Commissioning Brief - Supporting Information

Early vs late cranial reconstruction (cranioplasty) in patients who have undergone a supratentorial decompressive craniectomy

Closing date: 30 November 2017

This supporting document provides further information to support applicants for this call. It is intended to summarize what prompted the call and the existing evidence base, including relevant work from the HTA and wider NIHR research portfolio. It was researched and written on the basis of information from a search of relevant sources and databases, and in consultation with a number of experts in the field. Searches and information provided were up to date as of May 2017.

Source of topic
NHS England Specialised Commissioning and the Academic Committee of the Society of British Neurological Surgeons (SBNS).

Patient group
- Patients who have had a decompressive craniectomy for stroke or traumatic brain injury and require a subsequent cranioplasty
- 387 decompressive craniectomies and 884 cranioplasties (using bone graft and/or prosthesis) were performed between 2014 and 2015 (HES data, 2015)
- Cranioplasties are performed in specialist centres of which there are 40 in the UK

Images from:
https://www.mayfieldclinic.com/PE-TBI.htm

Decompressive craniectomy and a cranioplasty (using a plate)
Current practice and proposed intervention

Following a decompressive craniectomy (Figure 1A and 1B), reconstruction (Cranioplasty, Figure 1C and 1D) is not traditionally performed until 6-12 months post-craniectomy. This is thought to reduce the risk of infection.

Proposed intervention

Recent studies suggest that there is little difference in complication rates (including infection) between early and late cranioplasty, and an earlier cranioplasty may result in reduced operative time. Therefore, the suggested intervention is to perform cranioplasty within 3 months of the decompressive craniectomy.

Summary of completed research

Evidence Synthesis

Title: Early Cranioplasty is Associated with Greater Neurological Improvement: A Systematic Review and Meta-Analysis²

Neurosurgery

- Searched Medline, Scopus and Cochrane for studies of cranioplasty timing and neurological outcome after craniectomy
- Authors identified 8 retrospective cohort studies of 528 patients
- Regardless of timing, cranioplasty was associated with significant neurological improvement
- Post-cranioplasty neurological outcome was significantly improved in the early cohort and had a greater magnitude of change than the late cohort

Title: Cranioplasty optimal timing in cases of decompressive craniectomy after severe head injury: a systematic literature review³

Systematic Review, Interdisciplinary Neurosurgery
Searched Pubmed for reports of adult clinical series with a minimum number of 10 participants. Limited to English and human studies. References of retrieved articles also assessed for additional papers.

10 clinical series were included.

Reports suggested that late cranioplasty may reduce procedure associated complications.

Early cranioplasty was associated with complications but improved CSF dynamics and regional cerebral perfusion and metabolism, minimised sunken scalp complications, and reduced overall length of hospitalisation and cost of care.

‘Cranioplasty is a relatively simple procedure that is nevertheless burdened by considerable morbidity. However, an early cranioplasty procedure may improve the outcome in selected cases. Prospective, large-scale studies are necessary to outline the actual complication rate, the neurological outcome, and define the optimal timing for a cranioplasty’

Title: Early cranioplasty vs. late cranioplasty for the treatment of cranial defect: A systematic review

Systematic Review, Clinical Neurology and neurosurgery

Comparison of the effect of cranioplasty performed 1-3 months and 3-6 months following decompressive craniotomy.

Performed meta-analysis of operative time, complications and neurological function outcomes.

Included randomised and non-randomised trials.

Included 9 studies of 1209 participants and found no significant difference in overall complications, intracranial hematoma, infection rate or subdural fluid collection.

Early cranioplasty was associated with a significant reduction in operation time and an increase in hydrocephalus rates.

Title: Complications following cranioplasty and relationship to timing: A systematic review and meta-analysis

Systematic review and meta-analysis, Journal of Clinical Neuroscience

Evaluation of the relationship between cranioplasty timing and complications.

Included case series, case-control, cohort studies and clinical trials for cranioplasty timing after craniectomy in adults.

Included 25 retrospective observational studies.

Early cranioplasty had higher odds of hydrocephalus.

There was no difference in odds of overall complications, infections, reoperations, intracranial haemorrhage, extra-axial fluid collections, seizures or bone resorption.

Primary Research

There have been numerous studies of cranioplasty, but most are retrospective reviews, with inconsistent data, which is to be expected from the inherent bias in studies of this design. Most have found no association between complications and timing of cranioplasty, yet others found that timing of cranioplasty was a factor associated with complications or that urgency status (emergency or elective) was associated with complication rate. One study found a higher risk of bone graft resorption in patients <18 years old yet another reported that age was not predictive of morbidity and functional outcome. Operation times were found to be significantly longer in patients undergoing late cranioplasty and a separate study found that an operating time of >120 minutes was associated with graft infection. Some of the studies actually found that early cranioplasty was associated with better functional outcomes.


Retrospective study of 131 patients who had cranioplasty in a single institution between Jan 2008 and June 2015.

Patients were divided into early cranioplasty (≤90 days) and late cranioplasty (>90 days) following craniectomy and infection risk factors and rates were assessed.

The early cranioplasty group had a lower infection rate (7% vs 20%, p=0.02) and significant risk factors for infection were cranioplasty timing (though not on multivariate analysis), allograft material, reoperation prior to cranioplasty and age.
- Authors studied 16 patients who underwent cranioplasty following decompressive craniectomy for traumatic brain injury.
- Patients were divided into two groups (early vs late cranioplasty) and neurocognitive outcomes and CT perfusion assessed before and after cranioplasty
- Authors noted a positive effect of cranioplasty on neurologic and psychologic function in all patients, with a more remarkable improvement in the early cranioplasty group
- More complications were seen with the late cranioplasty group

- Retrospective analysis of 512 patients undergoing cranioplasty in two Western Australia hospitals between 2004 and 2015 to determine factors influencing complications and failure
- 8.2% of patients developed infection necessitating removal of the implant and 20.9% of those patients undergoing autologous cranioplasty suffered with bone resorption
- There was no significant association between cranioplasty resorption or infection and timing of cranioplasty

- Retrospective review of 78 patients who underwent cranioplasty following craniectomy between January 2011 and December 2014
- Overall rate of surgical site infection was 9% and was significantly associated with being female, having a primary etiology of traumatic brain injury, and with have had a bilateral cranioplasty
- ‘In terms of the time to cranioplasty or type of graft material, there were no differences in the [surgical site infection] occurrence rate’

- Retrospective evaluation of cranioplasty performed on 75 decompressive craniectomy patients between 2007 and 2014 who had supratentorial cerebral infarction
- Craniectomy was performed early in 16% of patients and late in the remainder. Overall complication rate was 18%
- Patients treated with early cranioplasty suffered with more complications than late cranioplasty patients

- Retrospective review of 186 patients to determine patient characteristics and operative factors that may lead to infection post-craniotherey
- Overall infection rate was 24% and was associated with wound rupture and postoperative fluid collection
- Time to cranioplasty was not associated with infection

- Retrospective analysis of 248 patients who had cranioplasty following craniectomy for traumatic brain injury to identify patient specific and procedural risk factors for complications
- Overall complication rate was 18.5% and complications included surgical site infections, epidural haematoma, hydrocephalus and new-onset seizures
- Patients with new-onset seizures (along the disease course), shunt-dependent hydrocephalus, or within the 51-70 year age group had a higher risk of a lower Glasgow Coma Score after cranioplasty
- No association was found between time to cranioplasty and outcome

- Retrospective single institution review of 87 patients who had cranioplasty following decompressive craniectomy due to traumatic brain injury or stroke
- Post-operative complications were noted in 36% of patients, with surgical site infection and bone flap resorption being the most common
- Only bone flap resorption was found to be associated with any predictive clinical parameters: young age, bone flap fragmentation, long storage time and GOS at time of cranioplasty
- There was also a significant association between bone flap resorption and a delayed time to cranioplasty


- Retrospective analysis of 88 cranioplasties following decompressive craniectomy
- Complication rate was 6.8%
- Authors found no association between the analysed variables (which included time to cranioplasty) and post-operative complications


- Observational retrospective review of 74 patients who had a cranioplasty following decompressive craniectomy
- Overall complication rate was 31%
- Most significant factors determining complications included: operating time, early cranioplasty, age of >20 and female gender


- Retrospective study of prospectively collected data on 162 cranioplasties performed between 2003 and 2012
- Overall complication rate 16.7%
- Presence of ventriculoperitoneal shunt during cranioplasty was the only significant factor associated with a higher rate of infection or flap depression
- No association between craniectomy indication, graft material and time to cranioplasty, with complications


- Retrospective review of 384 patients who had cranioplasties following craniectomy
- Overall complication rate was 31.3%
- Didn’t study timing to cranioplasty – did study urgency of cranioplasty (categorised as emergency or elective) and found no association between this and complication rate
- Comment by Tan et al: ‘One of these aspects is the timing of surgery. As the authors highlighted in their paper, there are contradictory data concerning this factor in the literature. However, we believe this factor needs to be analysed according to patient subgroups and the characteristics of the inflammatory response after the injury. For example, we have noticed that early surgery seems to be associated with more bleeding complications in patients with massive middle cerebral artery (MCA) infarction. This could be attributed to a higher degree of fragility of cerebral parenchyma in this group of patients in comparison with other groups. The primary problem in this group of patients is the severely compromised blood supply. Perhaps this leads to a suboptimal inflammatory response; thus, it may be rational to expect a delayed recovery course associated with unusual tissue fragility’ http://thejns.org/doi/pdf/10.3171/2015.6.JNS151378

• Prospective study of 55 cranioplasties
• Complication rate of 18.2%
• ‘The complication rate of cranioplasty is higher than for other elective neurosurgical procedures. Older age, poorer functional situation (worse Barthel index score) and early surgery (≤85 days) are independent risk factors for complications. However, cranioplasty produces clinical benefits beyond protection and aesthetic improvement. Earlier surgery and larger bone defects seem to increase the likelihood of clinical improvement.’


• A retrospective study of all autologous cranioplasties performed following decompressive craniectomy for traumatic brain injury between 2007 and 2010 at the Wessex Neurological Centre in Southampton
• 44 cases were included; severe complications reported in 30% of patients
• No significant predictor of poor outcome was detected (age, gender, presence of skull fracture, time to cranioplasty, seniority of operator, co-morbidities were assessed)


• 157 consecutive patients were divided into early (< 12 weeks, 78 patients) and late (≥12 weeks, 79 patients) cranioplasty cohorts
• Complication rates were lower in the early cranioplasty group, though these differences were not significant.
• There was a significantly higher risk of bone graft resorption in patients <18 years old
• The late cranioplasty group had significantly longer operative times.


• 166 cranioplasty patients attending two UK centres between 2006 and 2011 were retrospectively analysed
• 40.4% of patients suffered at least one complication during the median follow up of 15 months
• Logistic regression analysis found that initial operation, modified Rankin Score (measure of morbidity and function; mRS) at time of cranioplasty and complications being predictive of neurological outcome. Age at time of cranioplasty and timing of cranioplasty were not predictive of mRS at follow up.


• Retrospective review of 85 patients who underwent cranioplasty following decompressive craniectomy between 2009 and 2011 with >1 year follow up
• Authors assessed graft infection requiring removal of bone graft which occurred in 7.05% patients
• Infection rate was not related to time to cranioplasty, but was significantly related to operative times of >120 minutes


• 105 patients retrospectively reviewed for any association between timing of cranioplasty and neurological outcomes following decompressive craniectomy following traumatic brain injury
• Time to cranioplasty ranged from 113-245 days (mean 78.84 ± 49.04 days) and analysis of this and the Glasgow Outcome Scores of the patients found no significant association


• Single centre observational study of 147 patients
• Patients with shorter time to cranioplasty (<87 days) had better functional outcomes than patients with a longer time to cranioplasty. Age and pre-operative function scores
were also independent outcome factors. There was no difference in complication rates between the early and late cranioplasty groups.


- 239 patients were retrospectively reviewed for complication rates following cranioplasty for decompressive craniectomy
- Overall complication rate was 23.85% (including infection, hydrocephalus and new-onset seizures)
- Infection rates were predicted by reoperation following initial craniectomy and therapeutic indication (stroke)


- Retrospective chart analysis of 136 patients who had decompressive craniectomy and subsequent bone flap reinsertion
- 30.1% patients suffered complications which were most often infection or bone flap resorption
- Age, Glasgow Outcome Score prior to cranioplasty and nicotine abuse were predictors of complications. Patients who had early cranioplasty had better functional outcomes than patients with late cranioplasty.


- Retrospective cohort study of 74 patients who had undergone a decompressive craniectomy for stroke and subsequent cranioplasty were included
- 37 patients had an early cranioplasty (<10 weeks) and 37 had a late cranioplasty (≥10 weeks)
- Patients in the early cohort had a higher complication rate but this was not significant. The only predictor of complications was the presence of a ventriculoperitoneal shunt.


- Analysis of prospectively conducted database
- 280 patients included; 53 in the early group (≤2 months) and 227 in the late group (>2 months)
- Authors found complication rate higher in patients who had early cranioplasty vs late cranioplasty (25.9% vs 14.2% p=0.04)

Research in progress

Evidence Synthesis

David Clark, Angelos Kolias, Peter Hutchinson. Core outcomes and common data elements in cranioplasty: a systematic review. PROSPERO 2015

- Review Question:
  - What outcome measures are being used and what other data are being collected in the cranioplasty literature?
- Ongoing, anticipated completion April 2016

• Anticipated completion March 2018
• Authors aim to ‘determine whether there is enough evidence to confirm outcome improvement in patients after cranioplasty, to recommend the ideal interval of time to implantation, and to determine the best cranial defect substitute to decrease complications’
• This overlaps with the scope of the brief, but we don’t believe the question can be answered by another systematic review given that most published trials since the Tasiou et al review in 2014 are retrospective cohort studies with conflicting data

Primary Research

Proposal for establishment of the UK Cranial Reconstruction Registry (UKCRR)

• Includes patients aged 18-60 years with a skull defect due to craniotomy after traumatic brain injury
• Comparing cranioplasty performed at 4-6 weeks, 11-13 weeks and 23-25 weeks post craniectomy
• Primary outcomes: Glasgow coma scale, muscle strength, mini-mental state exam score, language ability, Glasgow outcome scale, brain infusion
• Estimate enrolment: 50 per group
• First enrolment 01/12/2012
• RCT

DRKS00007931: Cranioplasty after decompressive craniectomy – registry – German cranial reconstruction registry
• Date of first enrolment 21/04/2015
• Estimated enrolment 1000
• ‘The purpose of the register is to collect information on the advantages and disadvantages of the different treatment methods’
  o Will collect data on timing of cranioplasty, other necessary operations, details of underlying disease, index procedure and specifics of surgery plus an outcome assessment that will include cosmetic results
• Protocol published:

NIHR Evaluation, Trials and Studies Research

HTA – 12/35/57: Randomised Evaluation of Surgery with Craniectomy for patients Undergoing Evacuation of Acute Subdural Haematoma (RESCUE-ASDH)
Active End date 30/11/2020 http://www.rescueasdh.org/
Note: Study is assessing craniectomy vs craniotomy in the management of head injured adults undergoing acute subdural haematoma evacuation. This does not look at cranioplasty.

EME – 09/800/16: Randomised Evaluation of Surgery with Craniectomy for Uncontrollable Elevation of Intra-Cranial Pressure (RESCUE卿)
Active

References