



Research Article

Comparison of The Decompressive Surgery and Medical Therapy Alone Results in Malignant Middle Cerebral Artery Infarction

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Summary

Decompressive craniectomy is performed in the treatment of malignant middle cerebral artery (MCA) infarction as an alternative to medical treatment. The purpose of this cross-sectional trial is to compare the differences in morbidity and mortality rates of malignant MCA infarctions with decompressive surgery in comparison to conservative medical therapy alone (standard antiedema treatment).

The cases of malignant MCA infarctions observed and enrolled in this study were located in our hospital between November 2007 and June 2011. Ages of the 42 patients in the trial varied between 40 and 80, 20 of the patients were treated with decompressive craniectomy and 22 with medical therapy. Rates of survival for patients who were under 60 years old and treated with decompressive craniectomy were significantly higher than those above 60 ($p<0.05$). The survival rate of the patients who were treated within 6 hours after the onset of symptoms, especially within the surgery group, was significantly higher ($p<0.05$). At the end of the first months, the survival rate of the cases who were treated with decompressive craniectomy within 48 hours of stroke onset was 50%, after 48 hours of stroke onset was 33%.

Overall, survival rates in the decompressive craniectomy group were higher when compared with the medical treatment group. Decompressive craniectomy should be considered in cases where the patient is younger than 60 and surgery can be performed within 48 hours from the onset of symptoms as it decreases the rates of mortality and morbidity.

Key words: Antiedema treatment, decompressive hemicraniectomy, stroke, malignant middle cerebral artery infarction

Geniş Orta Serebral Arter İnfarktında Dekompresif Cerrahi ve Yalnızca Medikal Tedavi Sonuçlarının Karşılaştırılması

Özet

Dekompresif kraniektomi geniş orta serebral arter infarktında medikal tedaviye alternatif bir yöntem olarak gerçekleştirilmektedir. Bu kesitsel çalışmanın amacı geniş orta serebral arter infarktında yalnızca medikal tedavi ile dekompresif cerrahinin mortalite ve morbidite farklılıklarını karşılaştırmaktır.

Çalışmaya Kasım 2007 ile Haziran 2011 tarihleri arasında geniş orta serebral arter infarktı ile hastanemize başvuran hastalar dahil edilmiştir. Yaşları 40 ile 80 arasında değişen, 20'si dekompresif cerrahi ve 22'si medikal tedavi ile izlenen toplam 42 hasta çalışmaya dahil edilmiştir. Cerrahi tedavi yapılanlardan 60 yaş altındakilerin hayatta kalma oranı 60 yaş üstündekilere göre anlamlı oranda yüksek saptanmıştır ($p<0.05$). Özellikle cerrahi tedaviye alınan tüm hastalardan ilk 6 saat içinde tedaviye başlananların sağ kalım oranı anlamlı

derecede yüksek saptanmıştır ($p<0.05$). Birinci ay sonunda, cerrahi tedaviye ilk 48 saat içinde alınanların %50'si sağ kalırken, 48 saat sonra cerrahiye alınanların %33'ü sağ kalmıştır. Dekompresif cerrahi grubunda sağ kalım oranları yalnızca medikal tedavi grubundan daha yüksek olarak saptanmıştır. Dekompresif cerrahi özellikle 60 yaş altında ve ilk 48 saat içinde tedaviye alınan hastalarda mortalite ve morbiditeyi azaltmaktadır.

Anahtar Kelimeler: Antiödem tedavi, dekompresif hemikraniyektomi, inme, geniş orta serebral arter infarktı

INTRODUCTION

Severe middle cerebral artery (MCA) or malignant infarction occurs in 10% of stroke victims. Malignant MCA infarction is commonly associated with variable degrees of brain oedema and a high mortality rate⁽³⁾. A space-occupying or “ malignant infarction ” of the MCA is described by the involvement of at least one area of the MCA, including the basal ganglia, the development of brain oedema with effacement of the basal cisterns, and a midline shift with continuing clinical deterioration⁽³¹⁾. Despite intensive medical and surgical care, prognosis is often poor and mortality may be as high as 60%–80%. Surgical intervention can reduce that mortality compared to medical therapy alone⁽¹⁸⁾. MCA infarction is accompanied by severe brain oedema, leading to raised intracranial pressure (ICP) and subsequent brain herniation and reduction of regional cerebral blood flow⁽¹⁾. In 1956, Scarcella first described that the surgical removal of a large bone flap with duraplasty can reduce ICP and prevent brain herniation⁽²⁷⁾. Early death is a result of transtentorial herniation while delayed death is typically due to the medical complication associated with prolonged hospitalization⁽²⁾. Decompressive surgery can be life saving after malignant cerebral infarction. However, severe residual disability occurs in a high percentage of surviving patients⁽¹⁾. A large body of clinical and experimental data indicates that decompressive craniectomy is an effective strategy to reduce early case fatality in the setting of uncontrolled cerebral oedema⁽²⁴⁾.

Despite the decrease in mortality rates, fundamental questions remain unanswered

such as importance of preoperative neurological status, hemispheric dominance, patient selection criteria, surgical timing after stroke as well as the cut-off age for surgical treatment⁽¹⁾. The optimal operative time window when surgical decompression is superior to medical management alone is still being debated⁽²⁾. The challenge is the timely identification of which patients are likely to benefit the most from decompressive craniectomy⁽²⁴⁾. The purpose of this cross-sectional trial is to compare the differences in morbidity and mortality rates of malignant MCA infarction between decompressive surgery and conservative medical therapy alone.

MATERIAL AND METHODS

Patient selection

Between November 2007 and June 2011, 42 patients who were observed with malignant MCA infarction were admitted to the Suleyman Demirel University Medicine Faculty and treated with either decompressive craniectomy or medical therapy alone. The eligibility criteria is summarised in Table 1. The choice of decompression or medical treatment were offered to the relatives of patients.

Study design

In this cross-sectional study, patients underwent either surgical treatment or the most applicable medical treatment. All patients which were included in these treatments were between 40 and 80. The studies outcomes were based on the analysis of the National Institutes of Health Stroke Scale (NIHSS), modified Barthel index (mBI) and the modified Rankin

Scale (mRS) scores which were analyzed at the 1 month, 6 month and 1 year

interval. The study design is summarized as per Figure 1.

Table 1. Eligibility Criteria

Inclusion criteria
<ul style="list-style-type: none"> • Age; between 40 – 80 years old • NIHSS score ≥ 16 for lesion of right-sided infarction, ≥ 20 for lesion of left-sided infarction • Symptom onset before decompression >12 h and < 96 h • Written, informed consent by the patient or the legal representative • Decrease in the level of consciousness (NIHSS ≥ 1 in 1a. level of consciousness) • Visible ischemic sign involving > 2/3 of MCA territory on CT
Exclusion criteria
<ul style="list-style-type: none"> • Age < 40 and > 80 • Preexisting significant disability (mRS > 2) • Preexisting significant disability (mBI < 95) • Glaskow Coma Scale < 6 • Ischaemic stroke of the whole cerebral hemisphere (anterior, middle, and posterior cerebral artery territories) • Both pupil fixed and dilated • Significant contralateral infarction • Hemorrhagic infarction > 50% MCA territory on CT • Known systemic bleeding or coagulation disorder • Life expectancy < 3 years or any serious illness • Pregnancy • Contra-indication for anesthesia

* NIHSS = National Institutes of Health Stroke Scale; CT = Computed Tomography; MCA = Middle Cerebral Artery; ACA = Anterior Cerebral Artery; PCA = Posterior Cerebral Artery; mRS = modified Rankin Scale; mBI = modified Barthel Index

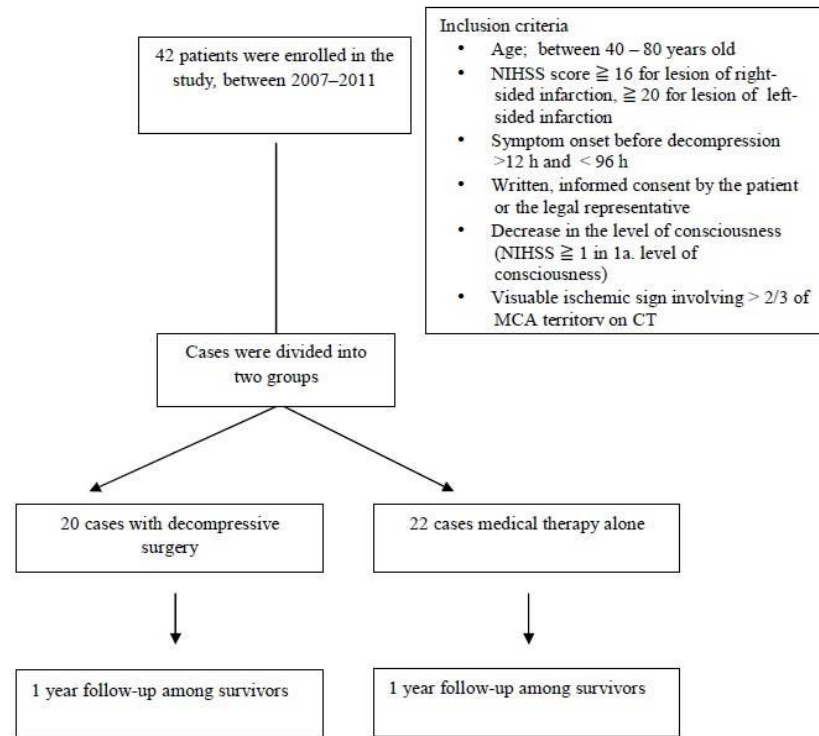


Figure 1: Study design

* This flow diagram outlines the main steps of this study design with inclusion criterias

* NIHSS: National Institutes of Health Stroke Scale

* MCA: Middle Cerebral Artery

* CT: Computerised Tomography

Functional outcome

Patients outcomes were defined by rating the activities in their daily life with measurements established in stroke research by the mRS, NIHSS and mBI. In most of the studies looking at the impact of surgical decompression on post stroke disability, measures of functional outcome have been represented by the mBI and the mRS, where a mBI of 60 and an mRS score of 3 or less identify favorable outcomes characterized by minimal-to-moderate disability, whereas a Barthel index less than 60 and an mRS of 4–6 define poor outcomes with moderately severe or very severe disability⁽²⁴⁾.

Surgical technique

Surgical decompression consisted of removal of a flap of bone at least 12 cm in

diameter from parts of the frontal, parietal, temporal, and occipital squama. The dura was opened, and an augmented dural patch was inserted. The position of the temporalis muscle and skin flap was then approximated and they were secured. Infarcted brain tissue was not resected. After the operation, patients were transferred to an intensive care unit. Cranioplasty was done at the earliest 6 weeks after the operation with the stored bone flap. The surgical technique is summarized as per Figure 2.

Conservative care

The recommendations for medical management of stroke-related malignant edema were admission to the intensive care unit, osmotherapy with mannitol, treatment of blood pressure if it is greater than

220/120 mm Hg, elevation of the head to 30°, maintenance of normothermia, normoglycemia, and normovolemia, intubation and mechanical ventilation if the patient's Glasgow coma score was ≤ 8 , signs of respiratory insufficiency was observed, or if the airway was compromised.

Statistical analysis

All outcomes measured were reported as descriptive data analysis, including mean, standard deviation, median, range, as well

as absolute and relative frequencies depending on the scales of the variables. Additionally, descriptive p-values for group comparison and the corresponding 95% confidence interval were indicated. Two-sample t testing methods, the Mann–Whitney U-test and χ^2 -testing were used to analyze group differences as applicable. Frequencies were compared using Fishers's exact test in four-field tables unless more than four fields were present ; in this case, the Chi2-test was calculated.

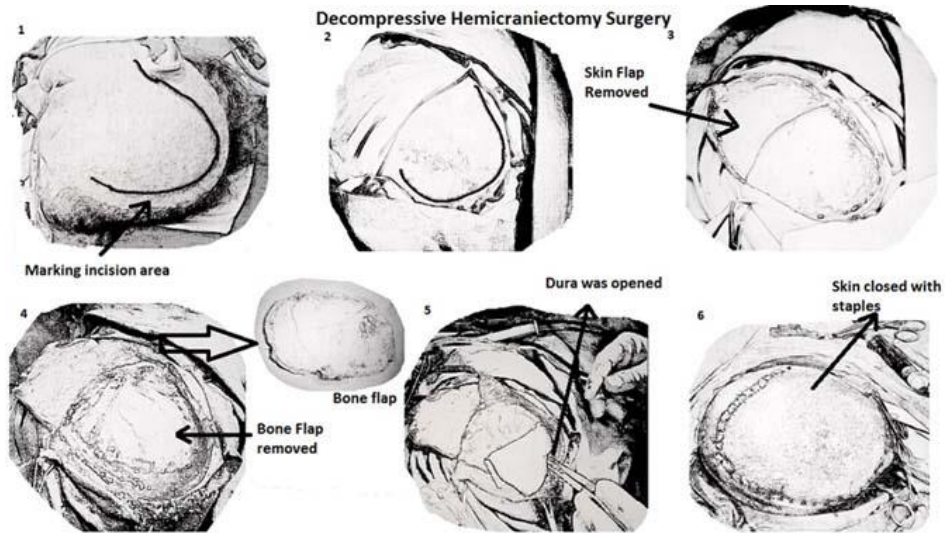


Figure 2: Surgical technique illustration

RESULTS

In this study, the first month and 12 months mortality end points and functional outcomes after 6 months and 12 months have been shown, each respectively. The first patient was enrolled in November 2007 and the last patient was enrolled in June 2011. Patient characteristics are detailed in Table 2. There were some imbalances in characteristics, such as a higher median National Institutes of Health Stroke Scale score in the conservative treatment group (22, versus 25 in the surgical treatment arm). The results show

that after 30 days 8 of 20 patients (40%) in the decompressive surgical treatment group had survived whereas in the conservative treatment group 8 of 22 patients (36.4%) had survived ($p = 0.808$). Survival after 12 months was 15% in the surgical group versus 16.3% in the conservative treatment group ($p = 1.0$). The results for functional outcome after 6 months and 12 months are given in Table 3. There were only 3 patients who survived in both of the groups at the end of 12 months.

Table 2. Demographic characteristics of patients

	DS (n=20)	MT (n=22)	P*
Age			
Median $\pm$ SD	65.5 $\pm$ 10.9	73 $\pm$ 10.5	0.419
NIHSS score on admission			
Median $\pm$ SD	22 $\pm$ 4.1	25 $\pm$ 4.1	0.012
WBC			
Median $\pm$ SD	11.5 $\pm$ 3.3	13.7 $\pm$ 5.6	0.099
Systolic blood pressure (mm Hg)			
Median $\pm$ SD	160 $\pm$ 27.5	160 $\pm$ 17.1	0.199
Body temperature (°C)			
Median $\pm$ SD	36.5 $\pm$ 0.4	36 $\pm$ 0.9	0.125
Serum glucose (on admission)			
Median $\pm$ SD	147 $\pm$ 60.4	142 $\pm$ 105.5	0.539
Time from symptom onset to treatment start (hours)			
Median $\pm$ SD	6 $\pm$ 3.7	10 $\pm$ 14.2	0.088
Decompressive surgery time (hours)			
Median $\pm$ SD	54 $\pm$ 20.9	-	
Mannitol usage time (days)			
Median $\pm$ SD	4 $\pm$ 1.6	6 $\pm$ 2.9	0.402
Death time (days)			
Median $\pm$ SD	9 $\pm$ 45.3	10 $\pm$ 33.9	0.452
History of Patients	DS n (%)	MT n (%)	P**
●Family history of stroke	2 (10.5)	5 (26.3)	0.405
●Hypertension	12 (60)	16 (72.7)	0.382
●Diabetes Mellitus	9 (45)	11 (50)	0.746
●Atrial Fibrillation	6 (30)	6 (27.3)	0.845
●Ischemic heart disease	7 (35)	10 (45.5)	0.491
●Obesity	8 (42.1)	8 (42.1)	1.0
●Hyperlipidemia	4 (20)	1 (4.5)	0.174
●Smoke	5 (26.3)	11 (57.9)	0.049
●Alcohol usage	-	2 (10.5)	0.486

* U; Mann-Whitney U test

** χ^2 ; Chi-square test

SD; standart deviation

CVI; cerebrovascular incident

DS: Decompressive Surgery group

MT: Medical Thearapy alone group

Table 3. Patient outcomes

	DS	MT	All patients	P
	n (%)	n (%)	n (%)	
Survival at first month				
Deaths	12 (%60)	14 (%63.6)	26 (%61.9)	0.808*
Alive	8 (%40)	8 (%36.4)	16 (%38.1)	
NIHSS on admission				
Median	22 ± 4.1	25 ± 4.1	24 ± 4.4	0.012 **
Range	16-34	18- 36	16 - 36	
NIHSS 1. month				
Median	16 ± 6.2	21 ± 5.6	17. 5 ± 5.9	0.342 **
Range	7 - 25	10 -25	7 - 25	
NIHSS 6. month				
Median	6 ± 2.6	10 ± 6.6	7 ± 5	0.212 **
Range	4 -10	6 - 19	4 - 19	
mRS 6. month				
Median	4 ± 1	4 ± 1	4 ± 0.8	1.0 **
Range	3 -5	3 - 5	3 -5	
Barthel indeksi 6. month				
Median	50 ± 34	30 ± 43.1	40 ± 34.7	1.0 **
Range	0 - 65	0 - 85	30 - 85	
Survival on 12month				
Death	17 (%85)	19 (%86.4)	36 (%85.7)	1.0 *
Alive	3 (%15)	3 (%16.3)	6 (%14.3)	
NIHSS 12. month				
Median	3 ± 0.5	8 ± 6.4	5 ± 5.7	0.046 **
Range	3 - 4	6 - 18	3 - 18	

mRS 12. month

Median	3 ± 1.5	4 ± 1.5	3.5 ± 1.3	0.822 **
Range	2 - 5	2 - 5	2 - 5	

Barthel indeks 12. month

Median	75 ± 39.6	30 ± 48.5	52.5 ± 40.9	1.0**
Range	15 - 90	0 - 95	15 - 95	

* χ^2 ; Chi-square test

** U ; Mann-Whitney U test

DS: Decompressive Surgery group

MT: Medical Thearapy alone group

DISCUSSION

Decompressive craniectomy procedures have been used to treat elevated intracranial pressure that is unresponsive to conventional treatment modalities⁽²⁹⁾. Surgical decompression has been reported as a treatment option for traumatic head injury, subdural haematoma, aneurysmal subarachnoid haemorrhage, massive cerebral and cerebellar infarction, intracerebral haematoma, cerebral venous and dural sinus thrombosis^(5,6,8,11,17,20,29).

Kocher first described decompressive craniectomy in 1901 for the treatment of posttraumatic brain oedema⁽²⁴⁾. In 1905, Harvey Cushing reported the use of this procedure to relieve the pressure caused by the growth of an intracranial neoplastic disorder⁽⁴⁾. In 1971, Kjellberg and Prieto described a bifrontal decompressive craniectomy procedure for the treatment of a massive infarction⁽¹⁹⁾. In 1996, Hacke et al. used the term “malignant middle cerebral artery infarction” to describe the life-threatening form of ischemic cerebral infarction. Despite intensive medical management, mortality rate of this malignant infarction is as high as 80%. Decompressive craniectomy remains the most attractive surgical treatment of malignant MCA infarction⁽²²⁾.

Opinions challenging the notion that decompressive surgery plays a life saving role in the setting of uncontrolled cerebral oedema does exist. These studies included the three European randomised trials that are DESTINY (Germany: Decompressive Surgery for the Treatment of Malignant Infarction), DECIMAL (France: Decompressive Craniectomy in Malignant Middle Cerebral Artery Infarcts) and HAMLET (Netherland: Hemicraniectomy after Middle Cerebral Artery Infarction with Life-threatening Oedema)^(12,14,24,31,33,34). In the DECIMAL trial patients were randomly assigned to surgery and conservative treatment or to medical treatment alone. Allowed time to surgical treatment from onset of symptoms was 30 hours. Inclusion criteria with regard to age was between 18 and 55. The primary endpoint was a favourable functional outcome defined by patient survival with a modified Rankin score (mRS) ≤ 3 at 6 months. The study was stopped at an early stage after 38 patients because of slow recruitment and significant differences in survival between both groups in the sequential analysis. In the DESTINY trial the maximum time from onset of symptoms to the beginning of treatment was 36 hours, and the upper age limit was 60 years old. Primary endpoint was favourable functional out-come (mRS 0 – 3) after six months. In the HAMLET

study, the allowed time until surgery was 96 hours and the age limit was from 18 to 60. The primary outcome measure was a favourable functional outcome after one year ($mRS \leq 3$). A prospective trial in the United States (HeADDFIRST: Hemicraniectomy and Durotomy upon Deterioration from Infarction Related Swelling Trial) was conducted on 25 patients, between 18 and 75. Twenty-one day mortality rates was 40% in the medical group and 21% in the surgical group. At 180 days, the mortality remained unchanged in the medical group and had risen to 36% in the surgical group ($P=0.39$)^(9,31).

HeADDFIRST study allowed randomization of patients up to 96 hours after stroke onset, which was the same as HAMLET but significantly longer than DECIMAL (30 hours) and DESTINY (36 hours). Studies that allowed later randomization should be associated with higher mortality, a finding that could not be verified by the HeADDFIRST study⁽⁹⁾. As stated by the HeADDFIRST study, the results can inform the interpretation of completed European trials concerning patient selection and medical management. At the end of the first month of this study, the survival rate of cases who were treated with decompressive craniectomy within 48 hours of stroke onset was 50% while after 48 hours was 33%. This showed that decompressive surgery within 48 hours was critical for the survival of patients.

Schwab et al analyzed the influence of early decompressive surgery (<24 hours after symptom onset) versus late surgery (>24 hours after first reversible signs of herniation) on mortality and functional outcome in 63 patients with acute complete middle cerebral artery infarction. Mortality was 16% in the early hemicraniectomy group versus 34.4% (11/32) in the late hemicraniectomy group⁽²⁸⁾. Data from a large non-randomized series have suggested that outcome is substantially improved if treatment is initiated within 24

hours of stroke onset as compared with longer time windows for treatment. Vahedi et al. reported with a pooled analysis of three randomized controlled trials that there was no difference in outcome found between patients treated on the first and those treated on the second day. In most patients, clinical signs of herniation appear after 2 days of stroke onset. Whether decompressive surgery is also beneficial if undertaken after the first 48 hours is currently being tested in HAMLET⁽³⁴⁾. In a series of 52 patients, Cho et al. reported a reduced mortality for both ultra-early surgery within 6 hours (8.7%) and early surgery within 24 hours (36.7%), compared to surgery after more than 24 hours (80%). However, clinicians have a real concern that very early surgery might lead to patients being selected for decompression who would not have gone on to develop a malignant picture. Therefore, Johnson R.D. et al. claimed that the “earlier the better” approach is not supported by the current clinical evidence and has potentially dangerous consequences⁽¹³⁾.

Some reports, that state severe aphasia as having an unacceptable impact on quality of life, argue against decompression in dominant hemispheric stroke⁽²⁴⁾. On the other hand, some of them including the DECIMAL trial, refute the significance of hemispheric laterality of infarction to functional outcome^(10,33). Furthermore, most of them believe that hemispheric dominance of infarction can affect the NIHSS score variability for inclusion criteria, but it should not be viewed as an exclusion criteria for hemicraniectomy in otherwise appropriate candidates^(12,15,24). Kastrau et al. evaluated the recovery from aphasic symptoms with infarction of the dominant hemisphere and subsequent treatment with hemicraniectomy in a trial which has 14 patients. Also, an increase of the ability to communicate was evident in 13 patients. They suggested that young age at the time of stroke and early poststroke decompressive surgery were identified as

main predictors for recovery from aphasia⁽¹⁶⁾. Solomon et al. undertook a questionnaire evaluation of stroke outcome in 209 patients at risk of stroke and found that disabling hemiplegia was considered a significantly worse outcome than general confusion, global aphasia or death. Johnson et al. suggested that hemispheric dominance may affect the rehabilitation potential of patients. Patients with dominant hemisphere infarcts who are aphasic with good leg function may be more responsive to rehabilitation than many patients with non-dominant hemisphere infarcts who have severe spatial deficits although they remain able to talk⁽¹³⁾. Of the 42 patients enrolled in the study 25 (59.5%) had right-sided infarction and 17 (40.5%) had left-sided infarction. At the end of the first month 44% of the patients who had right-sided infarction and 29.1% of the patients who had left-sided infarction survived. It can be claimed that left-sided infarction can increase mortality.

Upon arrival the NIHSS score analysis of the patients showed that those with left side infarctions on brain CT had a mean score of 26 while those with right side infarctions had a mean score of 23.3. The NIHSS score of these patients progressively decreased at the first, six and twelve month mark. At the end of the first year, the average NIHSS score of the patients which survived and had left side infarctions on brain CT was 18 while those with right side infarctions was 4.8. Based on these results the NIHSS score analysis of patients with left side infarctions on brain CT was consistently high since the onset of stroke and continued to remain high after one year.

Most of the studies report an age cut-off for functional benefit (survival with independency or acceptable degree of dependency) between 50 and 60 years old^(14,24,32-34). Kuroki K. et al. claimed that decompressive craniectomy reduced mortality and improved functional performance, so it seems that this surgery

should be aggressively considered for massive infarction of MCA territory for patients who are elder (over 70 years of age)⁽²¹⁾. Ramaswary et al. studied with children aged between 3-12 years old, who suggested that decompressive hemicraniectomy had an acceptable and life-saving treatment for MCA infarction in children and had functional outcomes that allowed for independent ambulation as well as expressive and receptive language skills (mRS 1-3)⁽²⁶⁾. Arac A. et al. reported that the mortality rate and functional outcome, as measured by the mBI and mRS, were significantly worse in patients over 60 following decompressive craniectomy for malignant infarction⁽¹⁾. In a systematic review by Gupta et al. the proportion of patients with severe disabilities was significantly higher among those older than 50 year in comparison to those younger than 50 (80% versus 32%). They suggested that age may be a crucial factor in predicting functional outcome after hemicraniectomy in patients with massive middle cerebral artery infarction⁽¹⁰⁾. Jae Won Yu et al. reported that in patients older than 70 years of age, the craniectomy group had a 30.0% one-month mortality rate, while the conservative care group had a 60.8% one-month mortality rate. For patients younger than 70, the craniectomy group showed a 28.9% one-month mortality rate, while the conservative care group showed a 54.5% one-month mortality rate⁽³⁶⁾.

In this study, survival of the all cases who are under 60 (44.4%), were significantly higher than the cases over 60 (6.1%) at the end of 12 months ($p<0.05$). Furthermore, at the end of the first month, the survival rate of patients below 60 in decompressive surgery group was 75% in comparison to those over 60 years of age which was 31.3%. Similar to other studies, this shows that decompressive surgery is more successful in younger patients.

Of the 42 patients enrolled in this trial, 20 patients were assigned to decompressive

craniectomy and 22 patients to medical therapy alone. At the end of first month, 40% of surgical group and 36% of medical treatment group survived ($p = 0.808$). Although this illustrates a favorable trend toward improved survival with surgical decompression, it did not reach statistical significance because of the small sample size of this clinical trial similar to the HeADDFIRST study. We believe other reasons that also led to statistical insignificance within this study include a higher number of patients that were above 60 (78.8%) in contrast to the other studies and a longer time period having passed prior to beginning treatment after the onset of symptoms and the application of decompressive surgery.

From a total of 42 patients enrolled in the study, 25 (59.5%) were treated 7 hours after the onset of stroke symptoms and had a survival rate of 24% whereas those treated within 6 hours had a survival rate of 58.8%. This shows that the survival rate of all patients who were treated within 6 hours after the onset of symptoms, especially within the surgery group, was significantly higher ($p < 0.05$) at the end of the first month. All of the multicentre randomized controlled trials include the main inclusion criteria that medical or surgery treatment must have started within at most 6 hours of randomization^(12,14,33). Thus, we decided that the lack of this criteria could have led to the rise in mortality rates that only 3 patients in each group lived to 12 months in this study.

In this study, mechanical ventilation was required for 16 patients (80%) in the decompressive surgery group while in the medical treatment group that number was at 15 patients (68.2%). It appears there's no statistically significant difference between the two treatment groups about the requirement of mechanical ventilation ($p: 0.384$). However, at the end of the first month, the number of deaths that occurred in patients in the medical treatment group who required mechanical ventilation was

significantly higher in statistical terms ($p < 0.05$).

In most of the studies, the functional outcome measures have been represented by the mBI and the mRS score to demonstrate the impact of surgical decompression on disability. A mBI score of 60 and an mRS score of 3 or less represent favorable outcomes characterized by minimal-to-moderate disability, whereas a mBI score less than 60 and an mRS of 4–6 define poor outcomes with moderately severe or very severe disability⁽²⁴⁾. Rahme R. et al. reviewed a total of 16 papers and 382 patients and concluded that there were low rates of mortality (24.3%), moderately severe disability (46.8% of survivors), and favorable functional outcomes (41% of survivors)⁽²⁵⁾. If craniectomy is performed early, especially in young patients, a satisfactory functional outcome can be achieved in a significant proportion of cases. Due to the small number of patients in both groups who survived at the end of 6 and 12 months, we decided that it would not be appropriate to come to a conclusion on the functional outcomes by performing a statistical analysis on the results of this study. The mean age of the sample of Decompressive surgery patients was 65.5 years while the mean age of the patients treated with conventional medical therapy was 73 year-old. This age difference should be also considered as a potential limitation of the study.

Although decompressive craniectomy decreases mortality with good functional and psychosocial outcomes, it has some short and long term complications such as bone flap necrosis, re-bleeding, surgical site infections, hydrocephalus^(7,23,25,30,35). These undesirable complications increase the mortality and lead to poor functional outcomes.

CONCLUSION

Malignant middle cerebral artery infarction occurs in a significant number of patients who suffer an ischemic stroke. The mortality rate in these patients is very high. In some of these patients, decompressive craniectomy appears to be a life-saving procedure. In this trial, survival rates in the decompressive craniectomy group were higher than the medical treatment group, although there was no statistical difference. While the applicability of decompressive craniectomy should be considered on the individual characteristics of every patient, in cases where the patient is younger than 60 years of age and especially within 48 hours from the onset of symptoms, it can reduce the risk of mortality and morbidity.

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REFERENCES

1. Arac A, Blanchard V, Lee M, et al. Assessment of outcome following decompressive craniectomy for malignant middle cerebral artery infarction in patients older than 60 years of age. *Neurosurg Focus*. 2009;26(6):E3
2. Arnaout OM, Aoun SG, Batjer HH, et al. Decompressive hemicraniectomy after malignant middle cerebral artery infarction: rationale and controversies. *Neurosurg Focus*. 2011;30(6):E18.
3. Bardutzky J, Schwab S. Antiedema therapy in ischemic stroke. *Stroke*. 2007;38(11):3084-94.
4. Burkert W, Paver HD. [Decompressive trepanation in therapy refractory brain edema]. *Zentralbl Neurochir*. 1988;49(4):318-23.
5. Cooper PR, Rovit RL, Ransohoff J. Hemicraniectomy in the treatment of acute subdural hematoma: a re-appraisal. *Surg Neurol*. 1976;5(1):25-8
6. Dierssen G, Carda R, Coca JM. The influence of large decompressive craniectomy on the outcome of surgical treatment in spontaneous intracerebral haematomas. *Acta Neurochir (Wien)*. 1983;69(1-2):53-60.
7. Ewald C, Duenisch P, Walter J, et al. Bone flap necrosis after decompressive hemicraniectomy for malignant middle cerebral artery infarction. *Neurocrit Care*. 2014;20(1):91-7.
8. Fisher CM, Ojemann RG. Bilateral decompressive craniectomy for worsening coma in acute subarachnoid hemorrhage. Observations in support of the procedure. *Surg Neurol*. 1994;41(1):65-74.
9. Frank JJ, Schumm LP, Wroblewski K, et al. Hemicraniectomy and durotomy upon deterioration from infarction-related swelling trial: randomized pilot clinical trial. *Stroke*. 2014;45(3):781-7.
10. Gupta R, Connolly ES, Mayer S, et al. Hemicraniectomy for massive middle cerebral artery territory infarction: a systematic review. *Stroke*. 2004;35(2):539-43
11. Heros RC. Surgical treatment of cerebellar infarction. *Stroke*. 1992;23(7):937-8.
12. Hofmeijer J, Kappelle LJ, Algra A, et al. Surgical decompression for space-occupying cerebral infarction (the Hemicraniectomy After Middle Cerebral Artery infarction with Life-threatening Edema Trial [HAMLET]): a multicentre, open, randomised trial. *Lancet Neurol*. 2009;8(4):326-33.
13. Johnson RD, Maartens NF, Teddy PJ. Decompressive craniectomy for malignant middle cerebral artery infarction: evidence and controversies. *J Clin Neurosci*. 2011;18(8):1018-22.
14. Juttler E, Schwab S, Schmiedek P, et al. Decompressive Surgery for the Treatment of Malignant Infarction of the Middle Cerebral Artery (DESTINY): a randomized, controlled trial. *Stroke*. 2007;38(9):2518-25.
15. Juttler E, Bosel J, Amiri H, et al. DESTINY II: DEcompressive Surgery for the Treatment of

- malignant infarction of the middle cerebral artery II. *Int J Stroke*. 2011;6(1):79-86.
16. Kastrau F, Wolter M, Huber W, et al. Recovery from aphasia after hemicraniectomy for infarction of the speech-dominant hemisphere. *Stroke*. 2005;36(4):825-9.
 17. Keller E, Pangalu A, Fandino J, et al. Decompressive craniectomy in severe cerebral venous and dural sinus thrombosis. *Acta Neurochir Suppl*. 2005;94:177-83..
 18. Kimberly WT, Sheth KN. Approach to severe hemispheric stroke. *Neurology*. 2011;76:50-6.
 19. Kjellberg RN, Prieto A, Jr. Bifrontal decompressive craniotomy for massive cerebral edema. *J Neurosurg*. 1971;34(4):488-93
 20. Kolias AG, Hutchinson PJ, Menon DK, et al. Decompressive craniectomy for acute subdural hematomas. *J Neurosurg*. 2014;120(5):1247-9
 21. Kuroki K, Taguchi H, Sumida M, et al. [Decompressive craniectomy for massive infarction of middle cerebral artery territory]. *No Shinkei Geka*. 2001;29(9):831-5.
 22. Lee SC, Wang YC, Huang YC, et al. Decompressive surgery for malignant middle cerebral artery syndrome. *J Clin Neurosci*. 2013;20(1):49-52.
 23. Lee MH, Yang JT, Weng HH, et al. Hydrocephalus following decompressive craniectomy for malignant middle cerebral artery infarction. *Clin Neurol Neurosurg*. 2012;114(6):555-9.
 24. Merenda A, DeGeorgia M. Craniectomy for acute ischemic stroke: how to apply the data to the bedside. *Curr Opin Neurol*. 2010;23(1):53-8.
 25. Rahme R, Zuccarello M, Kleindorfer D, et al. Decompressive hemicraniectomy for malignant middle cerebral artery territory infarction: is life worth living? *J Neurosurg*. 2012;117(4):749-54.
 26. Ramaswamy V, Mehta V, Bauman M, et al. Decompressive hemicraniectomy in children with severe ischemic stroke and life-threatening cerebral edema. *J Child Neurol*. 2008;23(8):889-94.
 27. Scarcella G. Encephalomalacia simulating the clinical and radiological aspects of brain tumor; a report of 6 cases. *J Neurosurg*. 1956;13(4):278-92..
 28. Schwab S, Steiner T, Aschoff A, et al. Early hemicraniectomy in patients with complete middle cerebral artery infarction. *Stroke*. 1998;29(9):1888-93.
 29. Schirmer CM, Ackil AA, Jr., Malek AM. Decompressive Craniectomy. *Neurocrit Care*. 2008;8(3):456-70..
 30. Sundseth J, Sundseth A, Berg-Johnsen J, et al. Cranioplasty with autologous cryopreserved bone after decompressive craniectomy. Complications and risk factors for developing surgical site infection. *Acta Neurochir (Wien)*. 2014;156(4):805-11
 31. Uhl E. Decompressive hemicraniectomy for space-occupying cerebral infarction. *Cent Eur Neurosurg*. 2009;70(4):195-206
 32. Uhl E, Kreth FW, Elias B, et al. Outcome and prognostic factors of hemicraniectomy for space occupying cerebral infarction. *J Neurol Neurosurg Psychiatry*. 2004;75(2):270-4.
 33. Vahedi K, Vicaute E, Mateo J, et al. Sequential-design, multicenter, randomized, controlled trial of early decompressive craniectomy in malignant middle cerebral artery infarction (DECIMAL Trial). *Stroke*. 2007;38(9):2506-17.
 34. Vahedi K, Hofmeijer J, Juettler E, et al. Early decompressive surgery in malignant infarction of the middle cerebral artery: a pooled analysis of three randomised controlled trials. *Lancet Neurol*. 2007;6(3):215-22.
 35. Vahedi K, Benoist L, Kurtz A, et al. Quality of life after decompressive craniectomy for malignant middle cerebral artery infarction. *J Neurol Neurosurg Psychiatry*. 2005;76(8):1181-2.
 36. Yu JW, Choi JH, Kim DH, et al. Outcome following decompressive craniectomy for malignant middle cerebral artery infarction in patients older than 70 years old. *J Cerebrovasc Endovasc Neurosurg*. 2012;14(2):65-74.