OR sciaticas[Tiab] OR sciatic[Tiab] OR spondylosis [Mesh] OR spondylosis[Tiab] OR "intervertebral disc degeneration"[Mesh] OR "intervertebral disc degeneration"[Tiab] OR "degenerative disc disease"[Tiab] OR "degenerative disc disorder"[Tiab] OR "spinal degeneration"[Tiab] OR facetarthrosis[Tiab]) OR "bone substitutes"[Mesh] OR "Bone transplantation"[Mesh] OR "graft rejection"[Mesh] OR "graft survival"[Mesh] OR transplantation, autologous"[Mesh] OR allograft[Mesh] OR "absorbable collagen sponge[Tiab] OR "autologous iliac crest bone"[Tiab] OR "bone marrow aspirate"[Tiab] OR coralline [Tiab] OR "compression-resistant matrix" [Tiab] OR "demineralized bone matrix"[Tiab] OR DBM[Tiab] OR "femoral ring allograft"[Tiab] OR hydroxyapatite[Tiab] OR "iliac crest bone graft[Tiab] OR "osteogenic protein"[Tiab] OR bonegraft[Tiab] OR "bone substitute"[Tiab] OR "bone morphogenic protein"[Tiab] OR "recombinant human bone morphogenetic protein"[Tiab] OR "tricalcium phosphate"[Tiab] OR autograft[Tiab] OR "bone graft substitutes[Tiab] OR "bone graft alternatives"[Tiab] OR "fusion extenders"[Tiab] OR ceramics[Tiab] OR "calcium sulphate"[Tiab] OR "tricalcium sulphate"[Tiab] OR "autologous growth factors"[Tiab] OR "AGF peptides"[Tiab] OR "stem cells"[Tiab] OR rhBMP-2[Tiab] OR rhBMP-7 OR OP-1[Tiab] OR "synthetic peptides"[Tiab]) **AND** (Osseointegration[Mesh] OR osseointegration[Tiab] OR "bony fusion"[Tiab] OR "spinal fusion/adverse effects"[Mesh] OR "spinal fusion/classification"[Mesh] OR fusing[Tiab] OR "fusion rate"[Tiab] OR "fusion rates"[Tiab] OR "radiographic fusion"[Tiab] OR "radiological fusion"[Tiab] OR "successful fusion"[Tiab] OR nonunion[Tiab] OR pseudoarthrosis[Tiab] OR pseudoarthrosis[Tiab] OR pseudarthrosis[Tiab] OR "bone union rate"[Tiab] OR "fused"[Tiab]) **NOT** (animals [Mesh] NOT humans [Mesh])

Search 2 (19 July 2021):

(Lumbar[Tiab] OR "Lumbar vertebrae"[Mesh] OR "lumbosacral region"[Mesh]) **AND** ("spinal fusion"[Mesh] OR "spinal fusion"[Tiab] OR "spine fusion"[Tiab] OR spondylodesis[Tiab] OR "spinal arthrodesis"[Tiab] OR "posterolateral fusion"[Tiab] OR "posterior lumbar fusion"[Tiab] OR "posterior fusion"[Tiab] OR "posterior spinal fusion"[Tiab] OR "posterolateral lumbar fusion"[Tiab] OR "posterior spine fusion"[Tiab] OR "posterolateral spine fusion"[Tiab] OR "posterolateral spinal fusion" OR "interbody fusion"[Tiab] OR "anterior spinal fusion"[Tiab] OR "anterior spine fusion"[Tiab] OR "anterior interbody fusion"[Tiab] OR "anterior lumbar interbody fusion"[Tiab] OR "transforaminal lumbar interbody fusion"[Tiab] OR "transforaminal interbody fusion"[Tiab] OR "lateral lumbar interbody fusion"[Tiab] OR "lateral interbody fusion"[Tiab] OR "posterior interbody fusion"[Tiab] OR "posterior lumbar interbody fusion"[Tiab] OR "extreme lateral interbody fusion"[Tiab] OR "extreme lateral lumbar interbody fusion"[Tiab] OR ALIF[Tiab] OR TLIF[Tiab] OR LLIF[Tiab] OR PLIF[Tiab] OR XLIF[Tiab]) **AND** ("lumbar vertebrae/diagnostic imaging"[Mesh] OR "Lumbosacral Region/diagnostic imaging"[Mesh] OR "Spine/diagnostic imaging"[Mesh] OR "pseudarthrosis/diagnostic imaging"[Mesh] OR radiography[MesH] OR "Tomography, X-ray"[Mesh] OR "Tomography, X-ray Computed"[Mesh] OR "X-ray"[Tiab] OR radiograph*[Tiab] OR "computed tomography"[Tiab] OR CT[Tiab] OR DEXA[Tiab] OR "Dual Energy X-ray Absorptiometry"[Tiab] OR SPECT[Tiab] OR "Single Photon Emission Computed Tomography"[Tiab] OR PET[Tiab] OR "Positron Emission Tomography"[Tiab] OR MRI[Tiab] OR "Magnetic Resonance Imaging"[Tiab] OR Absorptiometry, Photon[MesH] OR Tomography, Emission-Computed, Single-Photon[MesH] OR Positron Emission Tomography Computed Tomography[MesH] OR Magnetic Resonance Imaging[MesH]) **AND** ("Predictive value of tests"[Mesh] OR "Sensitivity and Specificity"[Mesh] OR "reference standards"[Mesh] OR "reproducibility of results"[Mesh] OR "observer variation"[Mesh] OR reliability[Tiab] OR "diagnostic accuracy"[Tiab] OR agreement[Tiab] OR "predictive value"[Tiab] OR "sensitivity"[Tiab] OR "specificity"[Tiab] OR "false positive"[Tiab] OR "false negative"[Tiab] OR "Surgical exploration"[Tiab] OR "direct observation"[Tiab] OR "surgically explored"[Tiab]) **AND** (solidity[Tiab] OR Osseointegration[Mesh] OR osseointegration[Tiab] OR "bony fusion"[Tiab] OR "spinal fusion/classification"[Mesh] OR fusing[Tiab] OR "fusion rate"[Tiab] OR "fusion rates"[Tiab] OR "radiographic fusion"[Tiab] OR "radiological fusion"[Tiab] OR "successful fusion"[Tiab] OR "solid fusion"[Tiab] OR nonunion[Tiab] OR pseudoarthrosis[Tiab] OR pseudarthrosis[Tiab] OR "bone union rate"[Tiab] OR "fused"[Tiab])

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Appendix B: Descriptive criteria identified in stage 1 (based on 118 articles) and the absolute frequency of reporting. For the criteria related to absence of motion, also the used cutoff values are summarized.

Category	Criteria	No. of Articles
Continuity of osseous bridging	Facet joint	9
	Interbody[a]	7
	Intertransverse	52
	Posterolateral	19
	Not specified	35
Absence of motion	Angular motion	
	≤1.5°	4
	≤2°	6
	≤3°	4
	≤4°	7
	≤5°	22
	Miscellaneous cutoff values[b]	3
	Translational motion	
	≤2mm	9
	≤3mm	11
	≤3°	2
	Miscellaneous cutoff values[b]	2
	Cutoff value not specified	2
Absence of static signs of nonunion	Implant failure / loosening / migration	21
	Radiolucency around the implant	14
	Radiographic gap / cleft / line in fusion mass	9
Miscellaneous		3

[a] **Articles that included both PLF and IBF and reported osseous bridging between vertebral bodies as criterion for PLF.**
[b] Cutoff values reported in a single article.

Appendix C: Reliability measures reported as secondary outcome by articles included from stage 1.		
Authors (year)	**Fusion assessment**	**Reliability measures**
Thomsen et al. (1997)[51]	Static X: continuous intertransverse bony bridges at one of the two sides, at all intended levels (2 observers).	Interobserver reliability = 82% (kappa = 0.55)
Molinari et al. (1999)[52]	Static X: Bridwell classification (2 observers).	Interobserver agreement = 99%
Möller et al. (2000)[53]	Static X: Lenke classification, grade A (2 observers).	Interobserver agreement = 88%
Korovessis et al. (2005)[54]	Static X: Christensen classification, grade 3 (2 observers, reassessment within 3 weeks).	Interobserver reliability: r = 0.71 Intraobserver reliability: r = 0.67
Sengupta et al. (2006)[55]	Presence of a solid fusion mass (static X), absence of halo around the implant (static X) and absence of motion (dynamic X). Assessed twice by 1 observer with 3 months interval.	Intraobserver reliability: kappa = 0.7 (good)
Yu et al. (2008)[56]	Static X: continuity in the fusion mass between the cephalad and caudal transverse process (2 observers).	Interobserver agreement = 92% (kappa = 0.623)
Acebal-Cortina et al. (2011)[57]	Static X: unnamed classification, type A and/or B (2 observers). Type A: Bilateral, uniform and continuous intertransverse mass; Type B: Unilateral uniform and continuous intertransverse mass with discontinuous, irregular or absent intertransverse counterlateral mass; Type C: Discontinuous, irregular or absent bilateral intertransverse mass.	Interobserver reliability: kappa = 0.80 (excellent)
Korovessis et al. (2012)[58]	CT: Christensen classification, grade 2 and 3 (2 observers).	Interobserver reliability: kappa = 0.85–0.89 Intraobserver reliability: kappa = 0.88–0.91
Yamada et al. (2012)[59]	CT: presence of continuous bone connecting the transverse processes, found by 2 observers.	Interobserver reliability: Cohen kappa = 0.69 (good)
Hurlbert et al. (2013)[60]	Bridging trabecular bone in both fusion masses (left and right intertransverse spaces) (static X), absence of traversing radiolucent lines (static X), ≤3mm translation (dynamic X) and <5° angulation (dynamic X). 2 principle investigators assessed 50 selected cases to determine concordance with the 2 observers.	Interobserver agreement = 88–92%

X = radiograph, CT = computed tomography, r = Pearson correlation coefficient, ICC = intraclass correlation coefficient

Appendix D: Quality assessment of the diagnostic accuracy studies included from stage 2 using the Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2) checklist.							
Studies	**Risk of bias**				**Applicability concerns**		
	Patient selection	**Index test**	**Reference standard**	**Flow and timing**	**Patient selection**	**Index test**	**Reference standard**
Kant et al. (1995)[26]	Unclear	Low	Unclear	Unclear	Low	Low	Low
Larsen et al. (1996)[28]	Unclear	Low	Unclear	Unclear	Low	Low	Unclear
Jacobson et al. (1997)[25]	High	Low	Low	High	Low	High	Low
Kanayama et al. (2006)[29]	Unclear	Low	High	High	Low	Low	Unclear
Carreon et al. (2007)[27]	Unclear	Low	Unclear	High	Low	Low	Low
Fogel et al. (2008)[24]	Unclear	Low	Unclear	High	Low	Low	Low
Spirig et al. (2019)[31]	Unclear	Low	Unclear	High	Low	Low	High

Appendix D: Quality assessment of the diagnostic reliability studies included from stage 2 using the Quality Appraisal of Reliability Studies (QAREL) checklist. Quality was considered high when ≥60% of the items was answered with 'Yes'.							
Items	**Carreon et al. (2007)[27]**	**Fogel et al. (2008)[24]**	**Christensen et al. (2001)[19]**	**Tokuhashi et al. (2008)[32]**	**Dakhil-Jerew et al. (2009)[33]**	**Gotfryd et al. (2014)[30]**	**Spirig et al. (2019)[31]**
1. Representative sample	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Representative raters	Yes	Yes	Yes	Unclear	Yes	Yes	Yes
3. Blinding (other raters)	Unclear	Yes	Yes	Unclear	Yes	Unclear	Yes
4. Blinding (own findings)	NA	NA	Yes	Unclear	Unclear	Unclear	NA
5. Blinding (reference standard / disease status)	Yes	Yes	NA	Unclear	NA	NA	Yes
6. Blinding (clinical information)	Yes	Unclear	Yes	Unclear	Yes	Unclear	Yes
7. Blinding (additional cues)	Yes	Yes	Yes	Yes	Unclear	Yes	Yes

8. Varied order of examination	NA	Unclear	Yes	Unclear	Unclear	Unclear	NA
9. Appropriate time interval	Yes	Yes	Yes	Yes	Yes	Yes	Yes
10. Appropriate application and interpretation	Yes	Yes	Yes	Yes	Yes	Yes	Yes
11. Appropriate statistics	No	No	Yes	Yes	Yes	Yes	No
Percentage 'Yes'	7/9 = 78%	7/10 = 70%	10/10 = 100%	5/11 = 45%	7/10 = 70%	6/10 = 60%	8/9 = 89%

NA = not applicable