

Data Extraction

Each retrieved citation was reviewed by two independent reviewers. Most articles were excluded on the basis of information provided by the title or abstract. Citations that appeared to be appropriate or those that could not be excluded unequivocally from the title and abstract were

identified, and the corresponding full text reports were reviewed by the two reviewers. Any disagreement between them was resolved by reviewer consensus. From the included articles, the following data was extracted: patient demographics, preexisting diagnosis, treatment, follow-up, inclusion/exclusion criteria, measure and definition of fusion, and fusion rate.

Inclusion/Exclusion Criteria

Table 1 PICO table describing inclusion and exclusion criteria

Study component	Inclusion	Exclusion
Population	<ul style="list-style-type: none"> • Human subjects • Adult patients (>18 y old) • Undergoing lumbar spine decompression and/or fusion for: <ul style="list-style-type: none"> Adult lumbar degenerative disk disease Lumbar disk herniation Lumbar spinal stenosis Lumbar spondylolisthesis or spondylosis 	<ul style="list-style-type: none"> • Animal studies • Pediatric patients (<18 y old)
	<ul style="list-style-type: none"> • Undergoing lumbar spine decompression and/or fusion for: <ul style="list-style-type: none"> Adult lumbar degenerative disk disease Lumbar disk herniation Lumbar spinal stenosis Lumbar spondylolisthesis or spondylosis 	<ul style="list-style-type: none"> • Patients undergoing cervical or thoracic spine surgery • Patients undergoing lumbar surgery for intradural pathology or spinal tumors • Surgeries associated with dural tears • Drains used for treatment of infectious process
Intervention	<ul style="list-style-type: none"> • Use of closed suction drains postoperatively 	<ul style="list-style-type: none"> • Studies where closed suction drains were not used
Comparators	<ul style="list-style-type: none"> • Nonuse of closed suction drains 	<ul style="list-style-type: none"> • Studies that did not use a control group
Outcomes	<ul style="list-style-type: none"> • Incidence of epidural hematoma • Incidence of superficial wound infection • Incidence deep infection • Incidence of postoperative blood transfusion 	<ul style="list-style-type: none"> • Subjective outcome measures

Abbreviation: PICO, population/patient, intervention/indicator, comparator/control, outcome.

Search Strategies

Bibliographic databases

Database	Platform	Years covered	Date conducted
Medline	OvidSP	1946–present	January 22, 2015
Embase	OvidSP	1947 to January 22, 2015	January 22, 2015
Biosis Previews	OvidSP	1969–2015 week 3	January 22, 2015
Cochrane Library	Wiley	To issue 01 of 12, January 2015	January 22, 2015
Medline	PubMed	1946 to present	January 22, 2015
Web of Science	Thomson Reuters	All (updated January 22)	January 22, 2015
Scopus	SciVerse	All (updated January 22)	January 22, 2015

Strategy: Medline via OvidSP

1 Computer-Assisted Instruction/ (9761)
2 Computer Communication Networks/ (13051)
3 Internet/ (52885)
4 Education, Distance/ (2743)
5 ((computer* or online or on-line or web or virtual or internet or technolog* or software* or multimedia or multi-media or simulat* or video* or game* or gaming) adj3 (train* or educat* or learn* or teach* or instruct* or curricul* or platform* or plat-form*)).tw,kf. (27900)
6 (e-learn* or elearn*).tw,kf. (1382)
7 (teleducat* or telinstruct* or (tele adj2 (train* or instruct* or educat*))).tw,kf. (119)
8 or/1-7 (93995)
9 exp Specialties, Surgical/ (166327)
10 exp Surgical Procedures, Operative/ (2502815)
11 Surgical Equipment/ (5124)
12 su.fs. (1655095)
13 Bariatric Medicine/ (38)
14 or/9-13 (3203292)
15 ed.fs. (227469)
16 exp Education, Medical/ (135659)
17 exp Education, Continuing/ (55873)
18 exp Educational Measurement/ (113340)
19 exp Curriculum/ (66904)
20 or/15-19 (390954)
21 14 and 20 (46926)
22 ((surge* or surgic* or operativ* or neurosurg* or ophthalmolog* or trauma* or urolog* or gynecolog* or bariatr* or orthoped* or orthopaed*) adj3 (skill* or train* or educat* or learn* or teach* or instruct* or curricul* or educat* or knowledge or competence*)).tw,kf. (29715)
23 21 or 22 (65044)
24 8 and 23 (4147)
25 ("10455902" or "15349113" or "19088658").ui. (3)
26 24 and 25 (3)
27 remove duplicates from 24 (3976)

Strategy: Embase via OvidSP

<1947 to 2015 January 22>
1 exp surgical drainage/ (67019)
2 drainage.tw,kw. (98928)
3 ((wound* or suction) adj3 drain*).tw,kw. (3915)
4 1 or 2 or 3 (136103)
5 exp spine/ (150402)
6 exp spine disease/ (162466)
7 exp spine injury/ (32664)
8 exp spinal nerve/ (127068)
9 or/5-8 (376452)
10 su.fs. (1716590)
11 9 and 10 (66590)
12 exp spine surgery/ (56891)
13 ((spine or spinal or lumbar) adj3 (surgery or surgeries or surgical or fusion or decompress* or replac*).tw,kw. (28199)
14 (laminectom* or laminotom*).tw,kw. (9946)
15 (dissectom* or dissectom*).tw,kw. (5456)
16 (spondylosyndes* or spondylo-syndes* or spondylodes* or spondylo-des*).tw,kw. (992)
17 or/11-16 (106084)
18 4 and 17 (2262)
19 exp postoperative complication/ (501090)
20 (suppurat* or abscess* or osteomyelitis or osteo-myelitis or dehiscen* or pus or hematoma* or haematoma*).tw,kw. (194608)
21 (adverse adj2 (outcome* or event* or reaction* or effect or effects)).tw,kw. (375948)
22 suppuration/ (3514)
23 pus/ (5954)
24 abscess/ (41461)
25 epidural abscess/ (2687)
26 exp hematoma/ (70774)
27 exp osteomyelitis/ (37398)
28 exp treatment outcome/ (1006751)
29 ((postoperati* or postsurg* or ((post or after or following) adj2 (operati* or surg* or fusion* or procedur*))) adj5 (complicat* or infect* or outcome*).tw,kw. (148647)
30 or/19-29 (1972414)
31 18 and 30 (1551)
32 (exp animal/ or exp juvenile animal/ or adult animal/ or animal cell/ or animal experiment/ or animal model/ or animal tissue/ or nonhuman/) not human/ (6149874)
33 31 not 32 (1539)
34 remove duplicates from 33 (1527)

Strategy: Biosis previews

<1969 to 2015 Week 03>
1 drainage.ti,ab,mi. (55468)
2 ((wound* or suction) adj3 drain*).ti,ab,mi. (995)
3 1 or 2 (55713)
4 ((spine or spinal or lumbar) adj3 (surgery or surgeries or surgical or fusion or decompress* or replac*).ti,ab,mi. (10759)
5 (laminectom* or laminotom*).ti,ab,mi. (3952)
6 (diskectom* or discectom*).ti,ab,mi. (1831)
7 (spondylosyndes* or spondylo-syndes* or spondylodes* or spondylo-des*).ti,ab,mi. (238)
8 or/4-7 (15426)
9 3 and 8 (219)
10 (suppurat* or abscess* or osteomyelitis or osteo-myelitis or dehiscen* or pus or hematoma* or haematoma*).ti,ab,mi. (66523)
11 (adverse adj2 (outcome* or event* or reaction* or effect or effects)).ti,ab,mi. (184047)
12 ((postoperati* or postsurg* or ((post or after or following) adj2 (operati* or surg* or fusion* or procedur*))) adj5 (complicat* or infect* or outcome*).ti,ab,mi. (43296)
13 10 or 12 (107236)
14 9 and 13 (100)
15 (animal* not (animal* and hominidae)).st,tn. (7275160)
16 14 not 15 (98)
17 remove duplicates from 16 (98)

Strategy: Cochrane Library

ID	Search	Hits
#1	drainage:ti,ab,kw	4,171
#2	((wound* or suction) near/3 drain*):ti,ab,kw	637
#3	#1 or #2	4,246
#4	((spine or spinal or lumbar) near/3 (surgery or surgeries or surgical or fusion or decompress* or replac*)):ti,ab,kw	2,875
#5	(laminectom* or laminotom*):ti,ab,kw	362
#6	(diskectom* or discectom*):ti,ab,kw	758
#7	(spondylosyndes* or spondylo-syndes* or spondylodes* or spondylo-des*):ti,ab,kw	24
#8	(or #4-#7)	3,426
#9	#3 and #8	40
#10	(suppurat* or abscess* or osteomyelitis or osteo-myelitis or dehiscen* or pus or hematoma* or haematoma*):ti,ab,kw	5,123
#11	(adverse near/5 (outcome* or event* or reaction* or effect or effects)):ti,ab,kw	73,716
#12	((postoperati* or postsurg* or ((post or after or following) near/2 (operati* or surg* or fusion* or procedur*))) near/5 (complicat* or infect* or outcome*):ti,ab,kw	26,024
#13	#10 or #11 or #12	100,129
#14	#9 and #12	21

Strategy: Medline via PubMed

Search	Query	Items found
#30	Search (#26) AND #29	50
#29	Search pubmednotmedline[sb]	1,383,825
#28	Search (#26) AND #27	21
#27	Search publisher[sb] NOT pmcbook	460,782
#26	Search (#14) AND #25	1,112
#25	Search (((((#15) OR #16) OR #17) OR #18) OR #21) OR #24	783,810
#24	Search (#22) AND #23	10,575
#23	Search complicat*[Other Term] OR infect*[Other Term] or outcome*[Other Term]	138,727
#22	Search postoperati*[Other Term] OR postsurg*[Other Term] OR ((post[Other Term] OR after[Other Term] OR following[Other Term]) AND (operati*[Other Term] OR surg*[Other Term] OR fusion*[Other Term] OR procedur*[Other Term])	121,630
#21	Search (#19) AND #20	392,366
#20	Search complicat*[Title/Abstract] OR infect*[Title/Abstract] or outcome*[Title/Abstract]	2,688,748
#19	Search (postoperati*[Title/Abstract] OR postsurg*[Title/Abstract] OR ((post[Title/Abstract] OR after[Title/Abstract] OR following[Title/Abstract]) AND (operati*[Title/Abstract] OR surg*[Title/Abstract] OR fusion*[Title/Abstract] OR procedur*[Title/Abstract]))	1,053,836
#18	Search adverse[Other Term] AND (outcome*[Other Term] OR event*[Other Term] OR reaction*[Other Term] OR effect[Other Term] OR effects[Other Term])	2,509
#17	Search adverse[Title/Abstract] AND (outcome*[Title/Abstract] OR event*[Title/Abstract] OR reaction*[Title/Abstract] OR effect[Title/Abstract] OR effects[Title/Abstract])	281,953
#16	Search suppurat*[Other Term] OR abscess*[Other Term] OR osteomyelitis[Other Term] OR osteo-myelitis[Other Term] OR dehiscen*[Other Term] OR pus[Other Term] OR hematoma*[Other Term] OR haematoma*[Other Term]	11,343
#15	Search suppurat*[Title/Abstract] OR abscess*[Title/Abstract] OR osteomyelitis[Title/Abstract] OR osteo-myelitis[Title/Abstract] OR dehiscen*[Title/Abstract] OR pus [Title/Abstract] OR hematoma*[Title/Abstract] OR haematoma*[Title/Abstract]	139,004
#14	Search (#4) AND #13	1,681
#13	Search ((((((#5) OR #6) OR #7) OR #8) OR #9) OR #10) OR #11) OR #12	70,192
#12	Search spondylosyndes*[Other Term] OR spondylo-syndes*[Other Term] OR spondylodes*[Other Term] OR spondylo-des*[Other Term]	1
#11	Search spondylosyndes*[Title/Abstract] OR spondylo-syndes*[Title/Abstract] OR spondylodes*[Title/Abstract] OR spondylo-des*[Title/Abstract]	646
#10	Search diskectom*[Other Term] OR discectom*[Other Term]	167
#9	Search diskectom*[Title/Abstract] OR discectom*[Title/Abstract]	4,319
#8	Search laminectom*[Other Term] OR laminotom*[Other Term]	169
#7	Search laminectom*[Title/Abstract] OR laminotom*[Title/Abstract]	7,006
#6	Search (spine[Other Term] OR spinal[Other Term] OR lumbar[Other Term]) AND (surgery[Other Term] OR surgeries[Other Term] OR surgical[Other Term] OR fusion [Other Term] OR decompress*[Other Term] OR replac*[Other Term])	2,453
#5	Search (spine[Title/Abstract] OR spinal[Title/Abstract] OR lumbar[Title/Abstract]) AND (surgery[Title/Abstract] OR surgeries[Title/Abstract] OR surgical[Title/Abstract] OR fusion[Title/Abstract] OR decompress*[Title/Abstract] OR replac*[Title/Abstract])	63,887
#4	Search ((#1) OR #2) OR #3	69,668
#3	Search (wound*[Other Term] OR suction[Other Term]) AND drain*[Other Term]	88
#2	Search (wound*[Title/Abstract] OR suction[Title/Abstract]) AND drain*[Title/Abstract]	6,711
#1	Search (drainage[Title/Abstract]) OR drainage[Other Term]	67,992

Strategy: Web of Science

ID	Results	Search
#16	308	#14 NOT #15
#15	3,428,484	TI = (animals OR animal OR mice OR mus OR mouse OR murine OR woodmouse OR rats OR rat OR murinae OR muridae OR cottonrat OR cottonrats OR hamster OR hamsters OR cricetinae OR rodentia OR rodent OR rodents OR pigs OR pig OR porcine OR swine OR swines OR piglets OR piglet OR boar OR boars OR "sus scrofa" OR ferrets OR ferret OR polecat OR polecats OR "mustela putorius" OR "guinea pigs" OR "guinea pig" OR cavia OR callithrix OR marmoset OR marmosets OR cebuella OR hapale OR octodon OR chinchilla OR chinchillas OR gerbillinae OR gerbil OR gerbils OR jird OR jirds OR merione OR meriones OR rabbits OR rabbit OR hares OR hare OR diptera OR flies OR fly OR dipteral OR drosophila OR drosophilidae OR cats OR cat OR carus OR felis OR nematoda OR nematode OR nematoda OR nematode OR nematodes OR sipunculida OR dogs OR dog OR canine OR canines OR canis OR sheep OR sheeps OR mouflon OR mouflons OR ovis OR goats OR goat OR capra OR capras OR rupicapra OR chamois OR haplorhini OR monkey OR monkeys OR macaque OR macaques OR primate OR primates OR anthropoidea OR anthropoids OR saguinus OR tamarin OR tamarins OR leontopithecus OR hominidae OR ape OR apes OR pan OR paniscus OR "pan paniscus" OR bonobo OR bonobos OR troglodytes OR "pan troglodytes" OR gibbon OR gibbons OR siamang OR siamangs OR nomascus OR symphalangus OR chimpanzee OR chimpanzees OR prosimians OR "bush baby" OR prosimian OR "bush babies" OR galagos OR galago OR pongidae OR gorilla OR gorillas OR pongo OR pygmaeus OR "pongo pygmaeus" OR orangutans OR pygmaeus OR lemur OR lemurs OR lemuriidae OR horse OR horses OR equus OR cow OR calf OR bull OR chicken OR chickens OR gallus OR quail OR quail OR bird OR birds OR quails OR poultry OR poultries OR fowl OR fowls OR reptile OR reptilia OR reptiles OR snakes OR snake OR lizard OR lizards OR alligator OR alligators OR crocodile OR crocodiles OR turtle OR turtles OR amphibian OR amphibians OR amphibia OR frog OR frogs OR bombina OR salientia OR toad OR toads OR "epidalea calamita" OR salamander OR salamanders OR eel OR eels OR fish OR fishes OR pisces OR catfish OR catfishes OR siluriformes OR arius OR heteropneustes OR sheatfish OR perch OR perches OR percidae OR perca OR trout OR trouts OR char OR chars OR salvelinus OR "fathead minnow" OR minnow OR cyprinidae OR carps OR carp OR zebrafish OR zebrafishes OR goldfish OR goldfishes OR guppy OR guppies OR chub OR chubs OR tinca OR barbels OR barbus OR pimphales OR promelas OR "poecilia reticulata" OR mullet OR mullets OR seahorse OR seahorses OR "mugil curema" OR "atlantic cod" OR shark OR sharks OR catshark OR anguilla OR salmonid OR salmonids OR whitefish OR whitefishes OR salmon OR salmons OR sole OR solea OR "sea lamprey" OR lamprey OR lampreys OR pumpkinseed OR sunfish OR sunfishes OR tilapia OR tilapias OR turbot OR turbots OR flatfish OR flatfishes OR sciuridae OR squirrel OR squirrels OR chipmunk OR chipmunks OR suslik OR susliks OR vole OR voles OR lemming OR lemmings OR muskrat OR muskrats OR lemmus OR otter OR otters OR marten OR martens OR martes OR weasel OR badger OR badgers OR ermine OR mink OR minks OR sable OR sables OR gulo OR gulos OR wolverine OR wolverines OR minks OR mustela OR llama OR llamas OR alpaca OR alpacas OR camelid OR camelids OR guanaco OR guanacos OR chiroptera OR chiropteras OR bat OR bats OR fox OR foxes OR iguana OR iguanas OR "xenopus laevis" OR parakeet OR parakeets OR parrot OR parrots OR donkey OR donkeys OR mule OR mules OR zebra OR zebras OR shrew OR shrews OR bison OR bisons OR buffalo OR buffaloes OR deer OR deers OR bear OR bears OR panda OR pandas OR "wild hog" OR "wild boar" OR fitchew OR fitch OR beaver OR beavers OR jerboa OR jerboas OR capybara OR capybaras)
#14	310	#13 AND #9
#1\32	428,3595	#11 OR #10
#12	87,879	TS = ((postoperati* or postsurg* or ((post or after or following) NEAR/2 (operati* or surg* or fusion* or procedur*))) NEAR/5 (complicat* or infect* or outcome*))
#11	244,058	TS = (adverse near/2 (outcome* or event* or reaction* or effect or effects))
#10	107,921	TS = (suppurat* or abscess* or osteomyelitis or osteo-myelitis or dehiscen* or pus or hematoma* or haematoma*)
#9	592	#8 AND #3
#8	31,485	#7 OR #6 OR #5 OR #4
#7	455	TS = (spondylosyndes* or spondylo-syndes* or spondylodes* or spondylo-des*)
#6	4,756	TS = (dissectom* or discectom*)
#5	5,867	TS = (laminectom* or laminotom*)
#4	24,993	TS = ((spine or spinal or lumbar) NEAR/3 (surgery or surgeries or surgical or fusion or decompress* or replac*))
#3	99,275	#2 OR #1
#2	2,198	TS = ((wound* or suction) NEAR/3 drain*)
#1	98,784	TS = drainage

Strategy: Scopus

ID	Search	Results
#1	TITLE-ABS-KEY(drainage)	195,646
#2	TITLE-ABS-KEY((wound* or suction) W/3 drain*)	22,858
#3	#1 OR #2	196,200
#4	TITLE-ABS-KEY((spine or spinal or lumbar) W/3 (surgery or surgeries or surgical or fusion or decompress* or replac*))	62,723
#5	TITLE-ABS-KEY(laminectom* or laminotom*)	18,579
#6	TITLE-ABS-KEY(diskectom* or discectom*)	8,406
#7	TITLE-ABS-KEY(spondylosyndes* or spondylo-syndes* or spondyloides* or spondylo-des*)	1,807
#8	#4 OR #5 OR #6 OR #7	77,096
#9	#3 AND #8	1,808
#10	TITLE-ABS-KEY(suppurat* or abscess* or osteomyelitis or osteo-myelitis or dehiscen* or pus or hematoma* or haematoma*)	252,235
#11	TITLE-ABS-KEY(adverse w/2 (outcome* or event* or reaction* or effect or effects))	471,783
#12	TITLE-ABS-KEY ((postoperati* OR postsurg* OR ((post OR after OR following) W/2 (operati* OR surg* OR fusion* OR procedur*))) W/5 (complicat* OR infect* OR outcome*))	796,760
#13	#10 OR #11 OR #12	1,438,720
#14	#9 AND #13	1,281
#15	(TITLE(animals) OR TITLE(animal) OR TITLE(mice) OR TITLE(mus) OR TITLE(mouse) OR TITLE(murine) OR TITLE(woodmouse) OR TITLE(rats) OR TITLE(rat) OR TITLE(murinae) OR TITLE(muridae) OR TITLE(cottonrat) OR TITLE(cottonrats) OR TITLE(hamster) OR TITLE(hamsters) OR TITLE(cricetinae) OR TITLE(rodentia) OR TITLE(rodent) OR TITLE(rodents) OR TITLE(pigs) OR TITLE(pig) OR TITLE(porcine) OR TITLE(swine) OR TITLE(swines) OR TITLE(piglets) OR TITLE(piglet) OR TITLE(boar) OR TITLE(boars) OR TITLE("sus scrofa") OR TITLE(ferrets) OR TITLE(ferret) OR TITLE(polecat) OR TITLE(polecats) OR TITLE("mustela putorius") OR TITLE("guinea pigs") OR TITLE("guinea pig") OR TITLE(cavia) OR TITLE(callithrix) OR TITLE(marmoset) OR TITLE(marmosets) OR TITLE(cebuella) OR TITLE(hapale) OR TITLE(octodon) OR TITLE(chinchilla) OR TITLE(chinchillas) OR TITLE(gerbillinae) OR TITLE(gerbil) OR TITLE(gerbils) OR TITLE(jird) OR TITLE(jirds) OR TITLE(merione) OR TITLE(meriones) OR TITLE(rabbits) OR TITLE(rabbit) OR TITLE(hares) OR TITLE(hare) OR TITLE(diptera) OR TITLE(flies) OR TITLE(fly) OR TITLE(dipteral) OR TITLE(drosophila) OR TITLE(drosophilidae) OR TITLE(cats) OR TITLE(cat) OR TITLE(carus) OR TITLE(felis) OR TITLE(nematoda) OR TITLE(nematode) OR TITLE(nematoda) OR TITLE(nematode) OR TITLE(nematodes) OR TITLE(sipunculida) OR TITLE(dogs) OR TITLE(dog) OR TITLE(canine) OR TITLE(canines) OR TITLE(canis) OR TITLE(sheep) OR TITLE(sheeps) OR TITLE(mouflon) OR TITLE(mouflons) OR TITLE(ovis) OR TITLE(goats) OR TITLE(goat) OR TITLE(capra) OR TITLE(capras) OR TITLE(rupicapra) OR TITLE(chamois) OR TITLE(haplorhini) OR TITLE(monkey) OR TITLE(monkeys) OR TITLE(macaque) OR TITLE(macaques) OR TITLE(primare) OR TITLE(primates) OR TITLE(anthropoidea) OR TITLE(anthropoids) OR TITLE(saguinus) OR TITLE(tamarin) OR TITLE(tamarins) OR TITLE(leontopithecus) OR TITLE(hominidae) OR TITLE(ape) OR TITLE(apes) OR TITLE(pan) OR TITLE(paniscus) OR TITLE("pan paniscus") OR TITLE(bonobo) OR TITLE(bonobos) OR TITLE(troglodytes) OR TITLE("pan troglodytes") OR TITLE(gibbon) OR TITLE(gibbons) OR TITLE(siamang) OR TITLE(siamangs) OR TITLE(nomascus) OR TITLE(symphalangus) OR TITLE(chimpanzee) OR TITLE(chimpanzees) OR TITLE(prosimians) OR TITLE("bush baby") OR TITLE(prosimian) OR TITLE(bush babies) OR TITLE(galagos) OR TITLE(galago) OR TITLE(pongidae) OR TITLE(gorilla) OR TITLE(gorillas) OR TITLE(pongo) OR TITLE(pygmaeus) OR TITLE("pongo pygmaeus") OR TITLE(orangutans) OR TITLE(pygmaeus) OR TITLE(lemur) OR TITLE(lemurs) OR TITLE(lemuridae) OR TITLE(horse) OR TITLE(horses) OR TITLE(pongo) OR TITLE(equus) OR TITLE(cow) OR TITLE(calf) OR TITLE(bull) OR TITLE(chicken) OR TITLE(chickens) OR TITLE(gallus) OR TITLE(quail) OR TITLE(bird) OR TITLE(birds) OR TITLE(quails) OR TITLE(poultry) OR TITLE(poultres) OR TITLE(fowl) OR TITLE(fowls) OR TITLE(reptile) OR TITLE(reptilia) OR TITLE(reptiles) OR TITLE(snakes) OR TITLE(snake) OR TITLE(lizard) OR TITLE(lizards) OR TITLE(alligator) OR TITLE(alligators) OR TITLE(crocodile) OR TITLE(crocodiles) OR TITLE(turtle) OR TITLE(turtles) OR TITLE(amphibian) OR TITLE(amphibians) OR TITLE(amphibia) OR TITLE(frog) OR TITLE(frogs) OR TITLE(bombina) OR TITLE(salientia) OR TITLE(toad) OR TITLE(toads) OR TITLE("epidalea calamita") OR TITLE(salamander) OR TITLE(salamanders) OR TITLE(eel) OR TITLE(eels) OR TITLE(fish) OR TITLE(fishes) OR TITLE(pisces) OR TITLE(catfish) OR TITLE(catfishes) OR TITLE(siluriformes) OR TITLE(arius) OR TITLE(heteropneustes) OR TITLE(sheatfish) OR TITLE(perch) OR TITLE(perches) OR TITLE(percidae) OR TITLE(perca) OR TITLE(trout) OR TITLE(trouts) OR TITLE(char) OR TITLE(chars) OR TITLE(salvelinus) OR TITLE("fathead minnow") OR TITLE(minnow) OR TITLE(cyprinidae) OR TITLE(carps) OR TITLE(carp) OR TITLE(zebrafish) OR TITLE(zebrafishes) OR TITLE(goldfish) OR TITLE(goldfishes) OR TITLE(guppy) OR TITLE(guppies) OR	2,865,120

(Continued)

ID	Search	Results
	TITLE(chub) OR TITLE(chubs) OR TITLE(tinca) OR TITLE(barbels) OR TITLE(barbus) OR TITLE(pimephales) OR TITLE(promelas) OR TITLE("poecilia reticulata") OR TITLE(mullet) OR TITLE(mullets) OR TITLE(seahorse) OR TITLE(seahorses) OR TITLE(mugil curema) OR TITLE(atlantic cod) OR TITLE(shark) OR TITLE(sharks) OR TITLE(catshark) OR TITLE(anguilla) OR TITLE(salmonid) OR TITLE(salmonids) OR TITLE(whitefish) OR TITLE(whitefishes) OR TITLE(salmon) OR TITLE(salmons) OR TITLE(sole) OR TITLE(solea) OR TITLE("sea lamprey") OR TITLE(lamprey) OR TITLE(lampreys) OR TITLE(pumpkinseed) OR TITLE(sunfish) OR TITLE(sunfishes) OR TITLE(tilapia) OR TITLE(tilapias) OR TITLE(turbot) OR TITLE(turbots) OR TITLE(flatfish) OR TITLE(flatfishes) OR TITLE(sciuridae) OR TITLE(squirrel) OR TITLE(squirrels) OR TITLE(chipmunk) OR TITLE(chipmunks) OR TITLE(suslik) OR TITLE(susliks) OR TITLE(vole) OR TITLE(voles) OR TITLE(lemming) OR TITLE(lemmings) OR TITLE(muskrat) OR TITLE(muskrats) OR TITLE(lemmus) OR TITLE(otter) OR TITLE(otters) OR TITLE(marten) OR TITLE(martens) OR TITLE(martes) OR TITLE(weasel) OR TITLE(badger) OR TITLE(badgers) OR TITLE(ermine) OR TITLE(mink) OR TITLE(minks) OR TITLE(sable) OR TITLE(sables) OR TITLE(gulo) OR TITLE(gulos) OR TITLE(wolverine) OR TITLE(wolverines) OR TITLE(minks) OR TITLE(mustela) OR TITLE(llama) OR TITLE(llamas) OR TITLE(alpaca) OR TITLE(alpacas) OR TITLE(camelid) OR TITLE(camelids) OR TITLE(guanaco) OR TITLE(guanacos) OR TITLE(chiroptera) OR TITLE(chiropteras) OR TITLE(bat) OR TITLE(bats) OR TITLE(fox) OR TITLE(foxes) OR TITLE(iguana) OR TITLE(iguanas) OR TITLE(Xenopus laevis) OR TITLE(parakeet) OR TITLE(parakeets) OR TITLE(parrot) OR TITLE(parrots) OR TITLE(donkey) OR TITLE(donkeys) OR TITLE(mule) OR TITLE(mules) OR TITLE(zebra) OR TITLE(zebras) OR TITLE(shrew) OR TITLE(shrews) OR TITLE(bison) OR TITLE(bisons) OR TITLE(buffalo) OR TITLE(buffaloes) OR TITLE(deer) OR TITLE(deers) OR TITLE(bear) OR TITLE(bears) OR TITLE(panda) OR TITLE(pandas) OR TITLE("wild hog") OR TITLE("wild boar") OR TITLE(fitchew) OR TITLE(fitch) OR TITLE(beaver) OR TITLE(beavers) OR TITLE(jerboa) OR TITLE(jerboas) OR TITLE(capybara) OR TITLE(capybaras))	
#16	#14 AND NOT #15	1,274

Study Quality

Articles selected for inclusion were classified by class of evidence. The method used for assessing the quality of evidence of individual studies as well as the overall quality of the body of evidence incorporated aspects of the rating scheme developed by the Oxford Centre for Evidence-Based Medicine¹ and used with modification by *The Journal of Bone*

and Joint Surgery American Volume (J Bone Joint Surg Am),² precepts outlined by the Grades of Recommendation Assessment, Development and Evaluation (GRADE) Working Group,³ and recommendations made by the Agency for Healthcare Research and Quality (AHRQ).⁴ Each individual study was rated by two different investigators against preset criteria that resulted in an evidence rating (class of evidence I, II, III, or IV). Disagreements were resolved through discussion.

Table 2 Definition of class of evidence for articles on therapy

Class	Risk of bias	Studies of therapy	Criteria
I	Low risk Study adheres to commonly held tenets and avoidance of bias	Good-quality RCT	<ul style="list-style-type: none"> • Random sequence generation • Allocation concealment • Intent-to-treat analysis • Blind or independent assessment for important outcomes • Cointerventions applied equally • F/U rate of 80%+ • Adequate sample size
II	Moderately low risk Study has potential for some bias; study does not meet all criteria for class I, but deficiencies not likely to invalidate results or introduce significant bias.	Moderate- or poor-quality RCT	<ul style="list-style-type: none"> • Violation of one of the criteria for good-quality RCT
		Good-quality cohort	<ul style="list-style-type: none"> • Blind or independent assessment in a prospective study, or use of reliable data in a retrospective study • Cointerventions applied equally • F/U rate of 80%+ • Adequate sample size • Controlling for possible confounding

(Continued)

Table 2 (Continued)

		Studies of therapy	
Class	Risk of bias	Study design	Criteria
III	Moderately high risk Study has significant flaws in design and/or execution that increase potential for bias that may invalidate study results.	Moderate- or poor-quality cohort	• Violation of any of the criteria for good-quality cohort
		Case-control	• Any case-control design
IV	High risk Study has significant potential for bias; lack of comparison group precludes direct assessment of important outcomes.	Case series	• Any case series design

Abbreviations: F/U, follow-up; RCT, randomized controlled trial.

Table 3 Class of evidence for included studies comparing the effect of postoperative drain placement after lumbar surgery

Methodological principle	Payne et al 1996 ⁵	Brown and Brookfield 2004 ⁶	Mirzai et al 2006 ⁷	Kanayama et al 2010 ⁸	Walid et al 2012 ⁹
Study design					
Randomized controlled trial	✓	✓	✓		
Prospective cohort study					
Retrospective cohort study				✓	✓
Case-control					
Case-series					
Random sequence generation ^a			✓		
Statement of concealed allocation ^a	✓	✓			
Intention-to-treat ^a	✓	✓	✓		
Independent or blind assessment			✓		
Cointerventions applied equally	✓	✓	✓		✓
Complete follow-up of ≥80%	✓	✓	✓	✓	✓
Adequate sample size					c
Controlling for possible confounding ^b		✓	✓		
Evidence level	II	II	II	III	III

Note: Blank cells indicate that the criterion was either not met or that it could not be determined.

^aApplies only to randomized controlled trials.

^bGroups must be comparable on baseline characteristics or evidence of control for confounding presented.

^cOne outcome, postoperative blood transfusion, met adequate sample size.

Determination of Overall Strength of Evidence

- After individual article evaluation, the overall body of evidence with respect to each outcome was determined based on precepts outlined by the GRADE Working Group¹ and recommendations made by the AHRQ.¹⁰ Qualitative analysis was performed considering the following AHRQ required and additional domains.⁴
- *Risk of bias* was evaluated during the individual study evaluation described above. After individual article review, the literature evidence was rated as “high” initially if the majority of the articles are level I or II. It was rated as “low” if the majority were level III or lower. This rating was the “baseline” strength of evidence. The consistency, directness, precision, and subgroup effects were considered for potential downgrading of the strength of the body of evidence (one or two levels depending on the degree and number of domain violations).

Criteria Evaluated for “Downgrading”

- *Consistency* refers to the degree of similarity in the effect sizes of different studies within an evidence base. If effect sizes indicated the same direction of effect and if the range of effect sizes was narrow, an evidence base was judged to be consistent. If meta-analyses were conducted, we evaluated the consistency with an “eyeball test.” This test consisted of a visual appraisal of the forest plots by two independent reviewers. Single-study evidence bases were judged “consistency unknown (single study)” and downgraded.
- *Directness* is concerned with whether the evidence being assessed reflected a single, direct link between the interventions of interest and the ultimate health outcome; that is, a determination of whether the most clinically relevant outcome was measured or a surrogate outcome was assessed. Directness also applies to indirect comparisons of treatment when head-to-head comparisons of interest could not be made within individual studies.
- *Precision* of evidence pertains to the degree of certainty surrounding an estimate of effect for a specific outcome,

based on whether the estimate of effect reached statistical significance and/or the inspection of confidence intervals around effect estimates. When there were only two subgroups, the overlap of the confidence intervals of the summary estimates of the two groups was considered. No overlap of the confidence intervals indicated statistical significance, but the confidence intervals could overlap to a small degree and the difference still be statistically significant.

- For evaluating *subgroup effects* (i.e., heterogeneity of treatment effects), we downgraded if the authors did not state a priori their plan to perform subgroup analyses and if there was no test for interaction.

Criteria used for “upgrading”

- Finally, if the strength of evidence was less than “high,” we upgraded the evidence if there was a dose–response association or a strong magnitude of effect.

Strength of Evidence for Existing Systematic Reviews

Level of evidence ratings for Cochrane reviews and other systematic reviews are assigned a baseline score of high if RCTs were used, low if observational studies were used. The rating could be upgraded or downgraded based on adherence to the core criteria for methods and qualitative and quantitative analyses for systematic reviews (there is a reference/evaluation table for this change).

The following four possible levels and their definition are reported:

- **High:** High confidence that the evidence reflects the true effect. Further research is very unlikely to change our confidence in the estimate of effect.
- **Moderate:** Moderate confidence that the evidence reflects the true effect. Further research may change our confidence in the estimate of effect and may change the estimate.
- **Low:** Low confidence that the evidence reflects the true effect. Further research is likely to change the confidence in the estimate of effect and likely to change the estimate.
- **Very low:** Evidence either is unavailable or does not permit a conclusion.

Table 4 Detailed GRADE table

Outcome	Studies	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Overall quality of evidence	Effect size
Hematoma	3 RCTs (n = 333)	Serious risk of bias ^a	No serious inconsistency	No serious indirectness	Serious risk of imprecision ^c	Undetected	Low	Drain: 2.9–13.6%; no drain: 3.1–16.7%
	2 retro cohorts (n = 962)	Serious risk of bias ^a	No serious inconsistency	No serious indirectness	No serious imprecision	Undetected	Insufficient	Drain: 1.1–1.6%; no drain: 1.1–2.6%
Superficial wound infection	2 RCTs (n = 283)	Serious risk of bias ^b	No serious inconsistency	No serious indirectness	Serious risk of imprecision ^c	Undetected	Insufficient	Drain: 4.6–7.1%; no drain: 3.0–7.3%
	2 retro cohorts (n = 962)	Serious risk of bias ^a	No serious inconsistency	No serious indirectness	No serious imprecision	Undetected	Insufficient	Drain: 1.0–5.7%; no drain: 1.1–5.4%
Deep infection	1 RCT (n = 83)	Serious risk of bias ^b	No serious inconsistency	No serious indirectness	Serious risk of imprecision ^c	Undetected	Insufficient	Drain: 7.1%; no drain: 7.3%
	1 retro cohort (n = 560)	Serious risk of bias ^a	No serious inconsistency	No serious indirectness	No serious imprecision	Undetected	Insufficient	Drain: 1.0%; no drain: 1.1%
Postoperative blood transfusion	1 retro cohort (n = 402)	Serious risk of bias ^a	No serious inconsistency	No serious indirectness	No serious imprecision	Undetected	Insufficient	Drain: 28.8%; no drain: 11.4%; RR: 3.5 (1.7, 7.0)

Abbreviations: GRADE, Grades of Recommendation Assessment, Development and Evaluation; RCT, randomized controlled trial; retro, retrospective cohort; RR, risk ratio.

^aSerious risk of bias: downgraded 1 because the majority of studies did not meet two or more important criteria of a good quality RCT or cohort (see ► **Table 3**).

^bSerious risk of bias: downgraded 2 because the majority of studies did not meet two or more important criteria of a good quality RCT or cohort including random sequence generation, statement of concealed allocation, independent or blind assessment, adequate sample size, or controlling for confounding (see ► **Table 3**).

^cSerious imprecision: relatively small sample sizes.

^dRange of upper bound of 95% confidence interval calculated using Hanley's rule of 3 when 0 events are reported for a given outcome.

Excluded Articles

Table 5 List of excluded articles

Authors	Year	Title	Reasons for exclusion
Blank et al	2003	The use of postoperative subcutaneous closed suction drainage after posterior spinal fusion in adolescents with idiopathic scoliosis	Adolescents population, scoliosis correction procedure
Diab et al	2012	Use and outcomes of wound drain in spinal fusion for adolescent idiopathic scoliosis	Adolescents population, scoliosis correction procedure
Ho et al	2007	Risk factors for the development of delayed infections following posterior spinal fusion and instrumentation in adolescent idiopathic scoliosis patients	Adolescents population, scoliosis correction procedure
Liang et al	2013	Comparison between subcutaneous closed-suction drainage and conventional closed-suction drainage in adolescent idiopathic scoliosis patients undergoing posterior instrumented spinal fusion: a randomized control trial	Adolescents population, scoliosis correction procedure
Ricart-Hoffiz et al	2011	Prospective, randomized study of surgical site infections with the use of perioperative antibiotics for 24 hours versus the duration of a drain after spinal surgery	Assessed antibiotics as a prognostic factor
Saulle et al	2013	Multiple-day drainage when using bone morphogenetic protein for long-segment thoracolumbar fusions is associated with low rates of wound complications	Assessed bone morphogenetic protein use as prognostic factor
Cho and Sung	2009	Traumatic subacute spinal subdural hematoma successfully treated with lumbar drainage: case report	Case report
Chimenti and Molinari	2013	Post-operative spinal epidural hematoma causing American Spinal Injury Association B spinal cord injury in patients with suction wound drains	Case report
Cho et al	2012	Hemostatic techniques reduce hospital stay following multilevel posterior cervical spine surgery	Cervical spine procedure
Parker et al	2007	Closed suction surgical wound drainage after orthopaedic surgery	Meta-analysis
Parker and Roberts	2001	Closed suction surgical wound drainage after orthopaedic surgery	Meta-analysis
Amiri et al	2013	Postoperative spinal epidural hematoma (SEH): incidence, risk factors, onset, and management	No lumbar drain used
Awad et al	2005	Analysis of the risk factors for the development of post-operative spinal epidural haematoma	No lumbar drains used
Scuderi et al	2005	Is wound drainage necessary after lumbar spinal fusion surgery?	No lumbar drains used
Sokolowski et al	2008	Prospective study of postoperative lumbar epidural hematoma—Incidence and risk factors	No lumbar drains used
Yamada et al	2014	Risk factors for postoperative spinal epidural hematoma	No lumbar drains used
Alsiddiky et al	2013	Wound healing without drains in posterior spinal fusion in idiopathic scoliosis	No lumbar drains used
Aono et al	2011	Incidence of postoperative symptomatic epidural hematoma in spinal decompression surgery	No lumbar drains used
Bendo et al	2000	Instrumented posterior arthrodesis of the lumbar spine in patients with diabetes mellitus	No lumbar drains used

(Continued)

Table 5 (Continued)

Authors	Year	Title	Reasons for exclusion
Djurasovic et al	2014	Determinants of hospital length of stay in patients undergoing lumbar spinal fusion	No lumbar drains used
Murillo et al	2013	Influence of perioperative protocol to reduce postoperative infection rates in spine surgery. Preliminary study	No lumbar drains used
Perry et al	1997	Wound infections following spinal fusion with posterior segmental spinal instrumentation	No lumbar drains used
Rao et al	2011	Risk factors for surgical site infections following spinal fusion procedures: a case-control study	No lumbar drains used
Shen et al	2014	Risk factors for delayed infections after spinal fusion and instrumentation in patients with scoliosis	No lumbar drains used
Sokolowski et al	2006	Delayed epidural hematoma after spinal surgery—a report of 4 cases	No lumbar drains used
Valentini et al	2008	Surgical site infections after elective neurosurgery: a survey of 1747 patients	No lumbar drains used
Viola et al	1997	Delayed infection after elective spinal instrumentation and fusion. A retrospective analysis of eight cases	No lumbar drains used
Fang and Wood	2013	Management of postoperative instrumented spinal wound infection	Postoperative spinal infection patients
Levi et al	1997	Management of postoperative infections after spinal instrumentation	Postoperative spinal infection patients
Reiffel et al	2013	A multi-disciplinary review of the potential association between closed-suction drains and surgical site infection	Review article
Schuster et al	2010	The influence of perioperative risk factors and therapeutic interventions on infection rates after spine surgery a systematic review	Systematic review
Sohn et al	2012	Is closed-suction drainage necessary for intradural primary spinal cord tumor surgery?	Tumor surgery population
Sohn et al	2013	Is closed-suction drainage necessary after intradural primary spinal cord tumor surgery?	Tumor surgery population
Mirzai et al	2006	Are drains useful for lumbar disk surgery? A prospective, randomized clinical study	Used lumbar drains in epidural space

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