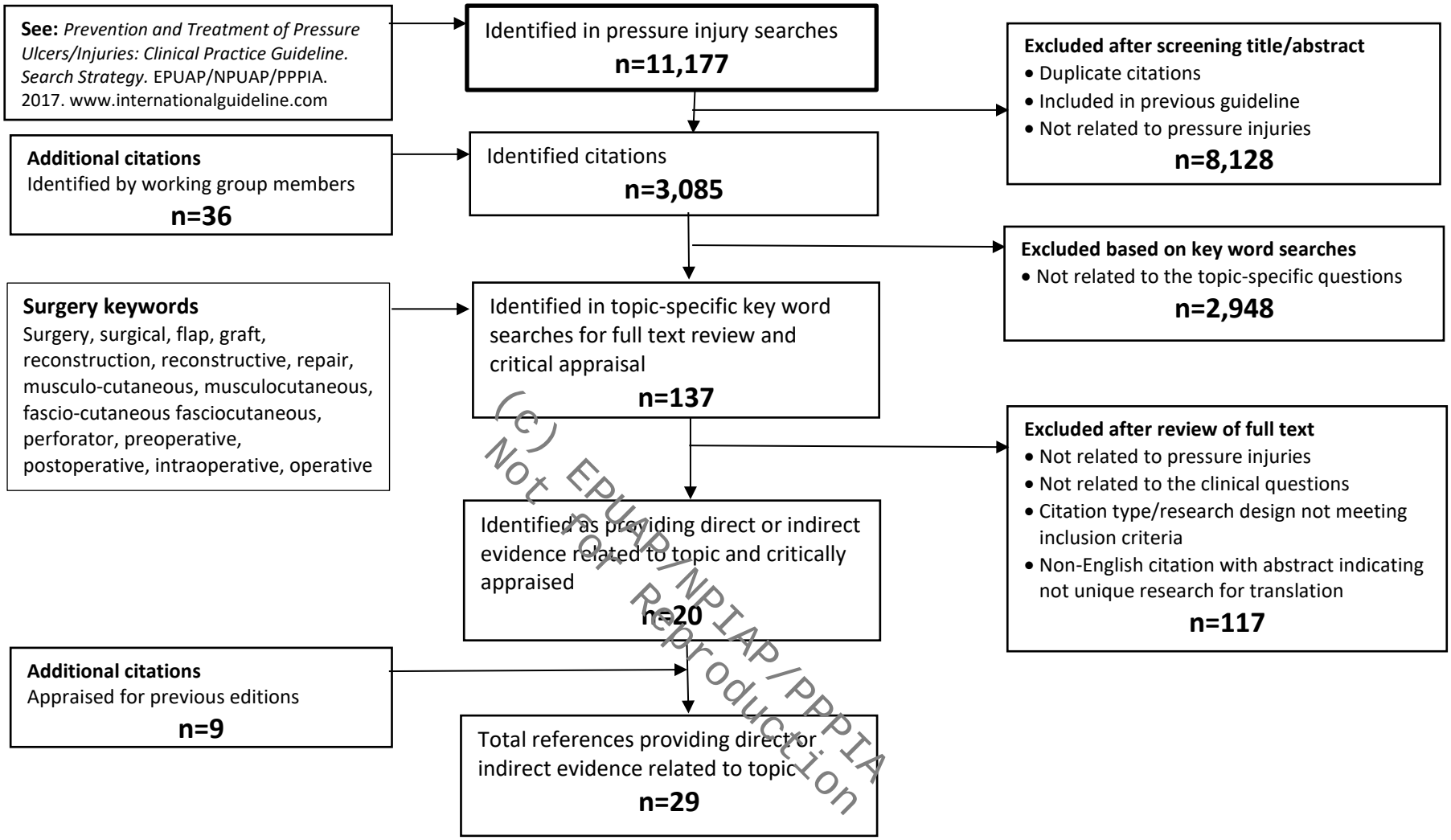
Search results for 2019 International Pressure Injury Guideline: Surgery



European Pressure Ulcer Advisory Panel, National Pressure Injury Advisory Panel and Pan Pacific Pressure Injury Alliance. Prevention and Treatment of Pressure Ulcers/Injuries: Clinical Practice Guideline. The International Guideline. Emily Haesler (Ed.). EPUAP/NPIAP/PPPIA; 2019

Articles Reviewed for International Pressure Injury Guideline

The research has been reviewed across three editions of the guideline. The terms pressure ulcer and pressure injury are used interchangeably in this document and abbreviated to PU/PI. Tables have not been professionally edited. Tables include papers with relevant direct and indirect evidence that were considered for inclusion in the guideline. The tables are provided as a background resources and are not for reproduction.

European Pressure Ulcer Advisory Panel, National Pressure Injury Advisory Panel and Pan Pacific Pressure Injury Alliance. Prevention and Treatment of Pressure Ulcers/Injuries: Clinical Practice Guideline. The International Guideline. Emily Haesler (Ed.). EPUAP/NPIAP/PPPIA; 2019

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
Clinical Question 1: What indicators are appropriate for considering eligibility for surgical intervention for a pressure injury?							
Ljung, Stenius, Bjelak, & Lagergren, 2017	Longitudinal cohort study	Consecutive patients have pressure injury surgery in one center in Switzerland (n=51 patients with 60 pressure injuries, 44/45 eligible participated at 3 years and 33/34 eligible participated at 10 years) Inclusion: Spinal cord injury Category/Stage IV pressure injury Characteristics: 80% male Average age 43 years (range 17-76) 67% paraplegic, 33% tetraplegic Having first, second or third surgery 95% gluteus maximus flap	**Selection for surgery** • Pressure injury expected not to heal within the next 6–12months • motivated and capable of following treatment	Outpatient appointment at 3 years (median 39 months) and 10 years (median 123 months) Clinical investigation, photography, questionnaires Data collection by nurse EQ-5D health questionnaire (100 point visual analog scale)	**Outcomes immediate/4 weeks** 96% patients were completely healed within 4 weeks 4% had general complications 6% had local complications including local bleeding, minor flap necrosis that healed within 3 months, persisting ulcer that healed within 2 months **Outcomes 3 years post op** 12% died before 3 year followup, 33% died before 10 year followup 11% developed recurrent or new pressure injuries within 3 years, of these 5% had repeat surgery At 3 years median health status values using a EQ-5D was 70 (median) compared with 30 (median) preoperatively **Outcomes 10 years post op** Between 3-10 years following surgery 27% had recurrence and 18% had a new pressure injury, of these 9% had repeat surgery At 3-10 years median health status values using a EQ-5D was 70 (median) compared with 30 (median) preoperatively **Author conclusion: pressure injury surgery in a structured treatment program promotes healing, prevention and health status**	• One center with small sample size	**Level of evidence: 3** **Quality: Moderate**

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Tashiro, Gerth, & Thaller, 2016	Retrospective cohort study of flap repair complications	Participants identified from the US National Inpatient Sample (2006-2011) using ICD codes associated with pressure ulcers and flap reconstructions (n=2,749 records) Characteristics: Median age 56 years (IQR 27) Mean length of stay 14 days (SD 19) Primarily male 61% Primarily white-skinned 68% Primarily lowest income quartile (32%)	Flap reconstruction: • sacrococcygeal (63%) • trochanteric (22%) • gluteal (14%)	Analysis of flap complication rates including flap loss, • hematoma, seroma, wound infection, or dehiscence	13% records indicated a flap complication occurred **Factors associated with flap complications** • Risk-adjusted multivariate analysis showed increased risk for: • females (OR 1.64, 95% CI 1.10 to 2.44, p=0.02) • Patients with renal failure (OR 4.99, 95% CI 2.23 to 11.16, p<0.001) • Obesity (OR 1.90, 95% CI 1.02 to 3.55, p=0.04) • Asian versus White (OR 4.78, 95% CI 1.40 to 16.32, p=0.01) • Trochanter versus gluteal flap (OR 4.54, 95% CI 2.38 to 8.33, p<0.001) • Sacrococcygeal versus gluteal flap (OR 1.72, 95% CI 1.02 to 2.86, p=0.04) **Resources** Significantly increased resource use (based on length of stay and total charges) associated with females, renal failure or cardiac arrhythmia, being in the lowest income quartile. **Author conclusions: Consider using advanced management strategies (e.g. vacuum assisted closure) for patients in demographics associated with high risk of complication.**	• Based on a data base review • Overall participant characteristics not described • Unclear if age and other diagnoses (e.g. diabetes) were considered in the analysis	**Level of evidence: 3 (prognosis)** **Quality: Moderate**
Bamba et al., 2017	Cohort study **reporting outcomes following flap reconstruction and investigating factors between those who di and did**	Patient records from one surgical center in US over a 20 year period were reviewed (n=276) Inclusion criteria: • Adult • Sacral, ischial or trochanter pressure ulcer	Most commonly performed flap was gluteal musculature (62.3%)	• Uncertain who performed assessments Major complications including recurrence, dehiscence, postoperative infection, flap necrosis **Univariate comparison between cohorts with**	**Complications** • 58.7% of surgical candidates had a complication • 6.5% had a post-operative flap infection • 28.6% had a PU recurrence • 31.2% had wound dehiscence **Multivariate analysis for any complications** • Age, BMI, diabetic status, smoking, wound size, osteomyelitis were not significantly related	• Length of follow up was unclear • Retrospective design relying on medical records • Recruitment was unclear – may or may not have been all cases • Longer operative times were	**Level of evidence: 3 (prognostic)** **Quality: High**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
	not have complications	Participant characteristics: • Mean age 42.9±16.1 • 73% males • Average BMI 25.1 • 24.6% smokers 82.6% had some form of paralysis		**and without complications** • Significant differences in: • Location of ulcer (p=0.001) with more complications occurring in those with ischial ulcers • Individuals with complications had significantly lower mean prealbumin (p=0.037) and albumin (p=0.003) • Individuals with complications were more likely to have required a blood transfusion (p<0.001) • Individuals with complications were more likely to have longer operative time (p=0.002) •	• Having an ischial PU was a significant factor : Relative risk (RR) 2.63, 95% CI 1.52 to 4.54, p<0.01 **Multivariate analysis for post op wound infection** • Age, BMI, smoking, wound size, osteomyelitis and anatomical location of PU were not significantly related • Having diabetes was a significant factor: RR 4.34, 95% CI 1.15 to 16.43, p=0.031 **Multivariate analysis for wound dehiscence** • Age, BMI, diabetic status, smoking, wound size, were not significantly related • Having an ischial PU was a significant factor RR 2.27, 95% CI 1.24 to 4.16, p<0.01 • Having osteomyelitis was a significant factor : RR 2.78, 95% CI 1.51 to 5.13, p<0.01 **Multivariate analysis for PU recurrence** • Age, diabetic status, wound size, osteomyelitis were not significantly related • Having an ischial PU was a significant factor : RR 3.46, 95% CI 1.76 to 6.81, p<0.01 • Having BMI<18.5 was a significant factor: RR 3.13, 95% CI 1.34 to 7.27, p<0.01 • Being a smoker was a significant factor: RR 2.33, 95% CI 1.16 to 4.7, p=0.0018 • **Author conclusions: Factors associated with poorer surgical outcomes included nutritional status, osteomyelitis, diabetes, smoking and location of the PU, however every individual is unique and should be evaluated individually**	associated with higher complications however this might indicate an overall more complex PU rather than a factor of operative time •	
Kierney et al., 1998 (repeated in CQ 2 and 4)	Cross sectional study of outcomes following pressure injury surgery	Consecutive participants underwent surgery at one center in US over a 12 year period (n=158, with n=268 pressure injuries)	**Selection for surgery** Ability to adhere to treatment protocol was required to receive surgery **Pre operative**	Five year follow up (mean followup 3.7 years (range 1 month to 15.5 years)	**Recurrence 25% of patients** Fasciocutaneous and myocutaneous were more durable than cutaneous only flaps	• Single center • Minimal details about participants and their risk factors	**Level of evidence: 4** **Quality: Moderate**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		Inclusion: "High grade" pressure injury Participant characteristics Primarily male Mean age 34.5 years 65% new/primary pressure sores and 35% recurrenr Primarily SCI patieents	• Optimization of nutritional status • Social care assistance • Wheelchair and mechanical device maintenance • Skin care education **Post operative** • Air fluidized bed for 2-3 weeks • Passive and active limb mobilization • Upper body strengthening • 7-10 day graduated sitting protocol in padded wheelchair until 3x4-hour sitting sessions/day achieved • Pressure release maneuvers at 15 minute intervals • Education and social interaction with other pressure injury recovery patients				
Keys, Daniali, Warner, & Mathes, 2010	Retrospective record review reporting **outcomes for PU surgery**	Records were reviewed in one US hospital for all patients who underwent flap surgery over a 15 year period (1993 to 2008). (n=135, flap surgeries = 227) Inclusion: • all flap surgery patients Exclusion: • Death within 6 mths • primary closure, skin grafts Characteristics	All patients underwent flap surgery. This was a retrospective review of outcomes and multivariate analysis of predictors for return to operating room.	Average follow up 4.4. years	**Wound dehiscence** • Total: 48.5% (n=110) • Requiring surgical revision 15.5% (n=36) **Recurrence** • Total 38.8% • Early recurrence 18.5%, late recurrence 20.3% **Multivariate analysis predictors for dehiscence** • Age < 45 years (OR 4.9, 95% CI 1.2 to 20.1) • History of same site failure (OR 3.8, 95% CI 1.2 to 11.9) • Poor diabetes control (OR 15.9, 95% CI 2.0 to 127) **Multivariate analysis predictors for recurrence**	• Single site audit, unclear if it is a single surgical team • Strategy of identifying long term complications is unknown (e.g. ongoing clinical reviews, patient reports) • Unclear if there was consideration of patients who may be reviewed by other facilities after surgery (e.g. may have had complications	**Level of evidence: 3 (prognostic)** **Quality: moderate**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		• Most flaps ischial (54%) followed by sacral (27%), and trochanter (18%) • Primarily male patients • median age 54 yrs 45% repeat flaps			• Ischial wound location (OR 2.87, 95% CI 1.5 to 5.6) • Previous same site flap failure (OR 3.3, 95% CI 1.4 to 7.6)	managed elsewhere).	
Thiessen et al., 2011 (repeated in CQ 3)	Retrospective clinical comparing **outcomes for muscle and non-muscle flaps**	Participants were a consecutive sample undergoing PU surgery over a 6 year period in Belgium (n=94) Exclusion: • trochanter PU Characteristics: • Mean age 45.99±17.9yrs • 77% had some level of paralysis • 43% were non-hospitalized • 47% were chronic (>3 mths) PU • 100% PU were stage IV	**Selection** Only individuals with adequate wound bed preparation, infection control and nutritional parameters were selected for surgery (no further information on parameters) **Pre-operative** 69% participants had pre-operative antibiotics **Operative phase** • All pressure injuries debrided and excised including surrounding scar tissue, underlying bursa and soft tissue calcification • Ossification padding of bone stumps performed • 61% fasciocutaneous or perforator flap,39% musculocutaneous flap	Mean follow up 3.10 ± 1.8 years •	**Outcomes for musculocutaneous versus fasciocutaneous flaps** • No significant difference in hospital stay duration (75.45±52.2 days vs 64.76±75.5 days, p=0.059) • No significant difference in wound dehiscence (47% vs, 44%, p=0.835) • No significant difference in infection (35% vs, 51%, p=0.135) • No significant difference in hematoma/seroma (22% vs, 27%, p=0.628) • No significant difference in flap necrosis (8% vs, 11%, p=0.735) • No significant difference in need for secondary procedure (34% vs, 39%, p=0.668) • No significant difference in recurrence (32% vs, 26%, p=0.648) **Post-operative outcomes risk (multivariate analysis)** • Non-paralyic patients had decreased risk of post-operative complications (OR 0.081, 95% CI 0.009 to 0.706, p=0.023) • Developing PU in a non-hospital environment had decreased risk of post-operative complications (OR 0.108, 95% CI 0.0021 to 0.563, p=0.008) • No relationship between type of flap and risk of complication **Study conclusions: there is no significant difference in outcomes between different flap types and selection should be based on quality of available tissue**	• Four surgical teams • The retrospective study design is subject to chart completeness and data collection errors • May not be adequate sample size for statistical power • •	**Level of evidence: 3** **Quality: moderate**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
Kurita et al., 2009	Case control study **investigating validated measurement systems to quantify surgical risk for people with PU**	Participants were all recruited from a Plastic Surgery department in Japan (n=112) Inclusion for PU cohort: (n=50 with n=71 PU surgeries) • underwent PU surgery • followed for > 30 days Inclusion for non-PU cohort: (n=62 with n=62 surgeries) • patients undergoing non-PU surgery (but not another type of chronic wound) • aged ≥ 15 years Characteristics of PU cohort: Mean age 72.1±17.5 yrs Characteristics of non-PU cohort: Mean age 47.2±20.8 yrs	**PU cohort** • types of surgery ○ debridement (n=29) ○ wound closure/suturing (n=5) ○ wound closure/skin graft (n=5) ○ wound closure/flap (n=32) • types of PU ○ grade III (n=7) and grade IV (n=64) PUs ○ sacral (n=54), trochanter (n=14), ischial (n=7), other (n=4) **Non PU cohort** • types of surgery ○ plastic surgery for facial disfigurement (N=17) ○ reduction of facial bone fracture (n=14) ○ resection and/or reconstruction for sift tissue malignancy (n=9) reconstruction of trauma burns (n16)	Risk of mortality calculated using: • Physiological and Operative Severity Score for enumeration of Mortality and Morbidity (POSSUM; has previously been validated) • O-POSSUM (POSSUM developed for orthopedic patients) • haemoglobin level • albumin level	• PU cohort – 8/50 patients died within 30 days; non-PU cohort 0/62 died • Patients with PU had lower haemoglobin and higher predicted mortality scores than non PU patients • O-POSSUM was significantly more likely to predict morbidity than haemoglobin levels ($p<0.01$) in participants with PU • O-POSSUM showed best discriminatory power with AUC of 0.83±0.08 • O-POSSUM and POSSUM were both valid predictive methods ($p>0.05$ for both) **Conclusion: The study provides support for POSSUM and O-POSSUM scores being used as a predictor for risk of mortality for patients undergoing PU surgery**	• Cohort of PU patients had demographics that increased surgical risk that were not related to having a PU (e.g. age) • No comparative analysis of demographics • Unclear how participants were selected for inclusion • Clear use of the tool is not described (e.g. how different PU surgeries were classified on an orthopedic tool) • Small cohort of deaths – may not have statistical power	**Level of evidence: 3 (prognostic)** **Quality: low**
Clinical Question 2: What preoperative interventions are effective for supporting the individual undergoing surgical intervention for a pressure injury?							
Bonomi, Salval, Brenta, Rapisarda, & Settembrini, 2016 (repeated under clinical question 3)	Case series exploring viability of perforator flaps	Undergoing flap surgery for Category/Stage III or IV pressure injuries in Italy (n=33)	**Pre surgery:** • Portable Doppler to assess flap positioning	• Flaps viable at 2-33 months • Mean followup 14.9 months (range 2-38)	• One flap completely necrosed (2.7%) • Partial necrosis in 2 cases (5.4%) • 91.9% flap survival rate 1 case of wound dehiscence (2.7%)	• Osteomyelitis workup preop not noted. • Post op protocol and sitting program not described.	**Level of evidence: 4** **Quality: Low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
Mathur, Tan, Bhat, & Rozen, 2016 (repeated under CQ 3 and 4)	Case series reporting outcomes from flap reconstructions of lumbar-sacral PUs	Participants were those with a lumbar-sacral defect presenting at a single center over a 20 year period (n=102) Inclusion criteria: • Lumbar-sacral defect Exclusion criteria: • Not reported Participant characteristics: • 94% were PU cases 94% males	**Pre-operative:** • CT angiogram conducted to demonstrate lumbar artery perforators	• None reported • Unknown follow-up duration	**Outcomes** • 3/102 flaps had necrosis, all salvageable • 2/102 flaps had recurrence **Authors conclusions: Contralateral-based transverse lumbar perforator flap reduces recurrence that is commonly seen in soft lumbosacral tissue defects**	• Unknown followup period • Outcome measures unclear • Single center, single surgeon • Inclusion criteria and recruitment is unclear • Small sample size • Minimal participant characteristics	**Level of evidence: 4** **Quality: Low**
Tadiparthi, Hartley, Alzweri, Mecci, & Siddiqui, 2016 (repeated under CQ 3 and 4)	Retrospective case series **reporting outcomes following flap repair of PU and inter-disciplinary pre and post operative management**	Participants were consecutive admissions for pressure ulcer management over a 7 year period at a multidisciplinary SCI unit in UK (n=45 participants with n=60 PU) Inclusion criteria: • Pressure ulcer Participant characteristics: • Mean age 47 years (range 15 to 96) • 78% paraplegic and 22% tetraplegic • 75% had multiple comorbidities • 33% known smokers • 100% PUs were grade 3 or 4 severity • 56% participants had multiple PU • 45% ischial, 23% trochanter, 20% sacral	Pre-operative: • Optimization of nutrition and comorbidity management prior to surgery • Education to carers and patients on skin care, pressure relief mechanisms and skin monitoring • Assessment of home circumstances in preparation for discharge following surgery	• Complications (major and minor) • Recurrence – defined as development of a new PU over a healed reconstruction • Mean followup 33 months (range 25 to 72 months)	**Treatment choices** • 28.9% of participants were treated conservatively with debridement, wound dressings and the interdisciplinary management plan • 71% participants underwent flap reconstruction with donor sites closed directly **Surgical outcomes** • 6% (n=2) experienced recurrence • 3% (n=1) experienced sinus with ongoing osteomyelitis • 15.6% had wound breakdown • 6.3% had seroma **Author conclusions: With meticulous interdisciplinary planning for management of PU and surgery with flap, a low complication rate can be achieved**	• Small sample size • Participants with major comorbidities or considered non-concordant were not offered surgery, therefore potential selection bias for surgical outcomes • Single center study • Outcomes reported by non-blinded surgeons	**Level of evidence: 4** **Quality: Moderate**

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Huang & Guo, 2015 (repeated in CQ 3 and 4)	A retrospective chart analysis to explore the outcomes of patients with pressure ulcers undergoing surgical treatment	• Participants recruited in orthopedic department in China (n= 77 with 96 pressure ulcers) Inclusion criteria • Category/Stage IV pressure ulcers on sacrum, ischium, trochanter • surgical intervention Exclusion criteria: • Category/Stage I to III pressure injury • other anatomical locations Participant characteristics: • Mean age 57 (21-82) • Primarily para and tetraplegic	**Pre Surgery** • Nutrition assessment & support • Wound cultures, appropriate antibiotics as required • Blood, plasma, Serum protein given if required	Follow-up 4 months -3 years •	No flap necrosis • Recurrence rate 0% • 100% completely recovered from pressure ulcers • 15.94% had complications none of which impeded full repair of lesion • Flap dehiscence =0% • Rate of primary healing 89.25% In conclusion although no detail of the preventative measures used to address the risk factors for pressure ulcers it does appear that treating infection preoperatively and addressing nutritional needs leads to better outcomes post operatively.	The study is longitudinal and demonstrates good outcomes although small numbers involved. •	**Level of evidence: 4** **Quality: Low**
Di Caprio et al., 2014 (repeated In CQ 3 and 4)	A retrospective observational study reporting outcomes and follow up following posterior thigh tissue expander rotational flaps to treat ischial pressure injuries	• Participants were recruited at a plastic surgery department in Italy (n=98) Inclusion criteria: • SCI • Category/stage III and IV ischial pressure injuries Exclusion criteria: • Pressure injury at other anatomical areas • Previous posterior leg operations • Unable to comply with up to 4 months process Participant characteristics: • Primarily males	**Pre Surgery** • X- ray, ECG, nutritional profile, bloods, urine	• Follow up in the first year was 1,3,6,12 months after that annual review. Clinical follow up was 1-24 years the median being 9 years(mean time =9.5 years)	Outcomes • All patients completely recovered from pressure injury (excepting 2 deaths during surgery) • 15.94% had complications, none of which impeded full repair of lesion • Complications included haematoma =2%, Distal flap necrosis =2 %, Superficial necrosis =3%, Seroma =4%, Expansion minor complications =11% • Flap dehiscence = 0% • Recurrence rate 28%(? due to poor compliance with preventive measures and care during post op period) • 19% needed a second expansion, 3% required third expansion, 1% required 4 reconstructions	The study is longitudinal and recommends the use of tissue expanders in the treatment of pressure ulcers as a good option	**Level of evidence: 4** **Quality: Low**

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		• Age 16-73 years, 70.4% < 50 years • 84.8% Category/Stage IV pressure injuries • period due to their underlying pathology •			The study explores the long term outcomes and follow up of 138 paraplegic and quadriplegic patients who received posterior thigh tissue expander rotational flaps to treat ischial pressure ulcers in a two stage reconstruction. The procedure provides plentiful amounts of tissue to allow for multiple repairs without creating new scars so that other reconstructive options can be preserved if needed in the future. The sutures are placed beyond the sitting position to prevent breakdown and preserve tissue.		
Grassetti et al., 2014 (repeated in CQ 3 and 4)	Retrospective analysis of later pressure injury surgery cases	Records for individuals over an 11 year period in Italy (n=143) Inclusion: Category/Stage IV pressure ulcer Perforator flap Exclusion: Surgical team not including the paper authors Characteristics: 100% white Caucasian 61% male Median age 51 years 46.2% ischial, 42.7% sacral, 11.2% trochanteric •	**Pre-operative** • Hand held Doppler to identify perforator • Multidisciplinary assessment to achieve wound bed preparation, incontinence management • Radiogram to identify osteomyelitis and fractures	Two years' followup •	• Mean hospital stay 16 days • Major complications 5.6% • 4.2% new pressure injury • Overall complications 22.4% • Suture dehiscence 14%, flap necrosis 6.3%, 22.4% recurrence • Overall cumulative probability of recurrence at 2 years was 22.4% (95% CI 15.2% to 28.9% • New occurrence with a probability at 2 years of 4.2% (95% CI 0.9% to 7.4%). • People with coronary disease had significantly more recurrence (p=0.026) • No significant relationship between recurrence and age, other disease, diagnosis, ulcer location, type of flap, complications	• Single center and single surgical team • Minimal information about inclusion criteria Relied on medical records	**Level of evidence: 4** **Quality: moderate**
Daniali, Keys, Katz, & Mathes, 2011	Retrospective case-controlled study **comparing pre-operative management**	Participants were recruited from a spinal cord center in the USA between 1996 and 2008 (n=65 had flap reconstruction had osteomyelitis and n=47 had	Preoperative vs post operative identification of osteomyelitis • Participants received either: ○ pre-operative MRI diagnosis of osteomyelitis (n=26)	• Recurrence of PU at the same anatomic site • Suture line dehiscence • Significant suture line dehiscence and	• Patients with a diagnostic preoperative MRI did not differ significantly in rates of pre-operative antibiotic administration compared to those without pre-operative MRI (26.9% versus 23.8% OR 1.2, p=0.81)	• Retrospective chart review subject to Inaccuracies of data recording	**Level of evidence: 3** **Quality: moderate**

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(repeated for CQ 4)	**and post-operative outcomes between pre-operative MRI diagnosis of osteomyelitis and intra-operative bone biopsy**	either MRI or bone culture diagnosis). Characteristics: • Mean age 56.2 to 58.7 years • Primarily males with SCI • The preoperative MRI group had more participants with stable PUs of unchanging size (46.2% versus 23.8%, p =0.04) • MRI group had a greater number of patients with a history of peripheral vascular disease (14.3% versus 0%, p=0.05)	○ post-operative bone culture diagnosis of osteomyelitis (n=21)	• Time until mobilization by physical therapy	• There was no significant difference in PU recurrence rates post-surgery between those with osteomyelitis diagnosed by MRI had and those with osteomyelitis diagnosed by bone culture (39% versus 29%,OR 2.4, p=0.22) • There was no significant difference in infection rates post-surgery between those with osteomyelitis diagnosed by MRI had and those with osteomyelitis diagnosed by bone culture (7.7% versus 14.3%,OR 0.50, p=0.44) **Study conclusions: the study concluded that there was no evidence that a preoperative MRI diagnosis of osteomyelitis significantly alters clinical or surgical management or patient outcomes**	• Study cohorts were small potentially limiting the study generalizability. Inherent bias as patients undergoing MRI are usually more stable.	
Kierney et al., 1998 (repeated in CQ 1 and 4)	Cross sectional study of outcomes following pressure injury surgery	Consecutive participants underwent surgery at one center in US over a 12 year period (n=158, with n=268 pressure injuries) Inclusion: "High grade" pressure injury Participant characteristics Primarily male Mean age 34.5 years 65% new/primary pressure sores and 35% recurrent Primarily SCI patients	**Selection for surgery** Ability to adhere to treatment protocol was required to receive surgery **Pre operative** • Optimization of nutritional status • Social care assistance • Wheelchair and mechanical device maintenance • Skin care education	• Five year follow up (mean followup 3.7 years (range 1 month to 15.5 years)	**Recurrence 25% of patients** Fasciocutaneous and myocutaneous were more durable than cutaneous only flaps •	• Single center • Minimal details about participants and their risk factors	**Level of evidence: 4** **Quality: Moderate**
Ahluwalia, Martin, & Mahoney, 2009 (repeated for CQ 4)	Retrospective medical record review **investigating complications of wound reconstruction by flap site**	Sample was a consecutive cohort of patients undergoing surgery in a 10 year period in one Canadian hospital (n=78 with n=93 PUs) Inclusion:	• All participants had a similar surgical regimen **Preoperative** • wound culture to guide post-op antibiotic therapy	• Demographics; location of sores; methods of reconstruction; flap selection; complications and recurrences • "Complication" was not defined	• Overall flap complication rate of 16% (17/104) was observed in flap • Complication rate for ischial flaps by site ○ Posterior medial thigh flap: 17% ○ Biceps femoris muscle combined with posterior medial thigh flap: 14% ○ Gluteus myocutanous flap: 12% ○ Gluteus fascio flap: 33%	• No control to suggest whether overall effect is due to study intervention • Single center • No statistical analysis	**Level of evidence: 4** **Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		surgical reconstruction of a stage III or IV PU Characteristics: 72/93 PUs were ischial mean age 43 years (range 15 to 71) 94% had SCI 63 fasciocutaneous flaps and 41 musculcutaneous flaps		• Records were reviewed for complications and recurrence rates	• Recurrence rate 7% **Study conclusion: authors recommend that for ischial PU reconstruction, a combination posterior medial thigh fasciocutaneous flap with a bicep femoris muscle flap is the preferred strategy. However, there is no statistical analysis to support this and the sample were surgeries performed by a single surgeon.**	• No demographics • Relied on accurate records for data base review • Unclear what was considered to be a "complication" and how this was assessed	
Estrella & Lee, 2010 (repeated in CQ 3 and 4)	retrospective chart review to **investigate outcomes for non-ambulatory patients with hypoalbuminemia who undergo sacral PU surgery**	Participants were a sample of patients have flap reconstruction over a 6 year period at a tertiary hospital in Philippines (n=16) Inclusion: • Non-ambulatory • stage III to IV sacral PU • moderate to severe hypoalbuminemia preoperatively (serum albumin <35g/L) • minimum of 3 month's post surgery follow up documented in record Exclusion: • ambulatory • serum albumin >35g/L • previous history of flap surgery Characteristics: • Mean age 54 years • 14/16 PU stage IV and 2/16 were stage II PU • 5/16 had PU in another anatomical location	**Pre surgery** • At time of referral all participants received high protein, high calorie diet for 3 weeks prior to surgery • All participants were managed on a regular hospital mattress with 3 to 4 hour repositioning • All PUs received moist gauze packs	• Outcomes measured included the number of surgeries needed for coverage and complications encountered • Average follow up 11.25 months after surgical closure	• Wound related complication rate 37.5% (n=6) including corner necrosis, delayed healing. • Recurrence rate was 12.5% (n=2) • No association was established between complications and number of surgeries for eventual closure (r=0.516) • More complications occurred in younger age group (< 54 years; p=0.039) • There was no correlation between wound complications and having a comorbidity (p=0.458) • **The study provides some evidence on rate of complications for surgery. The facility implemented PU prevention and management strategies that are no longer recommended.**	• No control group • Relied upon accurate records and data extraction • Many of the care initiatives pre and post surgery do not reflect best practice (e.g. no specialized surfaces, use of doughnut pillow following surgery, moist gauze packs only). • Surgery in only one hospital • Unclear if sample is consecutive • Minimal characteristics of participants reported • "complication" is not defined and its assessment is not reported	**Level of evidence: 4** **Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		• All participants were dependent on others for bed mobility • Average serum albumin 21g/L ± 5.7g/L • Co morbidity included CVA and diabetes					
Dowsett, Swan, & Orig, 2013; Singh et al., 2013 (repeated in CQ 3 and 4)	Prospective case series **outlining management strategy and outcomes**	Participants were recruited over 5 years from one tertiary facility in India (n=35 with n= 37 PU) Inclusion criteria: • Occurrence of a traumatic event in SCI below C4 • PU stage III or IV that fails to heal with conservative treatment • Signed consent • Aged >18 yrs Exclusion: • chronic mental illness Characteristics: • Mean age 34.12 yrs (range 17 to 57) • 72.9% Sacral, 21.6% trochanter	**Pre-operative** • 2/24 posture changes with encouragement to increase prone positioning in preparation for post-operative period • water or air bed • avoid bedding linen creases • clean intermittent self-catheterization • nutritious diet • daily antiseptic dressing +/- debridement as required **Intra-operative** PUs treated using classic and modified flaps with improvisations **Post-operative** • Daily inspection by surgeon, patient and/or caretaker • Avoid pressure on flap • 2/24 repositioning commenced at 2 weeks postoperative • Indwelling catheter for 2 weeks • Sitting allowed after 6 weeks Proper wheel chair cushions	• Overall outcome rated as excellent, good or poor (no indication of how this was determined) • wound dehiscence • flap necrosis and • recurrence • Follow up average duration 14.34 months	**Type of procedure** • 19 gluteus maximus V-Y advancement flaps • 6 tensor fascia lata flaps • 2 tensor fascia lata vastus lateralis flap • 3 gluteus maximus island flaps • 7 fasciocutaneous rotation flaps **Complications** • Partial flap necrosis 2.7% • PU recurrence at flap site 5.4% • Overall PU recurrence rate 11.4% **Overall outcome** • excellent in 32 (86.48%) • good in 4 (10.81%) • Poor in 1 (2.7%) •	• Small sample size • No factors that may influence post-surgical outcomes are reported (e.g. comorbidites) • One facility and possibly only one surgical team •	**Level of evidence: 4** **Quality: low**
Srivastava, Gupta, Taly, & Murali, 2009	Prospective case series **investigating the efficacy of surgical interventions**	Participants were those admitted in a one year period to a neurological ward in India (n=25 with n=39 ulcers)	**Preoperative management** • nursing care • bedside sharp debridement dressing • education	• postoperative complications • recurrence rate • neurological (ASIA grade)	**Healing** 87% had total healing 17.3% recurrence (13% at the same site and 4.3% at a new site) **Surgical complications** • Complication rate 10.2% (n=2)	• Small sample size • Selection bias in in terms of age at onset, level of lesion, and pattern of paralysis	**Level of evidence: 4** **Quality: moderate**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
(repeated in CQ 3 and 4)	**for PU in patients with spinal disorders**	Inclusion: • stage III, IV or unstaged pressure ulcers • spinal cord disorder Characteristics: • 33.3% sacral , 23% gluteal , 20.5% trochanter, 10.2% ischial, 5% heel, 5% sole of foot , 2.5% dorsum ankle • 36sample had > one PU • 58.9% stage IV, 33.3% stage III PU • 88% participants had a high risk Braden score (<16) • Spinal injuries included tranverse myelitis, spinal tuberculosis, SCI, tumors		• functional recovery (Barthel Index) • Mean follow up duration 15.4±7.45 months (range 12 to 21 months; 8% lost to follow up) •	• For split skin graft (n=13): ○ wound infection (n=2) • For flap mobilization and closures (n=23): ○ suture line dehiscence (n=2) **Length of stay** • Mean 97.36 days (range 16 to 269) • participants with a traumatic spinal pathology had a longer mean stay (180.55±65.45 days) compared with non-traumatic spinal pathology (134.71±42.34) **Barthel Index** • baseline: mean score 28.6±16.68 (range 5 to 75) • postoperative mean score 67.0±16.95 (range 25 to 100, p=not reported) • follow up mean score 74.61±23.97 (range 25 to 100, p=not reported)	• One surgical team • No statistical analysis • No factors that may influence post-surgical outcomes are reported (e.g. comorbidites) •	
Isken et al., 2009	Retrospective case series **reporting detecting the position of suitable perforators**	Participants were ambulatory patients requiring surgery between 2002 to 2007 (n=26) Inclusion and exclusion criteria not reported Characteristics: • Mean age 47.7 yrs (range 7 to 77 yrs) • Mean PU size 83cm^2 • 22 sacral PU, 6 trochanter PU, 8 ischial PU • 53.8% ambulatory participants with PU following surgery	Pre-operative • Color Doppler ultrasonography was performed using high sensitivity and low wall filter to detect blood vessels with low flow • Vascular structures with arterial flow pattern with flow direction to cutaneous layers were accepted as cutaneous perforating artery	• Flap viability • Operating time • Mean follow up 15.9 months	• 36 gluteal perforator flaps were performed, • Mean flap area 166 cm^2 • Mean duration of surgery 31.9 minutes • Complications: ○ Superficial epidermolysis (n=3 participants) ○ Wound site infection (n=2) 11.5% ○ wound dehiscence (n=2) 10% ○ Partial necrosis (n=2) 10% • 100% of perforators were identified precisely • Flap viability rate was 94.4% **Study conclusion: use of color Doppler ultrasonography to identify perforator vessels precisely prior to surgery is related to short operation time, high flap viability and low complication rates**	• Self reported surgical outcomes • No control for comparison • No comorbidities are reported • Participants inclusion/exclusion and recruitment strategy is not reported •	**Level of evidence: 4** **Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
Clinical Question 3: What intraoperative interventions are effective for supporting the individual undergoing surgical intervention for a pressure injury?							
Ljung et al., 2017 Repeated in CQ 1 and 4)	Longitudinal cohort study	Consecutive patients have pressure injury surgery in one center in Switzerland (n=51 patients with 60 pressure injuries, 44/45 eligible participated at 3 years and 33/34 eligible participated at 10 years) Inclusion: Spinal cord injury Category/Stage IV pressure injury Characteristics: 80% male Average age 43 years (range 17-76) 67% paraplegic, 33% tetraplegic Having first, second or third surgery 95% gluteus maximus flap	**Intraoperative** • Total excision of wound and any fistulas • Underlying bone smoothed • Musculocutaneous flap	Outpatient appointment at 3 years (median 39 months) and 10 years (median 123 months) Clinical investigation, photography, questionnaires Data collection by nurse EQ-5D health questionnaire (100 point visual analog scale) •	**Outcomes immediate/4 weeks** 96% patients were completely healed within 4 weeks 4% had general complications 6% had local complications including local bleeding, minor flap necrosis that healed within 3 months, persisting ulcer that healed within 2 months **Outcomes 3 years post op** 12% died before 3 year followup, 33% died before 10 year followup 11% developed recurrent or new pressure injuries within 3 years, of these 5% had repeat surgery At 3 years median health status values using a EQ-5D was 70 (median) compared with 30 (median) preoperatively **Outcomes 10 years post op** Between 3-10 years following surgery 27% had recurrence and 18% had a new pressure injury, of these 9% had repeat surgery At 3-10 years median health status values using a EQ-5D was 70 (median) compared with 30 (median) preoperatively **Author conclusion: pressure injury surgery in a structured treatment program promotes healing healing, prevention and health status**	• One center with small sample size	**Level of evidence: 3** **Quality: Moderate**
Chang, Lee, & Choi, 2016	Case series reporting outcomes following flap repair of sacral PU	Participants undergoing a perforator-based island flap repair conducted by the same surgeon over a 5 year period (n=26) Inclusion criteria: • PU Stage 4 Exclusion criteria:	• **Intraoperative:** • Perforator-based island flap repair of the sacrum • Excision of full surface area and complete debridement to reduce recurrence • Detection of perforators with Doppler probe	• Mean follow up was 6.9 months (range 3 to 22)	**Outcomes** • Major complications 0% • venous congestion observed in the • flap immediately post-surgery without impact on flap survival 11.5% • Temporary induration of the flap post-surgery that did not develop • into infection or lead to flap loss 15.4%	• Short followup • Single center, single surgeon • Inclusion criteria and recruitment is unclear • Small sample size • Minimal participant characteristics	**Level of evidence: 4** **Quality: Moderate**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		• Lower stage PUs or PUs with shallow depth or an even depth Participant characteristics: • 58% males • Mean age 64.8 years (range 27 to 84)			• Wound dehiscence 7.7% : Participants who experienced wound dehiscence were both diabetic and non-compliant with positioning • **Author conclusions: Perforator island flap with peripheral muscle patch can address an uneven depth in a PU sacral sore**		
Mathur et al., 2016 (repeated under CQ 2 and 4)	Case series reporting outcomes from flap reconstructions of lumbar-sacral PUs	Participants were those with a lumbar-sacral defect presenting at a single center over a 20 year period (n=102) Inclusion criteria: • Lumbar-sacral defect Exclusion criteria: • Not reported Participant characteristics: • 94% were PU cases 94% males	Intra-operative: • Flap reconstruction based on contralateral lower lumbar perforator performed	• None reported • Unknown follow-up duration	**Outcomes** • 3/102 flaps had necrosis, all salvageable • 2/102 flaps had recurrence **Authors conclusions: Contralateral-based transverse lumbar perforator flap reduces recurrence that is commonly seen in soft lumbosacral tissue defects**	• Unknown followup period • Outcome measures unclear • Single center, single surgeon • Inclusion criteria and recruitment is unclear • Small sample size • Minimal participant characteristics	**Level of evidence: 4** **Quality: Low**
Bonomi et al., 2016 (repeated under clinical question 2)	Case series exploring viability of perforator flaps	Undergoing flap surgery for Category/Stage III or IV pressure injuries in Italy (n=33)	**During surgery:** • Pressure injury flap surgery using Pacman perforator based V-Y advancement flaps • Excised necrotic tissue and underlying bursa down to healthy skin • Osteotomy of any bony prominences to even out irregular bony surfaces	• Flaps viable at 2-33 months • Mean followup 14.9 months (range 2-38)	• One flap completely necrosed (2.7%) • Partial necrosis in 2 cases (5.4%) • 91.9% flap survival rate 1 case of wound dehiscence (2.7%)	• Osteomyelitis workup preop not noted. • Post op protocol and sitting program not described.	**Level of evidence: 4** **Quality: Low**
Bertheuil, Huguier, Aillet, Beuzeboc, & Watier, 2013	Retrospective database review describing outcomes following flap surgery	Consecutive participants recruited in one surgical center over 12 years (n=23 with n=26 pressure injuries Inclusion:	**Intra-operative**: • Excision of bursa and devitalized soft tissue • Bacteriological samples of soft tissue and bone	• Post operative complications • Duration of drainage • Hospital duration • Time to seating in wheelchair • Recurrence	H**ealing** 61.5% of procedures achieved healing 11.5% achieved no primary healing **Course of care** • Mean hospital stay 14.26 ±6.42 days	• Methods of outcome measurement not reported • Small sample from one site •	**Level of evidence: 4** **Quality: Moderate**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
(repeated under clinical question 4)		• Category/Stage IV ischial pressure injury • Biceps femoris flap Exclusion: Different anatomical location Characteristics: • Mean age 40.4 years • Mean weight 68kgs • Primarily male and paraplegic • 73% first pressure injury • 44% were smokers		• Mean followup 68.4 months	• Mean duration until returned to wheelchair 41.66 ±16.49 days **Complications** • Only 30.8% of procedures had no complication • 27.9% had a pressure injury recurrence in a mean time of 26.8 months (range 8-24) • Wound dehiscence in 38.4% of procedures • 11.5% cases of seroma • 7.6% partial flap necrosis • 46.1%of pressure injuries (43.4% of patients) required at least one repeat surgery **Author conclusions: Success is determined by patient education and compliance. Do not return patient to seating until at least 4 weeks, then gradual increase based on wound conditions.**		
Tadiparthi et al., 2016 (repeated under CQ 2 and 4)	Retrospective case series **reporting outcomes following flap repair of PU and inter-disciplinary pre and post operative management**	Participants were consecutive admissions for pressure ulcer management over a 7 year period at a multidisciplinary SCI unit in UK (n=45 participants with n=60 PU) Inclusion criteria: • Pressure ulcer Participant characteristics: • Mean age 47 years (range 15 to 96) • 78% paraplegic and 22% tetraplegic • 75% had multiple comorbidities • 33% known smokers • 100% PUs were grade 3 or 4 severity	**Intra-operative:** • Flap reconstruction with adequate debridement and tension free closures • Adequate debridement • Tissue sent for guiding antibiotic therapy	• Complications (major and minor) • Recurrence – defined as development of a new PU over a healed reconstruction • Mean followup 33 months (range 25 to 72 months)	**Treatment choices** • 28.9% of participants were treated conservatively with debridement, wound dressings and the interdisciplinary management plan • 71% participants underwent flap reconstruction with donor sites closed directly **Surgical outcomes** • 6% (n=2) experienced recurrence • 3% (n=1) experienced sinus with ongoing osteomyelitis • 15.6% had wound breakdown • 6.3% had seroma **Author conclusions: With meticulous interdisciplinary planning for management of PU and surgery with flap, a low complication rate can be achieved**	• Small sample size • Participants with major comorbidities or considered non-concordant were not offered surgery, therefore potential selection bias for surgical outcomes • Single center study • Outcomes reported by non-blinded surgeons	**Level of evidence: 4** **Quality: Moderate**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		• 56% participants had multiple PU • 45% ischial, 23% trochanter, 20% sacral					
Chiu et al., 2017 (repeated under CQ 4)	Retrospective cohort study	All patient records from one surgical center in a Taipei over an 11 year period were reviewed (n=201 potential, n=181 sufficient data) Inclusion criteria: • musculocutaneous, fasciocutaneous, or perforator-based flap reconstruction for stage III or IV PU Exclusion criteria: • Insufficient data Participant characteristics: • No systemic infection/cellulitis pre-surgery	**Intra operative** • Reconstructive surgery (with osteotomy if necessary)	• Outpatient "regular" follow up and lost data followed up with phone calls • Mean follow up 55.4 months •	**Complications** • Complication rate: fasciocutaneous 46.5%, musculocutaneous 44.2%, and free-style perforator flap 48.8% • Recurrence rate: fasciocutaneous 15.1%, musculocutaneous 15.4%, and free-style perforator flap 18.6% **Multivariable logistic analysis for recurrence Significant factors:** • Albumin level OR 2.09, 95% CI 1.11 to 3.91, p=0.021 • Paraplegia OR 2.42, 95% CI 1.29 to 4.56, p=0.006 Ischial location OR 3.02, 95% CI 1.32 to 6.93, p=0.009	• Retrospective design relying on medical records • Small sample size from a single site • Individual characteristics not reported	**Level of evidence: 3** **Quality: Moderate**
Huang & Guo, 2015 (repeated in CQ 2 and 4)	A retrospective chart analysis to explore the outcomes of patients with pressure ulcers undergoing surgical treatment	• Participants recruited in orthopedic department in China (n= 77 with 96 pressure ulcers) Inclusion criteria • Category/Stage IV pressure ulcers on sacrum, ischium, trochanter • surgical intervention Exclusion criteria: • Category/Stage I to III pressure injury	**Surgery** • Wound Debrided, wide margins to remove necrosis • myocutaneous flaps and fasciocutaneous flaps	• Follow-up 4 months -3 years •	No flap necrosis • Recurrence rate 0% • 100% completely recovered from pressure ulcers • 15.94% had complications none of which impeded full repair of lesion • Flap dehiscence =0% • Rate of primary healing 89.25% In conclusion although no detail of the preventative measures used to address the risk factors for pressure ulcers it does appear that treating infection preoperatively and addressing nutritional needs leads to better outcomes post operatively.	The study is longitudinal and demonstrates good outcomes although small numbers involved. •	**Level of evidence: 4** **Quality: Low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		• other anatomical locations Participant characteristics: • Mean age 57 (21-82) • Para/tetraplegic					
Wettstein, Tremp, Baumberger, Schaefer, & Kalbermatten, 2013 (repeated in CQ4)	Longitudinal evaluation of a specific multidisciplinary intervention	Participants were consecutively recruited in one center in Switzerland (n=119 with n=170 pressure injuries)) Participant characteristics: Age range (22 to 84 years) Locations: ischial region (47%), sacral (18%), trochanteric (11%), foot (9%) and malleolar (8%) 68% Category/Stage IV, 29% Category/Stage III, 2% Category/Stage II	**Intraoperative:** biopsies if bone exposed	Ulcer healing complications hospital days recurrence (ranged from 6 months to 38 months)	**Outcomes** Recurrence 11% complications 26%: primarily dehiscence The average duration of hospitalization stay after the first debridement was 98±62 days if no complications occurred		**Level of evidence: 4** **Quality: High**
Di Caprio et al., 2014 (repeated In CQ 2 and 4)	A retrospective observational study reporting outcomes and follow up following posterior thigh tissue expander rotational flaps to treat ischial pressure injuries	• Participants were recruited at a plastic surgery department in Italy (n=98) Inclusion criteria: • SCI • Category/stage III and IV ischial pressure injuries Exclusion criteria: • Pressure injury at other anatomical areas • Previous posterior leg operations • Unable to comply with up to 4 months process	**Surgery** • Two stage operation expanders inserted into back of thigh and filled with 120 mls saline valve • Step 2: wound debrided and ischial bone smoothed to prevent recurrence. Rotational flap performed two drains inserted for up to 10 days and some pts needed tenotomy for spasticity	• Follow up in the first year was 1,3,6,12 months after that annual review. Clinical follow up was 1-24 years the median being 9 years(mean time =9.5 years)	Outcomes • All patients completely recovered from pressure injury (excepting 2 deaths during surgery) • 15.94% had complications, none of which impeded full repair of lesion • Complications included haematoma =2%, Distal flap necrosis =2 %, Superficial necrosis =3%, Seroma =4%, Expansion minor complications =11% • Flap dehiscence = 0% • Recurrence rate 28%(? due to poor compliance with preventive measures and care during post op period)	The study is longitudinal and recommends the use of tissue expanders in the treatment of pressure ulcers as a good option	**Level of evidence: 4** **Quality: Low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		Participant characteristics: • Primarily males • Age 16-73 years, 70.4% < 50 years • 84.8% Category/Stage IV pressure injuries • period due to their underlying pathology			• 19% needed a second expansion, 3% required third expansion, 1% required 4 reconstructions		
Greco et al., 2013 (repeated CQ 4)	Case serie study reporting outcomes from pressure injury surgery	All participants receiving surgery over a 15 year period at one center in (n=195 patients with n=338 pressure injuries) Participant characteristics: • Primarily male • Average age 49 years (range 21 to 84) • 189 had paraplegia or tetraplegia • Ischial, sacral and trochanteric mostly	**Surgery** • Primarily cutaneous flaps and fasciocutaneous flaps (dependent on anatomical location) • Wide removal of necrotic tissue, • bone remolding • bone samples	• Followup range 2 months to 7 years (mean 55.27 months, median 3.5 years)	Median healing time 18 days Complication rates for hematoma, infection, seroma were all below 3% Recurrence In 1.18% cases	• Minimal information about participants	**Level of evidence: 4** **Quality: Moderate**
Grassetti et al., 2014 (repeated in CQ 2 and 4)	Retrospective analysis of later pressure injury surgery cases	Records for individuals over an 11 year period in Italy (n=143) Inclusion: Category/Stage IV pressure ulcer Perforator flap Exclusion: Surgical team not including the paper authors Characteristics: 100% white Caucasian 61% male Median age 51 years	**Intra-operative** Bone biopsy and culture Excision of pressure injury plus bursa using VersaJet® (Smith and Nephew)	Two years' followup	• Mean hospital stay 16 days • Major complications 5.6% • 4.2% new pressure injury • Overall complications 22.4% • Suture dehiscence 14%, flap necrosis 6.3%, 22.4% recurrence • Overall cumulative probability of recurrence at 2 years was 22.4% (95% CI 15.2% to 28.9% • New occurrence with a probability at 2 years of 4.2% (95% CI 0.9% to 7.4%). • People with coronary disease had significantly more recurrence (p=0.026) No significant relationship between recurrence and age, other disease, diagnosis, ulcer location, type of flap, complications	• Single center and single surgical team • Minimal information about inclusion criteria • Relied on medical records	**Level of evidence: 4** **Quality: moderate**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		46.2% ischial, 42.7% sacral, 11.2% trochanteric					
Marriott & Rubayi, 2008	Retrospective review of individuals treated for osteomyelitis	Chart records for a 5-year period from one facility in US Three groups of patients were defined: acute osteomyelitis (n=55), chronic osteomyelitis (n=56), and negative osteomyelitis (control) (n=49)	Intraoperative bone sample 5 to 7day course of IV antibiotics is used to cover polymicrobial soft tissue colonization	Length od stay Recurrence	No statistical difference in postoperative stay or wound infection rate when comparing chronic osteomyelitis treated with 5 days of IV Chronic vs acute: 0.2636 for postoperative stay, 0.2046 for postoperative wound infection rate, 0.7899 for flap revision rate, and 0.0003 for ulcer recurrence rate **Surgical debridement, and muscle flap coverage shortens the necessary antibiotic treatment from 4 to 6 weeks, to 5 days**.	• Small single center study Minimal information regarding participants	**Level of evidence: 4** **Quality: moderate**
Larson, Hudak, Waring, Orr, & Simonelic, 2012 (repeated in CQ 4)	5-year retrospective study **reporting outcomes of a standardized clinical pathway**	Participants were a consecutive sample of patients undergoing PU surgery at one center over a 5 year period (n=101 with 179 PU) Inclusion: • All surgical patients in facility Characteristics: • Mean age 49.4 yrs • PU locations: Ischial-49.7%, sacral-26.8%, trochanteric- 19% • 87.7% of PU were stage 4 • 33% smokers, 21% renal disease	**Intraoperative** • Debridement of the wound and bursa using high jet water debridement (VersaJet®, Smith and Nephew) • Bone culture to detect osteomyelitis	Data abstracted included: • Demographics, • Comorbidities • Location and stage of ulcers • Treatment history with outcomes • Laboratory data Mean follow-up was 629 days	• Primary closure was performed on 45.8% and remaining 53.2% underwent flap closure • There was no correlation between positive bone cultures and recurrence or complications • The overall recurrence rate was 16.8% at a mean period of 435.9 days • New ulcer occurrence was 14.5% and the complication rate was 17.3% • Complications: o Suture line dehiscence – 27 (15%) o Infection – 4 (2.2%) o Distal flap necrosis – 1 (0.6%) **The author concludes that the protocol that had been unchanged for 10 years had an adequate success rate.**	• Unclear how many lost to follow up (7% lost to death) • No discussion of other literature or other protocols that may be appropriate or more successful • Protocol had not changed over a 10 year period • Patients may not have returned if there was a recurrence	**Level of evidence: 4** **Quality: moderate**
Thiessen et al., 2011 (repeated in CQ 1)	Retrospective clinical comparing **outcomes for muscle and non-muscle flaps**	Participants were a consecutive sample undergoing PU surgery over a 6 year period in Belgium (n=94) Exclusion:	**Operative phase** • All pressure injuries debrided and excised including surrounding scar tissue, underlying bursa and soft tissue calcification	Mean follow up 3.10 ± 1.8 years •	**Outcomes for musculocutaneous versus fasciocutaneous flaps** • No significant difference in hospital stay duration (75.45±52.2 days vs 64.76±75.5 days, p=0.059) • No significant difference in wound dehiscence (47% vs, 44%, p=0.835)	• Four surgical teams • The retrospective study design is subject to chart completeness and data collection errors	**Level of evidence: 3** **Quality: moderate**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		• trochanter PU Characteristics: • Mean age 45.99±17.9yrs • 77% had some level of paralysis • 43% were non-hospitalized • 47% were chronic (>3 mths) PU • 100% PU were stage IV	• Ossification padding of bone stumps performed • 61% fasciocutaneous or perforator flap,39% musculocutaneous flap		• No significant difference in infection (35% vs, 51%, p=0.135) • No significant difference in hematoma/seroma (22% vs, 27%, p=0.628) • No significant difference in flap necrosis (8% vs, 11%, p=0.735) • No significant difference in need for secondary procedure (34% vs, 39%, p=0.668) • No significant difference in recurrence (32% vs, 26%, p=0.648) **Post-operative outcomes risk (multivariate analysis)** • Non-paralytic patients had decreased risk of post-operative complications (OR 0.081, 95% CI 0.009 to 0.706, p=0.023) • Developing PU in a non-hospital environment had decreased risk of post-operative complications (OR 0.108, 95% CI 0.0021 to 0.563, p=0.008) • No relationship between type of flap and risk of complication **Study conclusions: there is no significant difference in outcomes between different flap types and selection should be based on quality of available tissue**	• May not be adequate sample size for statistical power • •	
Estrella & Lee, 2010 (repeated in CQ 2 and 4)	retrospective chart review to **investigate outcomes for nonambulatory patients with hypoalbumine mia who undergo sacral PU surgery**	Participants were a sample of patients have flap reconstruction over a 6 year period at a tertiary hospital in Phillipines (n=16) Inclusion: • nonambulatory • stage III to IV sacral PU • moderate to severe hypoalbuminemia preoperatively (serum albumin <35g/L) • minimum of 3 month's post surgery follow up documented in record	**Surgery** • All participants underwent a V-Y advancement flap coverage for the sacral PU with radical debridement of necrosis, padding of bony prominences, dead space management, negative suction drain, tension free closure	• Outcomes measured included the number of surgeries needed for coverage and complications encountered. Average follow up 11.25 months after surgical closure	• Wound related complication rate 37.5% (n=6) including corner necrosis, delayed healing. • Recurrence rate was 12.5% (n=2) • No association was established between complications and number of surgeries for eventual closure (r=0.516) • More complications occurred in younger age group (< 54 years; p=0.039) • There was no correlation between wound complications and having a comorbidity (p=0.458) **The study provides some evidence on rate of complications for surgery. The facility implemented PU prevention and management strategies that are no longer recommended.**	• No control group • Relied upon accurate records and data extraction • Many of the care initiatives pre and post surgery do not reflect best practice (e.g. no specialized surfaces, use of doughnut pillow following surgery, moist gauze packs only).	**Level of evidence: 4** **Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		Exclusion: • ambulatory • serum albumin >35g/L • previous history of flap surgery Characteristics: • Mean age 54 years • 14/16 PU were stage IV and 2/16 were stage II PU • 5/16 had additional PU in another anatomical location • All participants were dependent on others for bed mobility • Average serum albumin 21g/L ± 5.7g/L Co morbidity included CVA and diabetes				• Surgery in only one hospital • Unclear if sample is consecutive • Minimal characteristics of participants reported • "complication" is not defined and its assessment is not reported	
Srivastava et al., 2009 (repeated in CQ 2 and 4)	Prospective case series **investigating the efficacy of surgical interventions for PU in patients with spinal disorders**	Participants were those admitted in a one year period to a neurological ward in India (n=25 with n=39 ulcers) Inclusion: • stage III, IV or unstaged pressure ulcers • spinal cord disorder Characteristics: • 33.3% sacral , 23% gluteal , 20.5% trochanter, 10.2% ischial, 5% heel, 5% sole of foot , 2.5% dorsum ankle • 36sample had > one PU • 58.9% stage IV, 33.3% stage III PU	**interventions** • based on PU stage and presence/absence of eschar • 58.9% had flap closure • 33.3% had skin grafting • 7.6% surgical debridement	• postoperative complications • recurrence rate • neurological (ASIA grade) • functional recovery (Barthel Index) • Mean follow up duration 15.4±7.45 months (range 12 to 21 months; 8% lost to follow up) •	**Healing** 87% had total healing 17.3% recurrence (13% at the same site and 4.3% at a new site) **Surgical complications** • Complication rate 10.2% (n=2) • For split skin graft (n=13): ○ wound infection (n=2) • For flap mobilization and closures (n=23): ○ suture line dehiscence (n=2) **Length of stay** • Mean 97.36 days (range 16 to 269) • participants with a traumatic spinal pathology had a longer mean stay (180.55±65.45 days) compared with non-traumatic spinal pathology (134.71±42.34) **Barthel Index**	• Small sample size • Selection bias in in terms of age at onset, level of lesion, and pattern of paralysis • One surgical team • No statistical analysis • No factors that may influence post-surgical outcomes are reported (e.g. comorbidites) •	**Level of evidence: 4** **Quality: moderate**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		• 88% participants had a high risk Braden score (<16) • Spinal injuries included tranverse myelitis, spinal tuberculosis, SCI, tumors			• baseline: mean score 28.6±16.68 (range 5 to 75) • postoperative mean score 67.0±16.95 (range 25 to 100, p=not reported) • follow up mean score 74.61±23.97 (range 25 to 100, p=not reported)		
Clinical Question 4: What postoperative interventions are effective for supporting the individual undergoing surgical intervention for a pressure injury?							
Ljung et al., 2017 Repeated in CQ 1 and 3)	Longitudinal cohort study	Consecutive patients have pressure injury surgery in one center in Switzerland (n=51 patients with 60 pressure injuries, 44/45 eligible participated at 3 years and 33/34 eligible participated at 10 years) Inclusion: Spinal cord injury Category/Stage IV pressure injury Characteristics: 80% male Average age 43 years (range 17-76) 67% paraplegic, 33% tetraplegic Having first, second or third surgery 95% gluteus maximus flap	**Post operative** • Antibiotics for 1 week (broad spectrum coverage) for which first 3 days intravenous • Air fluidized bed • No wound dressing • After 7-11 days, commenced a 4-week program including flap monitoring, positioning and movement, nutrition and support surfaces • 2 weeks post-surgery gradual sitting • Pressure redistribution cushion (detailed treatment chart in paper)	Outpatient appointment at 3 years (median 39 months) and 10 years (median 123 months) Clinical investigation, photography, questionnaires Data collection by nurse EQ-5D health questionnaire (100 point visual analog scale) •	**Outcomes immediate/4 weeks** 96% patients were completely healed within 4 weeks 4% had general complications 6% had local complications including local bleeding, minor flap necrosis that healed within 3 months, persisting ulcer that healed within 2 months **Outcomes 3 years post op** 12% died before 3 year followup, 33% died before 10 year followup 11% developed recurrent or new pressure injuries within 3 years, of these 5% had repeat surgery At 3 years median health status values using a EQ-5D was 70 (median) compared with 30 (median) preoperatively **Outcomes 10 years post op** Between 3-10 years following surgery 27% had recurrence and 18% had a new pressure injury, of these 9% had repeat surgery At 3-10 years median health status values using a EQ-5D was 70 (median) compared with 30 (median) preoperatively **Author conclusion: pressure injury surgery in a structured treatment program promotes healing, prevention and health status**	• One center with small sample size	**Level of evidence: 3** **Quality: Moderate**
Han, Choi, Choi, & Rhie, 2016	Retrospective cohort study **comparing**	Retrospective review of patients undergoing PU flap repair in 6 year period at	**Post-operative management:** • Where possible, pressure on surgical site avoided	• Complication rate (flap necrosis, wound	**Outcomes** • Multiple repair group had significantly greater blood loss in surgery (p=0.004) and	• Similarity in wound care is not reported	**Level of evidence: 3 (prognosis)**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
	prognosis of multiple PU repairs versus a single PU repair	one surgical site in Korea (n=88 participants, 114 PU) Inclusion criteria: • Stage 4 PU • Resolution of wound infection and growth of healthy granulation tissue prior to surgery Exclusion criteria: • None stated Participant characteristics: • Mean age 55.6 years (SD 22.7) • Average no multiple PUs (when applicable) 2.4 • Mean PU size at baseline approx. 72cm^2 (no significant difference between groups) 56% participants had SCI, 26% general weakness, 15% cerebrovascular accident	• If impossible, hourly repositioning • Air-fluidized bed for minimum of 4 weeks • Graduated sitting program was initiated 6 weeks after the operation commencing with 3o mins daily and increasing by 30mins if tolerated Wound care 2-3 times weekly	disruption, hematoma, seroma, and infection) • Surgical variables • Mean follow up 1.3 years (range 4 months to 5 years) •	significantly longer time in surgery (p=0.005) • No significant difference in complications between single and multiple repair groups (10.3% versus 15%, p=0.507) • No significant difference on hospital stay between single and multiple repair groups (26 days versus 25.47 days, p=0.942) **Author conclusions: Although patients have greater risks (longer surgery and more blood loss) when multiple PUs are repaired in one surgery time, recovery is not significantly different to patients who have only one PU repaired therefore the option may reduce resource use and increase overall recovery time.**	• Relies on documentation	**Quality: Low**
Han, Ko, & Rhie, 2017	A retrospective chart review to ascertain the relationship between comorbid conditions and surgical outcomes in order to guide patient selection for pressure ulcer surgery	Retrospective record review of one surgical site in Korea (n=57) Inclusion criteria: • pressure ulcers on the sacrum, ischium, trochanter and multiple sites who received surgical interventions. Characteristics: • Age 61 (16-94) • Males 26 (45.6%) • Defect size 107.56 (12-794) cm sq	**Post operative:** 2 hourly repositioning air mattress (type unspecified) for at least 2 weeks	• No significant difference in age, hospital stay and BMI between pts with different surgical sites. • No pressure ulcer staging mentioned •	C**omplications** 14% of participants of which 21% had pneumonia Patients at risk of developing pneumonia 1.069 p<0.05 were older and increased 44.17 p< 0.05 fold in preoperative ventilator users **Wound complications** Risk increased 1.012 fold with large wound at baseline (OR 1.012, p<0.05) and increased 7.474 fold for individuals receiving hemodilution therapy (OR 7.474, p<0.05) • Patients with multiple surgical sites had larger defect sizes (p< 0.05)	• There may be more risk factors that affected participants – baseline factors poorly reported • Numbers small • Retrospective study • Only carried out in one site • Approx 12% had cancer comorbidity	**Level of evidence: 3 (prognostic)** **Quality: Low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		• Hospital stay 33 (7-80days) • BMI 18.9 (10.9-33.1 kg/m sq • Anatomical location: Ischium 9 (15.8%), sacrum 36 (63%), trochanter 3 (5.2%), multiple 9 (15.8%) • BMI was higher in the grade1 and grade 2 mobility groups than in the grade 4 mobility group (p <0.05)			• Surgical time greater in the multiple pressure injuries but duration of hospital stay did not really differ **This study demonstrates that surgical options should considered for patients with pressure injuries despite their risk of complications. The larger the wound and the use of ventilators did impact on post op complication.**		
Chiu et al., 2017 (repeated under CQ 3)	Retrospective cohort study	All patient records from one surgical center in a Taipei over an 11 year period were reviewed (n=201 potential, n=181 sufficient data) Inclusion criteria: • musculocutaneous, fasciocutaneous, or perforator-based flap reconstruction for stage III or IV PU Exclusion criteria: • Insufficient data Participant characteristics: • No systemic infection/cellulitis pre-surgery	Post operative: • Post-operative positioning to avoid weight on surgical site for 3 weeks • Gradual increase weight bearing on surgical site	• Outpatient "regular" follow up and lost data followed up with phone calls • Mean follow up 55.4 months •	**Complications** • Complication rate: fasciocutaneous 46.5%, musculocutaneous 44.2%, and free-style perforator flap 48.8% • Recurrence rate: fasciocutaneous 15.1%, musculocutaneous 15.4%, and free-style perforator flap 18.6% **Multivariable logistic analysis for recurrence Significant factors:** • Albumin level OR 2.09, 95% CI 1.11 to 3.91, p=0.021 • Paraplegia OR 2.42, 95% CI 1.29 to 4.56, p=0.006 Ischial location OR 3.02, 95% CI 1.32 to 6.93, p=0.009	• Retrospective design relying on medical records • Small sample size from a single site • Individual characteristics not reported	**Level of evidence: 3** **Quality: Moderate**
Tadiparthi et al., 2016 (repeated under CQ 2 and 3)	Retrospective case series **reporting outcomes following flap repair of PU and inter-**	Participants were consecutive admissions for pressure ulcer management over a 7 year period at a multidisciplinary SCI unit in UK (n=45 participants with n=60 PU)	**Post operative:** • Suction drainage for 3 weeks • Bed rest for 8 weeks then slow and gradual mobilization • Pressure sore mapping to adjust support surface	• Complications (major and minor) • Recurrence – defined as development of a new PU over a healed reconstruction	**Treatment choices** • 28.9% of participants were treated conservatively with debridement, wound dressings and the interdisciplinary management plan	• Small sample size • Participants with major comorbidities or considered non-concordant were not offered	**Level of evidence: 4** **Quality: Moderate**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
	disciplinary pre and post operative management	Inclusion criteria: • Pressure ulcer Participant characteristics: • Mean age 47 years (range 15 to 96) • 78% paraplegic and 22% tetraplegic • 75% had multiple comorbidities • 33% known smokers • 100% PUs were grade 3 or 4 severity • 56% participants had multiple PU • 45% ischial, 23% trochanter, 20% sacral	• Regular assessment in clinic • Antibiotic therapy if required based on lab results	• Mean followup 33 months (range 25 to 72 months)	• 71% participants underwent flap reconstruction with donor sites closed directly **Surgical outcomes** • 6% (n=2) experienced recurrence • 3% (n=1) experienced sinus with ongoing osteomyelitis • 15.6% had wound breakdown • 6.3% had seroma **Author conclusions: With meticulous interdisciplinary planning for management of PU and surgery with flap, a low complication rate can be achieved**	surgery, therefore potential selection bias for surgical outcomes • Single center study • Outcomes reported by non-blinded surgeons	
Bertheuil et al., 2013 (repeated under clinical question 3)	Retrospective database review describing outcomes following flap surgery	Consecutive participants recruited in one surgical center over 12 years (n=23 with n=26 pressure injuries Inclusion: • Category/Stage IV ischial pressure injury • Biceps femoris flap Exclusion: Different anatomical location Characteristics: • Mean age 40.4 years • Mean weight 68kgs • Primarily male and paraplegic • 73% first pressure injury • 44% were smokers	**Post operative care** • Supine on air fluidized bed for 3-4 weeks • Truncal flexion of 40° permitted only during meals • Hygiene and skin assessments in lateral decubitus position • Low residue fiber diet • Antibiotics only if signs of local infection	• Post operative complications • Duration of drainage • Hospital duration • Time to seating in wheelchair • Recurrence • Mean followup 68.4 months	H**ealing** 61.5% of procedures achieved healing 11.5% achieved no primary healing **Course of care** • Mean hospital stay 14.26 ±6.42 days • Mean duration until returned to wheelchair 41.66 ±16.49 days **Complications** • Only 30.8% of procedures had no complication • 27.9% had a pressure injury recurrence in a mean time of 26.8 months (range 8-24) • Wound dehiscence in 38.4% of procedures • 11.5% cases of seroma • 7.6% partial flap necrosis • 46.1%of pressure injuries (43.4% of patients) required at least one repeat surgery **Author conclusions: Success is determined by patient education and compliance. Do not**	• Methods of outcome measurement not reported • Small sample from one site •	**Level of evidence: 4** **Quality: Moderate**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
					return patient to seating until at least 4 weeks, then gradual increase based on wound conditions.		
Mathur et al., 2016 (repeated under CQ 2 and 3)	Case series reporting outcomes from flap reconstructions of lumbar-sacral PUs	Participants were those with a lumbar-sacral defect presenting at a single center over a 20 year period (n=102) Inclusion criteria: • Lumbar-sacral defect Exclusion criteria: • Not reported Participant characteristics: • 94% were PU cases 94% males	Post operative: • Nursed prone or on side until flap healed • Avoid direct pressure on flap	• None reported • Unknown follow-up duration	**Outcomes** • 3/102 flaps had necrosis, all salvageable • 2/102 flaps had recurrence **Authors conclusions: Contralateral-based transverse lumbar perforator flap reduces recurrence that is commonly seen in soft lumbosacral tissue defects**	• Unknown followup period • Outcome measures unclear • Single center, single surgeon • Inclusion criteria and recruitment is unclear • Small sample size • Minimal participant characteristics	**Level of evidence: 4** **Quality: Low**
Huang & Guo, 2015 (repeated in CQ 2 and 3)	A retrospective chart analysis to explore the outcomes of patients with pressure ulcers undergoing surgical treatment	• Participants recruited in orthopedic department in China (n= 77 with 96 pressure ulcers) Inclusion criteria • Category/Stage IV pressure ulcers on sacrum, ischium, trochanter • surgical intervention Exclusion criteria: • Category/Stage I to III pressure injury • other anatomical locations Participant characteristics: • Mean age 57 (21-82) • Primarily para and tetraplegic	**Post-Surgery** • Intensive nursing care • Education of pts and relatives on the management and prevention of pressure ulcers	Follow-up 4 months -3 years •	No flap necrosis • Recurrence rate 0% • 100% completely recovered from pressure ulcers • 15.94% had complications none of which impeded full repair of lesion • Flap dehiscence =0% • Rate of primary healing 89.25% In conclusion although no detail of the preventative measures used to address the risk factors for pressure ulcers it does appear that treating infection preoperatively and addressing nutritional needs leads to better outcomes post operatively.	The study is longitudinal and demonstrates good outcomes although small numbers involved. •	**Level of evidence: 4** **Quality: Low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
Wettstein et al., 2013 (repeated in CQ3)	Longitudinal evaluation of a specific multidisciplinary intervention	Participants were consecutively recruited in one center in Switzerland (n=119 with n=170 pressure injuries)) Inclusion criteria: Exclusion criteria: Participant characteristics: Age range (22 to 84 years) Locations: ischial region (47%), sacral (18%), trochanteric (11%), foot (9%) and malleolar (8%) 68% Category/Stage IV, 29% Category/Stage III, 2% Category/Stage II •	Post operative: • Two drains inserted (one left 2 weeks and other removed if output <20ml over 24 hours, strict immobilization for 4 weeks on a KCl mattress • Passive hip flexion to 30° for 30 minutes commenced week 2, scheduled mobilization commenced week 4 (2x30mins sitting increasing to 2 x 4 hour session as soon as 90° hip flexion possible without tension) • If osteomyelitis, strict immobility for 6 weks	Ulcer healing complications hospital days recurrence (ranged from 6 months to 38 months)	**Outcomes** Recurrence 11% complications 26%: primarily dehiscence The average duration of hospitalization stay after the first debridement was 98±62 days if no complications occurred		**Level of evidence: 4** **Quality: High**
Jiang et al., 2014	A multi centre RCT to evaluate the of efficacy of two different pressure redistribution mattresses in the prevention of pressure injuries in patients post operatively.	Participants were recruited in 12 hospital in China (n=1074) Inclusion criteria : • age > 18 years • Braden Scale score < 16 • Operating time >120 min Exclusion criteria: • On limited repositioning orders • Dropped intervention within 72 hours • Incomplete data • Category/Stage I or II pressure injury Participant characteristics: • Mean age 57 (range 18-88) • Males 57%	Participants were randomized to receive specific mattress for pre and post surgery period: • Static WAFFLE® air mattress group (n =562) • Dynamic air mattress group (n=512) **Pre Surgery** Surgical Risk assessment form (SPURA) Nurses received training on Braden and NPUAP staging, and operation processes of the two types of mattress. **Post-Surgery** Patients observed for 5 days Repositioned 2 hourly Skin inspection Braden daily Pts were deemed low medium and high risk of ulcers	• Study conducted to calculate pts who developed pressure ulcers over the first 5 days post op	**Outcome 1** • Incidence 1% (Primarily Category/Stage I, but some Category/Stage II pressure injuries) • Incidence by ward location: ICU 1.95%, Surgical wards 1.95%, Ortho 0.29% (1/344) • No significant difference based on mattress group (static group = 1.07% versus dynamic group = 0.98% (p= 0.882) • No significant difference between mattresses for patient comfort (p>0.05) **Study Conclusion** **The effects on the two air mattresses on pressure ulcer prevention were similar. The static air mattress group does not rely on power and therefore maybe cheaper and more convenient if the patient is moved around a lot.**	• The nurse education and 2 hourly turning may also have influenced the results as staff knew patients were participating in study, which may have had the "Hawthorne effect" No mention of patients lost or dropped out, unclear if ITT analysis	**Level of evidence: 1** **Quality: Moderate**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		• Mean surgery duration 120 -960 mins • Mean Braden Scale score 6-17 • 14.34% in SICU post op, 32.03% Orthopedic post op , 53.63% general surgical wards post op					
Di Caprio et al., 2014 (repeated In CQ 2 and 3)	A retrospective observational study reporting outcomes and follow up following posterior thigh tissue expander rotational flaps to treat ischial pressure injuries	• Participants were recruited at a plastic surgery department in Italy (n=98) Inclusion criteria: • SCI • Category/stage III and IV ischial pressure injuries Exclusion criteria: • Pressure injury at other anatomical areas • Previous posterior leg operations • Unable to comply with up to 4 months process Participant characteristics: • Primarily males • Age 16-73 years, 70.4% < 50 years • 84.8% Category/Stage IV pressure injuries • period due to their underlying pathology	**Post-Surgery** • Passive lower limb mobilization • Commence sitting p • Rehab with passive exercises gradually sitting out post removal of sutures for mealtimes 3 weeks post op with 2 60 minute sitting periods per day for 2 weeks, gradually increasing to 2 hours (sitting coincided with meals)	• Follow up in the first year was 1,3,6,12 months after that annual review. • Clinical follow up was 1-24 years the median being 9 years(mean time =9.5 years)	Outcomes • All patients completely recovered from pressure injury (excepting 2 deaths during surgery) • 15.94% had complications, none of which impeded full repair of lesion • Complications included haematoma =2%, Distal flap necrosis =2 %, Superficial necrosis =3%, Seroma =4%, Expansion minor complications =11% • Flap dehiscence = 0% • Recurrence rate 28%(? due to poor compliance with preventive measures and care during post op period) • 19% needed a second expansion, 3% required third expansion, 1% required 4 reconstructions	The study is longitudinal and recommends the use of tissue expanders in the treatment of pressure ulcers as a good option •	**Level of evidence: 4** **Quality: Low**
Greco et al., 2013 (repeated CQ 3)	Case serie study reporting outcomes from pressure injury surgery	All participants receiving surgery over a 15 year period at one center in (n=195 patients with n=338 pressure injuries) Participant characteristics: • Primarily male	**Post surgery** • 15 days antibiotic therapy, if complicated by osteomyelitis then 6 weeks antibiotics or until inflammatory markers reduced • Flat lying on an air fluidized therapy bed	• Followup range 2 months to 7 years (mean 55.27 months, median 3.5 years)	Median healing time 18 days Complication rates for hematoma, infection, seroma were all below 3% Recurrence In 1.18% cases	• Minimal information about participants	**Level of evidence: 4** **Quality: Moderate**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		• Average age 49 years (range 21 to 84) • 189 had paraplegia or tetraplegia • Ischial, sacral and trochanteric mostly	• No regular turning				
Grassetti et al., 2014 (repeated in CQ 2 and 3)	Retrospective analysis of later pressure injury surgery cases	Records for individuals over an 11 year period in Italy (n=143) Inclusion: Category/Stage IV pressure ulcer Perforator flap Exclusion: Surgical team not including the paper authors Characteristics: 100% white Caucasian 61% male Median age 51 years 46.2% ischial, 42.7% sacral, 11.2% trochanteric	**Post-operative** Passive and active upper body strengthening exercises commenced immediate post-op 2-3 weeks bed rest on air fluidized bed Antibiotics when appropriate based on culture Nutritionist consultation and program as appropriate Graduated sitting regimen over 7 to 10 days until upright sitting posture achieved for 3 hours/day with padded wheelchair Pressure release maneuvers taught and used every 15 mins	Two years' followup •	• Mean hospital stay 16 days • Major complications 5.6% • 4.2% new pressure injury • Overall complications 22.4% • Suture dehiscence 14%, flap necrosis 6.3%, 22.4% recurrence • Overall cumulative probability of recurrence at 2 years was 22.4% (95% CI 15.2% to 28.9% • New occurrence with a probability at 2 years of 4.2% (95% CI 0.9% to 7.4%). • People with coronary disease had significantly more recurrence (p=0.026) No significant relationship between recurrence and age, other disease, diagnosis, ulcer location, type of flap, complications	• Single center and single surgical team • Minimal information about inclusion criteria • Relied on medical records	**Level of evidence: 4** **Quality: moderate**
Finnegan, Gazzerro, Finnegan, & Lo, 2008	RCT comparing two high specification mattresses for post op healing	Participants were recruited in a surgical center in US (n=37 randomized, Inclusion criteria Aged over 18 years Surgical repair of full thickness pressure injury Exclusion criteria Unlikely or unwilling to comply with treatment Characteristics Mean age 56 years (range 20-80) Mean weight 74kg (range 41 to 123) Long term paralysis	Participants were randomly assigned to receive post operatively: • Alternating pressure support surface (NIMBUS® 3 Professional, Huntleigh Healthcare (n=15 received therapy), or • air-fluidized bed system (Clinitron®, Hill-Rom Inc.) (n=18) Other management was standardized in the facility so the same in both groups and included **Total bed rest for 6 weeks**	• integrity of the surgical site • Healing based on whether tissue edges were in apposition (no gaping, dehiscence, or sinus), also considered exudate, edema, inflammation, infection, evaluated on discharge by on-blinded staff • tissue integrity at other anatomical locations • acceptability • 7 day followup	**mean length of stay** 8.0 days (range 0 to 21; median 7.0 days) for both groups **Healing** • ON discharge from acute care to rehab at mean 8 days, 86% had intact and healthy wound site • Healing was 78% in air fluidized vs 87%in alternating pressure air mattress **Feedback** • 88% of participants rated an opinion, more patients rated alternating pressure as comfortable than rated air fluidized as comfortable. More patients rated air	• No statistical analysis • Subjective outcomes measured by non-blinded staff • Comorbidities and patient characteristics poorly reported • No ITT analysis • Small sample	**Level of evidence: 1** **Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
				• cost based upon rental costs per day of inpatient car	fluidized as uncomfortable. No statistical analysis • 43% of nurses (n=14) felt an alternating pressure air mattress exceeded their expectation vs 43% for the air fluidized **Cost** Air fluidized bed was 52% higher than alternating pressure mattress ($9295 versus $4445, US dollars in 2007) **Alternating pressure air mattresses could be a cost-effective alternative to air-fluidized therapy for post-operative management following reconstructive surgery**		
Kierney et al., 1998 (repeated in CQ 2 and 4)	Cross sectional study of outcomes following pressure injury surgery	Consecutive participants underwent surgery at one center in US over a 12 year period (n=158, with n=268 pressure injuries) Inclusion: "High grade" pressure injury Participant characteristics Primarily male Mean age 34.5 years 65% new/primary pressure sores and 35% recurrenr Primarily SCI patieents	**Post operative** • Air fluidized bed for 2-3 weeks • Passive and active limb mobilization • Upper body strengthening • 7-10 day graduated sitting protocol in padded wheelchair until 3x4 hour sitting sessions/day achieved • Pressure release maneuvers at 15 minute intervals • Education and social interaction with other pressure injury recovery patients	• Five year follow up (mean followup 3.7 years (range 1 month to 15.5 years)	**Recurrence 25% of patients** Fasciocutaneous and myocutaneous were more durable than cutaneous only flaps	• Single center • Minimal details about participants and their risk factors	**Level of evidence: 4** **Quality: Moderate**
Srivastava et al., 2009 (repeated in CQ 2 and 3)	Prospective case series **investigating the efficacy of surgical interventions for PU in patients with spinal disorders**	Participants were those admitted in a one year period to a neurological ward in India (n=25 with n=39 ulcers) Inclusion: • stage III, IV or unstaged pressure ulcers	**Postoperative management** • continuous negative pressure for 48 to 72 hours • appropriate wound hygiene • sutures removed day 10 gradual mobilization and weight bearing • rehabilitation counselling	• postoperative complications • recurrence rate • neurological (ASIA grade) • functional recovery (Barthel Index) • Mean follow up duration 15.4±7.45	**Healing** 87% had total healing 17.3% recurrence (13% at the same site and 4.3% at a new site) **Surgical complications** • Complication rate 10.2% (n=2) • For split skin graft (n=13): ○ wound infection (n=2)	• Small sample size • Selection bias in in terms of age at onset, level of lesion, and pattern of paralysis • One surgical team • No statistical analysis	**Level of evidence: 4** **Quality: moderate**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		• spinal cord disorder Characteristics: • 33.3% sacral , 23% gluteal , 20.5% trochanter, 10.2% ischial, 5% heel, 5% sole of foot , 2.5% dorsum ankle • 36sample had > one PU • 58.9% stage IV, 33.3% stage III PU • 88% participants had a high risk Braden score (<16) • Spinal injuries included transverse myelitis, spinal tuberculosis, SCI, tumors		months (range 12 to 21 months; 8% lost to follow up) •	• For flap mobilization and closures (n=23): ○ suture line dehiscence (n=2) **Length of stay** • Mean 97.36 days (range 16 to 269) • participants with a traumatic spinal pathology had a longer mean stay (180.55±65.45 days) compared with non-traumatic spinal pathology (134.71±42.34) **Barthel Index** • baseline: mean score 28.6±16.68 (range 5 to 75) • postoperative mean score 67.0±16.95 (range 25 to 100, p=not reported) • follow up mean score 74.61±23.97 (range 25 to 100, p=not reported)	• No factors that may influence post-surgical outcomes are reported (e.g. comorbidites) •	
Dowsett et al., 2013; Singh et al., 2013 (repeated in CQ 2)	Prospective case series **outlining management strategy and outcomes**	Participants were recruited over 5 years from one tertiary facility in India (n=35 with n= 37 PU) Inclusion criteria: • Occurrence of a traumatic event in SCI below C4 • PU stage III or IV that fails to heal with conservative treatment • Signed consent • Aged >18 yrs Exclusion: • chronic mental illness Characteristics: • Mean age 34.12 yrs (range 17 to 57) • 72.9% Sacral, 21.6% trochanter	**Post-operative** • Daily inspection by surgeon, patient and/or caretaker • Avoid pressure on flap • 2/24 repositioning commenced at 2 weeks postoperative • Indwelling catheter for 2 weeks • Sitting allowed after 6 weeks • Proper wheel chair cushions	• Overall outcome rated as excellent, good or poor (no indication of how this was determined) • wound dehiscence • flap necrosis and • recurrence Follow up average duration 14.34 months	**Type of procedure** • 19 gluteus maximus V-Y advancement flaps • 6 tensor fascia lata flaps • 2 tensor fascia lata vastus lateralis flap • 3 gluteus maximus island flaps • 7 fasciocutaneous rotation flaps **Complications** • Partial flap necrosis 2.7% • PU recurrence at flap site 5.4% • Overall PU recurrence rate 11.4% **Overall outcome** • excellent in 32 (86.48%) • good in 4 (10.81%) • Poor in 1 (2.7%)	• Small sample size • No factors that may influence post-surgical outcomes are reported (e.g. comorbidites) • One facility and possibly only one surgical team •	**Level of evidence: 4** **Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
Larson et al., 2012 (repeated in CQ 3)	5-year retrospective study **reporting outcomes of a standardized clinical pathway**	Participants were a consecutive sample of patients undergoing PU surgery at one center over a 5 year period (n=101 with 179 PU) Inclusion: • All surgical patients Characteristics: • Mean age 49.4 yrs • PU locations: Ischial-49.7%, sacral-26.8%, trochanteric- 19% • 87.7% Category/Stage IV • 33% smokers, 21% renal disease	**Post-operative** • 3 weeks flat bedrest • Alternating pressure bed Gradual sitting using a pressure mapping cushion	Data abstracted included: • Demographics, • Comorbidities • Location and stage of ulcers • Treatment history with outcomes • Laboratory data • Mean follow-up was 629 days	• Primary closure was performed on 45.8% and remaining 53.2% underwent flap closure • There was no correlation between positive bone cultures and recurrence or complications • The overall recurrence rate was 16.8% at a mean period of 435.9 days • New ulcer occurrence was 14.5% and the complication rate was 17.3% • Complications: o Suture line dehiscence – 27 (15%) o Infection – 4 (2.2%) o Distal flap necrosis – 1 (0.6%) **The author concludes that the protocol that had been unchanged for 10 years had an adequate success rate.**	• Unclear how many lost to follow up (7% lost to death) • No discussion of other literature or other protocols that may be appropriate or more successful • Protocol had not changed over a 10 year period • Patients may not have returned if there was a recurrence	**Level of evidence: 4** **Quality: moderate**
Daniali et al., 2011 (repeated for CQ 2)	Retrospective case-controlled study **comparing pre-operative management and post-operative outcomes between pre-operative MRI diagnosis of osteomyelitis and intra-operative bone biopsy**	Participants were recruited from a spinal cord center in the USA between 1996 and 2008 (n=65 had flap reconstruction had osteomyelitis and n=47 had either MRI or bone culture diagnosis). Characteristics: • Mean age 56.2 to 58.7 years • Primarily males with SCI • The preoperative MRI group had a more participants with stable PUs of unchanging size (46.2% versus 23.8%, p =0.04) • MRI group had more patients wit history of peripheral vascular disease (14.3% versus 0%, p=0.05)	Preoperative vs post-operative identification of osteomyelitis • Participants received either: o pre-operative MRI diagnosis of osteomyelitis (n=26) o post-operative bone culture diagnosis of osteomyelitis (n=21)	• Recurrence of PU at the same anatomic site • Suture line dehiscence • Significant suture line dehiscence and • Time until mobilization by physical therapy	• Patients with a diagnostic preoperative MRI did not differ significantly in rates of pre-operative antibiotic administration compared to those without pre-operative MRI (26.9% versus 23.8% OR 1.2, p=0.81) • There was no significant difference in PU recurrence rates post-surgery between those with osteomyelitis diagnosed by MRI had and those with osteomyelitis diagnosed by bone culture (39% versus 29%,OR 2.4, p=0.22) • There was no significant difference in infection rates post-surgery between those with osteomyelitis diagnosed by MRI had and those with osteomyelitis diagnosed by bone culture (7.7% versus 14.3%,OR 0.50, p=0.44) **Study conclusions: the study concluded that there was no evidence that a preoperative MRI diagnosis of osteomyelitis significantly alters clinical or surgical management or patient outcomes**	• Retrospective chart review subject to Inaccuracies of data recording • Study cohorts were small potentially limiting the study generalizability. • Inherent bias as patients undergoing MRI are usually more stable.	**Level of evidence: 3** **Quality: moderate**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
Ahluwalia et al., 2009 (repeated for CQ 2)	Retrospective medical record review **investigating complications of wound reconstruction by flap site**	Sample was a consecutive cohort of patients undergoing surgery in a 10 year period in one Canadian hospital (n=78 with n=93 PUs) Inclusion: surgical reconstruction of a stage III or IV PU Characteristics: • 72/93 PUs were ischial • mean age 43 years (range 15 to 71) • 94% had SCI • 63 fasciocutaneous, 41 musculcutaneous flaps	**Post-operative** • antimicrobial therapy guided by pre-operative cultures • 4 to 5 days in hospital • 5 weeks of bed rest followed by gradual weight bearing • high protein, high calorie diet.	• Demographics; location of sores; methods of reconstruction; flap selection; complications and recurrences • "Complication" was not defined • Records were reviewed for complications and recurrence rates	• Overall flap complication rate of 16% (17/104) was observed in flap • Complication rate for ischial flaps by site o Posterior medial thigh flap: 17% o Biceps femoris muscle combined with posterior medial thigh flap: 14% o Gluteus myocutanous flap: 12% o Gluteus fascio flap: 33% • Recurrence rate 7% **Study conclusion: authors recommend that for ischial PU reconstruction, a combination posterior medial thigh fasciocutaneous flap with a bicep femoris muscle flap is the preferred strategy. However, there is no statistical analysis to support this and the sample were surgeries performed by a single surgeon.**	• No control to suggest whether effect is due to study intervention • Single center • No statistical analysis • No relevant demographics • Relied on accurate records for data base review • Unclear what was considered to be a "complication" and how this was assessed	**Level of evidence: 4** **Quality: low**
Estrella & Lee, 2010 (repeated in CQ 2 and 3)	retrospective chart review to **investigate outcomes for nonambulatory patients with hypoalbumine mia who undergo sacral PU surgery**	Participants were a sample of patients have flap reconstruction over a 6 year period at a tertiary hospital in Philippines (n=16) Inclusion: • Non-ambulatory • stage III to IV sacral PU • moderate to severe hypoalbuminemia preoperatively (serum albumin <35g/L) • minimum of 3 month's post surgery follow up documented in record Exclusion: • ambulatory • serum albumin >35g/L	**Post surgery** • Prone positioning with lateral position 3 to 4 hours for 1 to 2 weeks or until wound healed • Where prone was not tolerated, doughnut air cushion was used • Sitting initiated at 3 to 4 weeks • Strengthening exercises and encouragement of self care • Passive range of motion exercise • Wound cleaned daily (some wound managed with wet to dry gauze).	• Outcomes measured included the number of surgeries needed for coverage and complications encountered • Average follow up 11.25 months after surgical closure	• Wound related complication rate 37.5% (n=6) including corner necrosis, delayed healing. • Recurrence rate was 12.5% (n=2) • No association was established between complications and number of surgeries for eventual closure (r=0.516) • More complications occurred in younger age group (< 54 years; p=0.039) • There was no correlation between wound complications and having a comorbidity (p=0.458) • **The study provides some evidence on rate of complications for surgery. The facility implemented PU prevention and management strategies that are no longer recommended.**	• No control group • Relied upon accurate records and data extraction • Many of the care initiatives pre and post surgery do not reflect best practice (e.g. no specialized surfaces, use of doughnut pillow following surgery, moist gauze packs only). • Surgery in only one hospital • Unclear if sample is consecutive	**Level of evidence: 4** **Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		• previous history of flap surgery Characteristics: • Mean age 54 years • 14/16 PU were stage IV and 2/16 were stage II PU • All participants were dependent on others for bed mobility • Average serum albumin 21g/L ± 5.7g/L • Co morbidity included CVA and diabetes				• Minimal characteristics of participants reported • "complication" is not defined and its assessment is not reported	
Clinical Question 5: What interventions are effective for reducing recurrence of a pressure injury following surgical intervention?							
Previnaire, Fontet, Opsomer, Simon, & Ducrocq, 2016	Retrospective case series **reporting the effectiveness of lipofilling surgery for preventing PU recurrence**	Retrospective review of consecutive patients undergoing lipofilling at one center in France (n=10) Inclusion criteria: • Adult patients with SCI • History of ischial tuberosity and pelvic PU surgery • At risk of PU recurrence due to unsatisfactory adipose tissue thickness Participant characteristics: • 8 patients paraplegic and 2 patients tetraplegic • Mean age 44.1± yrs (range 36 to 58) • Mean time since SCI 21.1± 9.4 yrs • Mean time since last PU repair surgery 5.2±5.6yrs • Mean previous surgical repair of PU 3.2	Lipofilling (fat grafting) was performed using three stages: water jet assisted liposuction, decantation, and reinjection of the autologous fat in three-dimensional plan.	• Follow up at day 14, and 1,3 and 6 month • mean follow up 16 mths (range 4-24) • Evaluations included : ○ weight and BMI ○ seating pressure map ○ photographic assessment ○ skinfold thickness using caliper pinch test ○ Fat waste as a global assessment ○ Self-perceived QOL using patient global impression of improvement (PGI-I) questionnaire ○ PUs graded using NPUAP staging system	**PU recurrence** 30% of patients had a PU following surgery (3 Stage I, one Stage 2) **QOL** improved in 6 patients, unchanged in 4 patients and worsened for none **Ischial tuberosity adipose tissue thickness** Significant improvement (3.5 to 5.5 cm) in 7/9 patients	• Follow up time frame may be insufficient to truly evaluate the effectiveness of the intervention • Surgeon performing procedure was also responsible for measuring at least some of the outcome measures • Small sample size • Unclear why these specific patients were chosen	**Level of evidence: 4** **Quality: moderate**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		• Eight patients at mild risk of PU and 2 at no risk; however 50% had recurrent stag II PUs following previous surgery • All patients used air filled or contour foam seating cushions					
Cost effectiveness							
Filius et al., 2013	Cross sectional study to calculate the direct medical costs for patients who had surgical treatment for Category/Stage III and IV pressure injuries	All participants at one center in Netherlands over a 3 year period (n=52 pressure injuries in n=40 patients) Inclusion criteria: • Category/Stage III and IV pressure injuries receiving surgical interventions. • History of pressure injuries healed at least one year on a different anatomical location. Exclusion criteria: • admitted initially to a different dept. • Category/Stage I and II pressure injuries Participant characteristics: • Age 48 (22-83) • Males 38 (72%) • Tetraplegic 13 (25%), Paraplegic 32 (62%), Others 7 (13%) • Ischium 38 (53%), Sacrum 14 (19%), Greater trochanter 11	Pre Surgery Data registration first day admission baseline characteristics obtained from hospital EPR. Medical Hx used to calculate Charlson co morbidity Costs calculated xrays, number of surgeries, negative pressure wound therapy, in patient days and complications. Surgery Costs divided into three groups Group one patients with a single pressure ulcer on extremity €30,286 Group two patients with a pressure on trunk € 10,113 Group three patients with multiple pressure ulcers €40,882 (p=0.008) Post-Surgery No differences were found in relation to risk factors among the groups. Hospitalization Length of stay accounted for majority of costs 75% followed by surgery 24% radiology and wound therapy was limited <1%	Direct costs included the following 1.in patient days 2.Surgery 3.Radiology exams 4. Wound therapy • Follow up • Study conducted to calculate pts who had surgery between 2007-2010	**Costs** • Mean cost €20,957 • patients with a single pressure injury on extremity €30,286 (n=5) • patients with a pressure injury on trunk € 10,113 (n=32) • patients with multiple pressure injuries €40,882 (n=15)(p=0.008) Only 43% were discharged within a week. **This study demonstrates that patients with multiple pressure injuries have more costs associated with longer hospitalization. Early discharge reduces cost by referring to rehab early.**	Retrospective chart analysis makes it difficult to fully understand the risk factors of pressure ulcers involved. • No conflicts of interest declared	Moderate quality economic analysis

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		(15%), Extremity 8(11%), Head 1 (1%)					
Education and quality of life							
Rintala, Garber, Friedman, & Holmes, 2008	Randomized controlled trial **investigating an education program post-surgery to reduce PU recurrence rates**	Participants were recruited from a veterans affairs medical center in US (n=41) Inclusion/exclusion not stated Characteristics • Mean age 50 to 54 years • Mean time since SCI 15 to 20 years • Significant difference between groups in type of flap surgery (p=0.02) • group 3 had significantly shorter time since last surgical closure (1.05 yrs vs 6.30 yrs, p=0.03)	• All participants received standard care pre and post surgery. • Participants were randomized to receive: • enhanced education and monthly structured follow up intervention for 2 years after discharge (group 1, n= 20,n=18 analyzed) • monthly contacts for up to 2 years after discharge to assess skin status, with no education during or after hospitalization (group 2, n=11, n=10 analyzed) • minimal contact via mail every 3 months for up to 2 years after discharge only to assess skin status, but received, with no education during or after hospitalization (group 3, n=10, n=10 analyzed) • Standard education consisted of 1 to 2 hours of 1:1 education on prevention incl nutrition, smoking, skin inspection and care; a manual that included sections on PU prevention; training for families by phone/mail; therapist-supervised progressive sitting program and education on transfers and seating.	• primary outcome was time to pressure ulcer recurrence • Self assessed health status • Skin status was assessed through phone interview • Follow up was 2 years (or until recurrence) •	• Significantly fewer participants in group 1 had a recurrence of PU by 24 months (33% vs 60% vs 90%, p=0.007) • For group 1 odds ratio (OR) of a PU by 24 months was 0.228 (95% CI 0.080 to 0.647, p=0.003) • No significant differences between groups 2 and 3 in recurrence	• Small sample size • Inappropriate randomization method and allocation concealment • Study did not reach sample size required for statistical power • Groups 1 and 2 participated in another study concurrently • Nonequivalent groups at baseline • Self-assessed outcomes • Two participants had MS, both assigned to group 1 •	**Level of evidence: 1** **Quality of evidence: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
			Enhanced education included 1 to 4 additional hours 1:1 over four sessions on etiology, prevention and pressure relieving devices; one session for families, additional education monthly for 25 minutes via phone.				
Yarkin, Tamer, Gamze, Irem, & Huseyin, 2009	Prospective observational study **investigating impact of PU reconstruction surgery on psychiatric state**	Participants and their caregivers were a sample of successive surgical patients recruited in Turkey (n=20 people with PU plus their caregivers, n=17 patients and n=18 caregivers completed study) Inclusion: • Reconstructive PU surgery in Jan 2006 to Jan 2008 • Spinal cord injury (SCI) Exclusion criteria: • Experienced progressive depression during the course of 6 month follow up Characteristics: • 15/17 participants were paraplegic and 2/17 were quadriplegic • 18 PUs of which all were full-thickness, 15 were sacral and 3 were trochanter • 5/17 participants had PU recurrence during 6 month follow up • 23 local fasciocutaneous flap surgeries performed in total	• Participants completed the outcomes measure test tools prior to surgery and at 6 month follow up • Instructions were provided by a psychiatrist	• Psychiatric state and quality of life (QOL) measured using Beck depression inventory (BDI), trait anxiety inventory (TAI), and the short form-36(SF36) • Components reported from SF-36 included physical function, physical role difficulty, pain, general health, energy, social function, emotional role difficulty and mental health. • Self-administered tools • 6 month follow up	**Patient participants** • Prior to surgery, all SF-36 outcome measures were significantly lower than the national average ($p<0.05$ for all) • At 6 month follow up, all SF-36 outcome measures except physical role difficulty on SF-36 were significantly lower than the national average ($p<0.05$) • There was a statistically significant improvement in all SF-36 outcome measures ($p<0.05$ for all) between preoperative measures and 6 month follow up • There was a statistically significant improvement in BDI score between preoperative measures and 6 month follow up(17.9±5.99 preop versus 10.8±5.50 postop, $p<0.05$) • There was a statistically significant improvement in TAI score between preoperative measures and 6 month follow up(44.4±10.81 preop versus 29.2±5.79 postop, $p<0.05$) • There was a positive correlation between BDI score and PU recurrence ($p<0.05$) **Caregiver participants** • There was no significant difference between SF-36 outcome measures for physical function, physical role difficulty, pain, general health or energy when compared with national average. • There was significantly lower scores for social function, emotional difficulty and mental health compared with the national average ($p<0.05$ for all).	• Compares to a national average, but no details of the national average cohort are provided • Perioperative protocol is not reported clearly • Self-completed outcome measurement tools, subject to bias • Insufficient details provided regarding the participants and aspects of their life that may impact psychosocial scores • Excluded participants with progressive depression •	**Level of evidence: 3** **Quality: low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		• All participants had at least 5 years of formal education			• There was a statistically significant improvement in TAI score between preoperative measures and 6 month follow up(53.0±7.78 preop versus 27.2±4.81 postop, p<0.05) • There was a statistically significant improvement in BDI score between preoperative measures and 6 month follow up(16.0±4.05 preop versus 10.3±1.78 postop, p<0.05) • There was a positive correlation between TAI score and PU recurrence (p<0.05) • **The study provides evidence that people with PU and their caregivers have more depression and lower QOL than average and that surgery may improve this' however the small study sample and insufficient participant characteristics prevent any generalization of the study results.**		
Background information: Outcomes/Complications and Length of Stay							
Biglari et al., 2014	Case series of flap surgeries	Participants had SCI were undergoing flap surgery in a single center in Germany (n=352 with n=657 pressure injuries Characteristics: • 92% had SCI from trauma • 43% ischial pressure injuries, 21.7% sacrum, 18.9% trochanter	Management not reported	• 6 week followup for only 79.5% cases (n=280)	**Complications** 21% had complications Suture line dehiscence 31% Wound infection 25.2% Hematoma 19.5% Partial flap necrosis 13.7% Total flap necrosis 10.3% Course Hospital duration average between 34.3 – 119 days (average time reported by type procedure)	• Limited information about participants, including method of recruitment • No standard deviations • Unclear how outcomes measured	**Level of evidence: 4** **Quality: Low**
Kenneweg, Welch, & Welch, 2015	Retrospective cohort study **investigating factors that influence healing following PU flap surgery**	Participants identified via retrospective record review for all PU flap cases between 2004 and 2013 (all ulcers, n=102; patients with primary flap repair, n=54; patients with recurrent flap repair, n=40)	Flap reconstruction	• All demographics recorded • NPUAP staging system used • Complications	**Post-operative outcomes** *Primary ulcers vs Recurrent ulcers* • Delayed healing: 35.19% vs 17.50%, p=0.029 (total 26.73%) • Flap loss: 5.56% vs 0%, p=0.065 (total 2.97%) • Infection 7.41% vs 2.5%, p=0.1473 (total 10.89%)	• Relied on record review • Duration of follow up is unclear – if mean time is total follow up, then study period is too	**Level of evidence: 3 (prognosis)** **Quality: Moderate**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		Characteristics: • Mean age 45 years • Recurrent flap repair group had significantly longer time since paralysis (277 months vs 172 months, p=0.0004) 63% had concurrent osteomyelitis, 50% concurrent hypertension			• Wound dehiscence: 42.59% vs 30%, p=0.106 (total 37.62%) • Recurrence during study period 14.63% vs 25.71%, p=0.113 • Mean time to sitting 24.49 days vs 28.08 days, p=0.1304 (total 27.14 days) • Mean time to follow up 44.34 days vs 43.46 days, p=0.46 (total 42.98) **Factors associated with PU closure** • BMI r= –0.223, p=0.033 • Smaller wound surface area r=–0.341, p=0.002 • Fewer debridements r=–0.0.221, p=0.05 • Hemoglobin r=0.346, p=0.001 • Hematocrit r=0.254, p=0.001 • Prealbumin r=0.323, p=0.015 • Creatinine r=–0.327, p=0.001 • Total protein r=–0.389, p=0.012 **Logistic regression for predicting closure** Prealbumin OR 1.163, 95%CI 1.007 to 1.344 Haematocrit OR 2.024, 95% CI 0.949 to 4.318 Hemoglobin OR 0.242 95% CI 0.029 to 1.984 Creatinine OR 0.01 95% CI 0 to 0.873	short for conclusive results	
Diamond et al., 2016	A retrospective observational database review exploring post op complications in patients with pressure ulcers who have surgery	• Participants were recruited through a database review of one Department of Surgery in USA (n=729) patients Inclusion criteria: • Patients with trunk pressure ulcers Exclusion criteria • Emergency surgery • Interventions that did not address the pressure ulcer	Pre Surgery No information Surgery (44%) Flap closure (n=320) Debridement 56% (n=409) Surgery time was shorter for debridement group (28vs 96 mins) Post-Surgery • Not reported	• Surgery a good option for patients with pressure ulcers if patients are suitable for anaesthetic • Debridement group were sicker and had more co morbidities • NPUAP • Follow up 30 days	• 1.9% recurrence rate at 30 days • 4.7 % reoperation rate • infection SSI 8% • dehiscence 4.7% Comparison of surgical types • Debridement group older 63 vs 53yrs more septic 43%vs 13%and had more co morbidities than the flap group for example diabetes and renal failure • Debridement group had more sepsis and post-operative shock (13%vs 2.5%) with higher hospital readmission	The NSQIP was not able to demonstrate surgical intention and timing Selection bias may have contributed to results • The 30 day NSQUIP did not capture the delayed recurrence	**Level of evidence: 4** **Quality: High**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		Participant characteristics: • Not reported • No significant difference in groups (type of surgery) with regard to frailty degree of contamination and technical repair			• Mortality rates were higher in the debridement group vs the flap group **Complications were low 1.9% recurrence. It would appear that the flap group had better outcomes although the debridement group were older more septic and had more co morbidities than the flap group.**		
Firriolo et al., 2017	Cross sectional evaluation of recurrence rates in children undergoing pressure injury surgery	• Records for individuals aged 21 years and lower ere reviewed for a 18 year period (n=24 undergoing 30 flap repairs) Inclusion Aged 21 years or below Pressure injury diagnosis At least one flap reconstruction Participant characteristics: 67% myelomeningocele 23/24 wheelchair dependent 6 underweight, 12 healthy weight, 5 overweight 15/24 ischial flaps, 8/24 sacral flaps	Flap surgery	• Record review	• Ulcers with evidence of osteomyelitis required a statistically significantly greater number of operations (P = 0.003) • Ulcers with evidence of osteomyelitis required a statistically significantly more hospital admissions (P = 0.019), • Ulcers with evidence of osteomyelitis required a statistically significantly longer cumulative length of stay (P =0.031) • Recurrence rate 42.3% • ulcer recurrence was associated with preoperative noncompliance with non-operative management (P= 0.030) **Author conclusion: Ulcer recurrence rates are similar in children as in adults**	Single center Relied on record reviews Does not state how non-compliance was measured	**Level of evidence: 4** **Quality: Low**
Josvay et al., 2014	Cross sectional survey exploring recurrence rates	Participants recruited at a hospital in Hungary (n=98, 58 responded with completed surgery (59%) Inclusion: Had PU surgery Characteristics		• Mean follow up 5.2 years	Recurrence rate 5.47%	• Survey response • Small number • Minimal information about participants • One center	**Level of evidence: 4** **Quality: Low**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		• Primarily male • 32 sacral PU, 74 ischial PU, 13 trochanteric PU • Primarily paraplegic or tetraplegic patients					
Schryvers, Stranc, & Nance, 2000	Retrospective study	All admissions to the SCI unit with Category/Stage IV pressure injuries over a 20 year period (n=168, n=598 pressure injuries) Inclusion: Category/Stage IV pressure injuries 94.5% had paraplegia or tetraplegia 78% male 38% < Grade 8 schooling, 47% Grade 8-12 schooling 43% on welfare and 38% with pension 28% living alone, 27% independent in self care but live with family, 32% dependent for self care but living alone or with family, 13% living in hospital or home care	• N=421 pressure injuries received a surgical intervention	•	• 31% experienced wound dehiscence • 11% required second surgeries • 9% did not heal before discharge • 16% had osteomyelitis •	•	**Level of evidence: 4** **Quality: low**
Laing, Ekpete, Oon, & Carroll, 2010	Retrospective analysis reporting **outcomes for PU surgery**	Records for all participants receiving surgery for PU between 2001 and 2007 in one facility in Ireland (n=41 with n=58 PU) Inclusion: • Surgery for PU Characteristics: • mean age 52.1 yrs (range 36 to 79) • 80%sample were male	• All patients underwent initial surgical debridement followed by application of negative pressure wound therapy using the vacuum-assisted closure 24 to 48 hours following surgery	• Requirement for reconstruction following surgical debridement • Time from presentation to complete wound healing • Complications • Mean follow-up was 18 months	• Following debridement, surgical reconstruction procedures were required for approximately 50% of patients (n=20 patients, n=23 procedures) • Mean time from debridement to definitive reconstruction was 4.3 weeks • Reconstructive procedures: o Primary closure (n=1) o Split-thickness graft (n=5) o Local fasciocutaneous flap (n=4) o Musculcutaneous flap (n=11) • Post-reconstructive complications occurred in 25% (n=10) • Complications:	• Relied on medical record accuracy • One facility and possibly only one surgical team •	**Level of evidence: 4** **Quality: moderate**

Ref	Type of Study	Sample	Intervention(s)	Outcome Measures & Follow-up	Results	Limitations and comments	
		• 50% had grade IV PU, 43% had grade II PU, 7% had grade II PU • 29% had associated osteomyelitis and 41% were MRSA positive • 41% ischial PU, 29% sacral PU, 16% trochanter PU, 12% heel PU 36.6% participants had a co-morbidity, primarily chronic respiratory disease, diabetes or cardiac failure			○ Bleeding requiring transfusion, all occurring post debridement (n=5) ○ Partial flap necrosis (n=3) ○ Ulcer recurrence (n=0) • The mean time to complete wound healing from initial presentation was 12.4 weeks (range 6 to 22 weeks) **The authors propose that a two stage process (debridement followed by reconstruction if required) prevents the flap concealing bleeding, allows for antibiotic management based on biopsy and allows for assessment of patient compliance. However, there is no comparison to support this interpretation of the data.**		
Kim, Kim, Kim, & Kim, 2013	Retrospective review **comparing outcomes for different types of flap surgery**	Participants were all recruited at surgical center in Korea. conventional flap group was recruited from 1998 to 2002 (n=17) and perforator based flaps group recruited 2002 to 2007 (n=21 with n=23 PU) Inclusion: • trochanter PU requiring surgery Characteristics: • mean age 56.6 yrs • grade III or IV PU • mean PU size 90cm2 • Mean flap size 108cm2 • No significant differences between groups	Participants received either: • Conventional tensor fascia lata (TFL) flap (n=17) • tensor fascia lata perforator-based island flap(TFL-PBIF) Intra-operative Handheld Doppler to identify perforators (nearest to defect)	• recurrence rates • Complications • Mean follow up was 9.6 months	• There was no significant difference in recurrence rates between groups (1 case in each group, p=1.00) • Total complications (41.2% vs 17.4%, p=0.153) • Complications were not significantly different between groups (TFL vs TFL-PBIF): ○ Hematoma (11.7% vs 4%, p=0.565) ○ Seroma (5.8% vs 4%, p=1.00) ○ Graft ulceration (11.7% vs 0%, p=0.174) ○ Wound dehiscence (11.7% vs 4%, p=0.565) ○ Partial necrosis (0% vs 4%, p=1.00)	• Selection of participants is not clear • Single surgeon • Short follow up period	**Level of evidence: 4** **Quality: moderate**

Table 1: Level of Evidence for Intervention Studies

Level 1	**Experimental Designs** • Randomized trial
Level 2	**Quasi-experimental design** • Prospectively controlled study design • Pre-test post-test or historic/retrospective control group study
Level 3	**Observational-analytical designs** • Cohort study with or without control group • Case-controlled study
Level 4	**Observational-descriptive studies (no control)** • Observational study with no control group • Cross-sectional study • Case series (n=10+)
Level 5	**Indirect evidence**: studies in normal human subjects, human subjects with other types of chronic wounds, laboratory studies using animals, or computational models

Table 2: Levels of evidence for diagnostic studies in the EPUAP-NPUAP-PPPIA guideline update

Level 1	Individual high quality (cross sectional) studies according to the quality assessment tools with consistently applied reference standard and blinding among consecutive persons.
Level 2	Non-consecutive studies or studies without consistently applied reference standards.
Level 3	Case-control studies or poor or non-independent reference standard.
Level 4	Mechanism-based reasoning, study of diagnostic yield (no reference standard). Low and moderate quality cross sectional studies.

Table 3: Levels of evidence for prognostic studies in the EPUAP-NPUAP-PPPIA guideline update

Level 1	A prospective cohort study.
Level 2	Analysis of prognostic factors amongst persons in a single arm of a randomized controlled trial.
Level 3	Case-series or case-control studies, or low quality prognostic cohort study, or retrospective cohort study.

APPRAISAL FOR STUDIES PROVIDING DIRECT EVIDENCE (i.e. ELIGIBLE FOR SUPPORTING AN EVIDENCE-BASED RECOMMENDATIONS

Each criteria on the critical appraisal forms was assessed as being fully met (Y), partially met or uncertain (U), not met/not reported/unclear (N), or not applicable (NA). Studies were generally described as high, moderate, or low quality using the following criteria:

- High quality studies: fully met at least 80% of applicable criteria
- Moderate quality studies: fully met at least 70% of applicable criteria
- Low quality studies: did not fully meet at least 70% of applicable criteria

CROSS SECTIONAL/SURVEY/PREVALENCE STUDIES/OBSERVATIONAL

Endnote ID	Author/year	Focussed question	Sampling method	Representative sample	States number invited participants	Clear outcome measures	Valid reliable outcome measurement	Comparable results for multiple sites	Confounders identified and accounted for	Minimal bias	Reliable conclusions	Level of evidence	Quality
16255	Diamond et al., 2016	Y	Y	Y	N	Y	Y	NA	Y	Y	Y	4	High
6334	Josvay et al., 2014	Y	Y	U	Y	Y	N	NA	N	N	N	4	Low

RCTS

Endnote ID	Author/year	Focussed question	Assignment randomised	Adequate concealment method	Subjects and investigators blinded	Groups comparable at commencement	Only difference btw groups was treatment	Valid, reliable outcome measure	% drop out in study arms is reported and acceptable	Intention to treat analysis	Comparable results for multiple sites	Minimal bias	Reliable conclusions	Level of evidence	Quality
7864	Jiang et al., 2014	Y	U	U	N	Y	Y	Y	U	U	Y	Y	Y	1	Moderate

PROGNOSTIC STUDIES

	Author/year	Adequate description of baseline characteristics	Satisfactory study attrition	Clear outcome measures/prognostic factors	Range of prognostic factors/confounders measured identified and	Method of measuring prognostic factor is reported, valid and reliable	Same method of measure of prognostic factor for all	Continuous variables or appropriate cut offs	Percent participants with complete data acceptable	Appropriate imputation method	Confounders/prognostic factors accounted for in analysis	Selective reporting avoided	Adequate sample size (10 PIs per factor)	Level of evidence	Quality
14195	Han et al., 2017	N	NA	Y	Y	U	U	Y	U	U	N	U	U	3	Low

CASE SERIES

	Author/year	Focussed question	Participant characteristics reported	Inclusion criteria defined	Consecutive recruitment	Participants entered at same disease stage	Intervention clearly reported	Outcomes relevant and defined apriori	Valid, reliable outcome measurement	Per cent drop out reported and acceptable	Estimates of random variability	Comparable results for multiple sites	Minimal bias	Reliable conclusions	Level of evidence	Quality
10718	Previnaire et al., 2016	Y	Y	Y	Y	Y	Y	Y	Y	N/A	N	N/A	N	U	4	moderate
12988	Chang et al., 2016	Y	U	N	U	Y	Y	Y	U	NA	N	NA	N	Y	4	moderate
13727	Tadiparthi et al., 2016	Y	Y	Y	Y	Y	Y	N	U	Y	N	NA	U	Y	4	moderate
1430	Bertheuil et al., 2013	Y	Y	Y	Y	U	Y	Y	U	NA	Y	NA	U	U	4	moderate
2986	Biglari et al., 2014	Y	N	N	N	U	N	Y	U	NA	N	NA	N	N	4	Low
13682	Bonomi et al., 2016	Y	N	N	U	Y	N	Y	U	N	NA	NA	Y	Y	4	Low
8352	Huang & Guo, 2015	N	Y	N	N	Y	N	Y	Y	NA	N	NA	Y	Y	4	Low
2757	Di Caprio et al., 2014	Y	N	Y	U	Y	Y	N	U	NA	N	NA	Y	U	4	Low
6075	Wettstein et al., 2013	Y	Y	Y	Y	Y	Y	Y	Y	NA	N	NA	Y	Y	4	High
5970	Greco et al., 2013	N	Y	N	U	Y	Y	Y	Y	NA	N	NA	Y	Y	4	Moderate
15075	Firriolo et al., 2017	N	Y	N	Y	U	N	N	U	NA	N	NA	Y	U	4	Low
6666	Grassetti et al., 2014	Y	Y	Y	U	Y	Y	N	U	NA	Y	NA	Y	Y	4	Moderate

COHORT STUDIES

	Author/year	Focussed question	Comparable source populations	States number invited	Likelihood of outcome at enrolment considered	Per cent drop out in study arms is reported	Comparison btw drop outs and participants	Clear outcome measures	Assessment blinded, or discuss potential bias	Valid, reliable assessment with supporting reference	More than one measure of exposure	Confounders identified and accounted for	Provides confidence intervals	Minimal bias	Reliable conclusions	Level of evidence	Quality
8088	Kenneweg et al., 2015	U	N	N	NA	NA	NA	Y	N	Y	N	U	Y	Y	Y	3 (prognostic)	moderate
10714	Tashiro et al., 2016	Y	U	N	Y	NA	NA	Y	N	N	N	Y	Y	Y	Y	3	Moderate
10695	Han et al., 2016	N	N	Y	N	N	NA	Y	U	U	U	N	N	Y	Y	3 (prognostic)	Low
14545	Bamba et al., 2017	Y	Y	Y	Y	NA	NA	Y	N	U	U	Y	Y	Y	Y	3	High
14068	Chiu et al., 2017	Y	Y	N	Y	NA	NA	Y	Y	Y	N	N	Y	N	U	3	Moderate
14202	Ljung et al., 2017	Y	Y	Y	Y	Y	N	Y	N	Y	Y	N	N	Y	Y	3	Moderate

ECONOMIC EVALUATIONS

	Author/year	Focussed question	Economic importance of question is clear	Choice of study design is justified	All costs are included and measured and valued appropriately	Outcome measures to answer study question are relevant and measured and valued appropriately	Discounting of future costs and outcome measures is performed correctly when appropriate	Assumptions explicit and a sensitivity analysis conducted	Results provide information relevant for policy providers	Minimal bias	Reliable conclusions	Level of evidence	Quality
6199	Filius et al., 2013	Y	Y	Y	N	Y	NA	N	Y	Y	Y	NA	Moderate

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