UNIVERSITÉ DE NANTES

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FACULTÉ DE MÉDECINE

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Année : 2021 N° 2021-225

THÈSE

pour le

DIPLÔME D'ÉTAT DE DOCTEUR EN MÉDECINE

(Médecine Physique et de réadaptation)

par

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Présentée et soutenue publiquement le 20 octobre 2021

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THE INFLUENCE OF CRANIOPLASTY ON THE IMPROVEMENT OF FUNCTIONAL IMPAIRMENTS : TRAUMATIC BRAIN INJURY VERSUS VASCULAR CAUSES

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2021

Thèse pour le diplôme d'état de

Docteur en médecine

Spécialité Médecine Physique et de Réadaptation

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Merci à Amandine CHENET pour ses idées, sa disponibilité et ses conseils avisés.

Merci au Professeur Brigitte PERROUIN-VERBE pour sa confiance dans le sujet de l'étude.

Merci aux membres du jury ; Pr Brigitte PERROUIN-VERBE, Pr Kevin BUFFENOIR et Pr Antoine ROQUILLY pour leur temps, leur lecture et leurs retours sur ce travail.

Merci aux kinésithérapeutes, ergothérapeutes, orthophonistes, neuropsychologues, aides soignants et infirmiers de l'hôpital Saint Jacques qui ont réalisé les évaluations auprès des patients.

Un grand merci à ma famille dont chaque membre a mis son grain de sel au projet. Merci à mon grand frère qui m'a accompagnée dans la réalisation de l'étude statistique. Merci à ma mère pour ses corrections en langue anglaise, merci à mon père pour ses conseils de mise en page.

Merci à mes colocataires Marion, Alix et Julien pour leur soutien et leur bichonnage.

Merci à Robin pour ses encouragements constants.

The influence of cranioplasty on the improvement of functional impairments: traumatic brain injury versus vascular causes

Introduction

Decompressive craniectomy is a surgical procedure required to release resistant intra cranial pressure. It is used to manage refractory intracranial pressure, despite medical therapeutics, in patients with severe head injuries. It can be indicated for malignant strokes, severe traumatic brain injuries, or severe brain oedema secondary to infective or neoplasic processes.

It consists in a section of the skull removal, with an opening of the underlying dura, which gives additional space for the damaged swollen brain to decompress and decrease intracerebral pressure.

Skull defect has been practiced since ancient times. We find traces of the first trepanations at the beginning of the Neolithic, around 10 000 before JC. Archeological evidence of these trepanations can be found in Europe, Asia, Africa and America.

Theodore Kocher, a swiss surgeon, was the first to describe the procedure as treatment to raise intracranial pressure [1] , and the practice was properly developed from the seventies for severe traumatic brain injuries (Ransohoff et Benjamin 1971; Kjellberg et Prieto 1971) and then for strokes (greenwood 1968).

However the utility of the procedure and its effects on patients outcome is still questioned [„3–5]. Indeed craniectomy involves significant morbidity because of surgery complications, including seizures, hydrocephalus, subdural hygroma, and infection [6] . Some studies also denounce a higher rate of severe disability among treated patients as the DECRA study [7].

To add on, cranial reconstruction requires an additional operation called cranioplasty, which is

also associated with significant morbidity [6,8]. Cranioplasty is the surgical repair of the skull defect. Different techniques are used, with biological or non biological material.

The main objective of the procedure is to protect the parenchyma from external aggressions and to restore the aesthetic shape of the skull.

The first clinical descriptions of the trephine syndrome by Grant and Norcross in 1939 [9], confirmed by Yamaura and Makino [10], introduced the idea of a therapeutic interest of the gesture.

This syndrome corresponds to a new neurological attack, or a notable and rapid worsening of the previous clinical state, associated with a concavity of the scalp on the craniectomized area. The physiopathological hypothesis is a poor cerebral tolerance to atmospheric pressure. These symptoms typically regress when the cranioplasty is performed [11].

This description suggests a neurological benefit of the cranioplasty. In recent years its role in improving cortical and subcortical functions has been increasingly recognized. However there is no available high level of evidence study on this subject. Very few studies have a prospective point of view, and none include subgroup analysis of etiologies (cf table 9).

In our Physical Medicine and Rehabilitation unit, we suspect by observation a better post cranioplasty recovery of neurological impairments for head trauma than for vascular etiologies.

Since cranioplasty involves various pathologies, it seemed interesting to us to separate etiologies of traumatic origin from vascular etiologies (thrombotic or hemorrhagic) in their neurological outcome, and then confirm or not our suspicion.

The aim of this study is therefore first to confirm prospectively and retrospectively, that there is an effect of cranioplasty on neurological prognosis, by assessing cognitive, language, motor deficits and functional skills during the hospital management of the Physical Medicine and Rehabilitation unit (PMR). We wish to differentiate this effect as well as possible from the standard recovery due to lesion resorption, brain plasticity and rehabilitation.

We want to describe whether one field of impairments responds better to cranioplasty than another.

Our second aim is then to test our hypothesis of a better functional prognosis in post cranioplasty for traumatic brain injury patients than for patients with vascular brain injury.

Material and Methods

This prospective and retrospective observational study was conducted in the head injury unit of the PMR department in Nantes, France. The Institute's ethics committee approved it.

Prospective study

Study population

For the prospective part of the study, we consecutively recruited 14 patients with previous decompressive craniectomy who were admitted to our unit, between September 2019 and September 2020. They were recruited on a non-opposition basis.

Our inclusion criteria were to be aged between 18 and 75, to have undergone a decompressive craniectomy, hemispheric or bi frontal, in the previous year, for a vascular or traumatic etiology. Patients were not to have undergone cranioplasty yet.

We excluded patients with a history of head trauma or cerebrovascular disease before the current episode, patients with prior psychiatric pathology precluding rehabilitation, and patients who did not undergo craniectomy for decompression. Patients in post-cranioplasty who required further cranial flap removal due to a complication were also excluded (cf table1).

Prospective study criteria
Inclusion criteria
To be aged between 18 and 75
To have undergone a decompressive craniectomy in the previous year
Vascular or traumatic etiologies
No cranioplasty done at the time of inclusion
Exclusion criteria
Previous history of neurological disease with impairments
Previous psychiatric pathology preventing rehabilitation
Non decompressive craniectomy
Need for removal of the cranioplasty flap

Table 1 inclusion/exclusion criteria prospective study

Finally we excluded 5 patients. Three of them were excluded because they were discharged from hospital before their cranioplasties, so we could not follow up. One of them was excluded because of a lack of data. Indeed, for this patient, the surgery was cancelled in the context of the pandemic and then rescheduled quickly without having time to organize the preoperative workup. One patient was excluded because of an empyema that required removal of the cranioplasty flap.

In total we analysed 9 patients, 5 in the traumatic brain injury group and 4 in the vascular group. In the vascular etiologies group, 3 patients had an ischemic stroke, 1 patient had an ischemic stroke secondary to hemorrhage, 2 patients had superior sagittal vein thrombosis (cf figure 1).

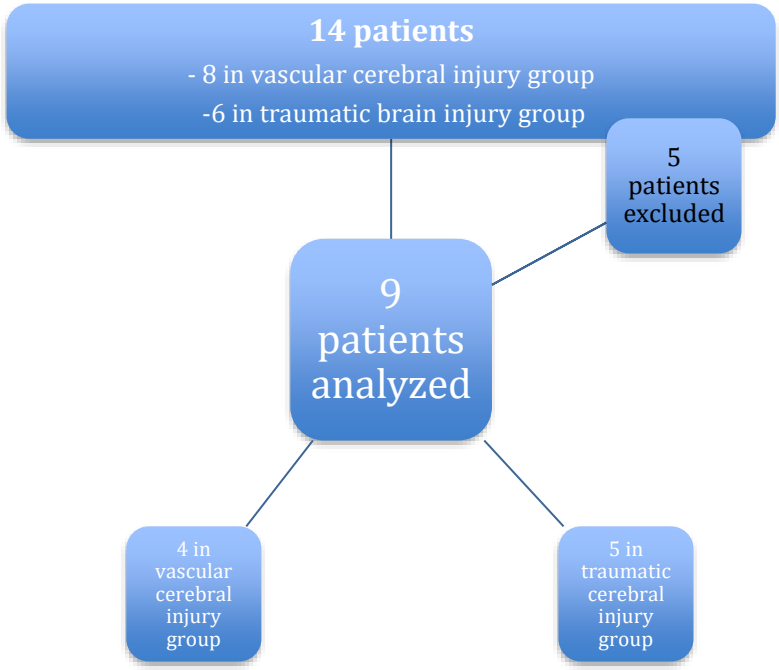


Figure 1

Endpoints and procedure

The timing of cranioplasty did not follow a fixed time interval. It depended mostly on factors unrelated to the patients, like surgeon availability and operating room schedule. The covid pandemic also delayed some surgeries. For all the procedures, custom bone protheses were used.

We collected data on the characteristics of our patients: age, sex, time between craniectomy

and cranioplasty, time spent in intensive care during the initial phase, time spent in rehabilitation.

We chose a functional scale as the main criteria, this scale is the FIM [12].

The FIM (Functional Independence Measure) instrument is a basic measurement scale of disability severity and consists of 18 items, each of which is rated on a seven-point ordinal scale. The higher the score on an item, the more capable the patient is of performing that task independently. The total score ranged from 18 to 126. We assessed the patient's independence via the FIM score at 1 month before surgery and at 1, 3, and 6 months after cranioplasty. A deviation of 2 weeks from the official measurement date was accepted.

We also collected all FIM assessments performed on the unit outside the protocol during the study period.

As secondary end points, we assessed the length of full hospitalization in rehabilitative medicine, as well as the evolution of motor, cognitive, and language impairments, 1 month before surgery and at 1, 3, and 6 months after cranioplasty. A 2-week deviation from the official measurement date was also accepted (cf table 2).

The motor assessment included:

- Berg's test[13], a 56-point balance assessment
- a walking speed test on 10 meters
- a 6 minute test which corresponds to the maximum walking distance reached in 6 min (note that the walking assessments were performed with technical assistance if necessary).
- a Fugl Meyer assesment [14], performance-based impairment index of the upper limb. This test is designed to assess motor function, balance, sensation and joint function in patients. The motor domain includes items assessing movement, coordination and reflex actions of the shoulder, elbow, forearm and hand. The score is scaled to 66 points (with the part assessing reflexes removed from the analysis to facilitate collection).

A cognitive assessment was realised with a WAIS's subtest and the apple test.

The Wechsler Adult Intelligence Scale (WAIS) is one of the most widely used instruments for measuring cognitive functioning. We chose one of its subtests, the "barrage" test. A group of

geometric shapes is presented to the subject, who has to cross out the target images within a limited time of 45 seconds. It assesses processing speed, visuomotor abilities and selective visual attention.

The maximum score is 72. We used two different versions to avoid retest bias.

The apple test[15] is a neglect assesment which distinguishes egocentric neglect from allocentric neglect. It consists of 150 apples scattered pseudo-randomly on a page, with complete and incomplete apples (half on the left, half on the right). The instruction is to cross out the complete apples while ignoring all incomplete apples.

A language assessment using the Language Screening Test (LAST)[16] comprises 5 subtests and a total of 15 items. To avoid retest bias, we used the 2 parallel versions of the scale.

In order to simplify the analysis of the data we have accounted for all errors on the test.

FIM assessments were conducted during multidisciplinary meetings involving nurses, physicians, health care assistants, and rehabilitators.

The rehabilitator in charge of the patient usually performed the assessments: physiotherapist, occupational therapist, speech therapist, neuropsychologist.

The data were collected and analysed by the author.

	D-1 month	1 month	3 months	6 months
MIF	X	X	X	X
BERG	X	X	X	X
Fugl Meyer	X	X	X	X
Walking speed	X	X	X	X
LAST	X	X	X	X
WAIS subtest	X	X	X	X
Apple Test	X	X	X	X

Table 2 : Planing of assesments

Retrospective study

Population

For our retrospective study, we requested from the archives of the hospital of Nantes, the data of the decompressed patients craniectomized between 2010 and 2020, who had realized a rehabilitation in the PMR unit of universital hospital of Nantes**.** We obtained a list of 61 patients. Our inclusion criteria were to be aged between 18 and 75, to have undergone decompressive craniectomy followed by a cranioplasty, in a context of traumatic or vascular brain injury (hemorrhagic or ischemic stroke, meningeal hemorrhage, venous thrombosis), and to have been hospitalized in the Neurologic Physical Medicine and Rehabilitation Department of Nantes University Hospital before and after the cranioplasty. We excluded patients with prior neurological disability and patients with a new stroke or severe brain injury within 1 year of craniectomy.

We also excluded patients who required a second craniectomy due to a complication (empyema, prosthesis fracture...).

We obtained a list of 61 patients who met these criteria. After reading the archive files, 23 patients did not meet the inclusion criteria.

5 patients had not undergone a craniectomy (embarres, craniotomy), 1 patient had received a non-decompressive craniectomy in the context of sepsis, 1 patient had died before his cranioplasty, 1 patient had been craniectomized before the established time interval, 1 patient had not undergone rehabilitation in the unit, 7 patients had not been hospitalized for rehabilitation before their cranioplasty.

After data collection, we excluded 16 patients because of missing records, at least one pre-cranioplasty FIM evaluation, and one posterior evaluation. 22 patients were therefore analyzed retrospectively.

Retrospective study criteria
Inclusion criteria
To be aged between 18 and 75
To have undergone a decompressive craniectomy
Vascular or traumatic etiologies
At least two FIM scores available in the file, before and after cranioplasty with maximum 6 month difference
Hospitalized in the PMR at the Saint Jacques Hospital before and after the cranioplasty.
Exclusion criteria
Need for removal of the cranioplasty flap
Previous history of neurological disease with impairments

Table 2 inclusion/exclusion criteria retrospective study

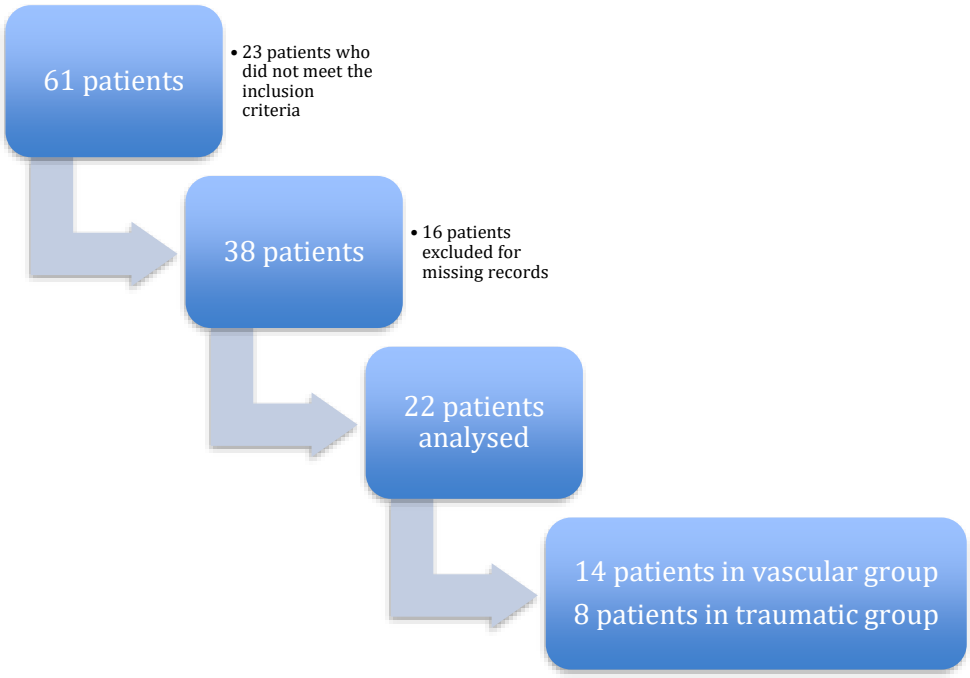


Figure 2

Endpoints and procedure

Data collection was performed both on paper and computerized records.

As for the prospective part of the study the main criterion was the FIM score.

We screened the charts to collect as many FIM assessments as possible between craniectomy and cranioplasty; and as many assessments as possible within two years after cranioplasty. FIMs are usually evaluated in a multi-professional staff meeting, in the unit. We assume that the scores collected were all performed in this manner.

The maximum number of FIM assessments collected was 6 per patient with a minimum of 2. We added the retrospective data to the prospective data to perform a second, more powerful analysis.

We used a linear regression model for the data analysis, on each parameter studied. Given the small number of patients analysed, the lack of randomization and the multiple time observations for each parameter, we chose to use an individual fixed effect. The fixed effect allows us to weigh the effect of unobservable individual variables for each patient. Excluding the effect of such characteristics is crucial as they could greatly affect our estimates of the treatment effect. Especially as the groups have not been balanced on characteristics through a randomization.

An implicit assumption of our research design is that the natural progression of functional autonomy would be the same in both groups, absent the cranioplasty. Yet, we further allow for a deviation across groups at a constant pace through the introduction of a linear trend in our preferred specification.

The results are expressed both in levels and in logs. Using the log of the dependent variable in linear regressions has several advantages: it limits the sensitivity of estimates to one or several outliers, can be interpreted as percentages, and translates a different underlying assumption on what the linear trend captures (i.e. a constant pace of progression in percentage of the baseline level rather than a constant value). However, due to the scale nature of most of the studied outcomes, we still consider regressions in levels as our baseline results, and the regressions in logs a sensitivity check.

Results

We performed a first analysis of prospective observations of the studied parameters. Then, in a second step, we integrated the retrospective data with the prospective ones in order to gain power on the common parameters; the FIM and the length of stay in PMR.

The mean age of the included patients was 39, with a mean of 40 in the traumatic brain injury

group versus 36 for vascular etiologies.

The average time interval between craniectomy and cranioplasty is 177 days with 179 days for the traumatic group versus 175 for the vascular group.

Demographic characteristics :		traumatic	vascular	total
Patients	number	5	4	9
Age	years	43,1	36	40,6
Gender	male female	5 0	1 3	6 3
Delay between craniectomy and cranioplasty	number of days	179,2 (143-243)	175(100-315)	177
Type of craniectomy	hemispheric bifrontal	5 0	3 1	8 1
Time spent in intensive care unit	number of days	33 (7-59)	13,5 (3-27)	24
Length of stay in PMR	number of days	269,7	189,5	229,6

Table 3 : Demographic characteristics prospective population

Demographic characteristics :		traumatic	vascular	total
Patients	number	8	14	22
Age	years	32,3	43	41
Gender	male female	7 1	8 6	15 7
Delay between craniectomy and cranioplasty	Number of days	133	156	148
Lenght of stay in PMR	Number of days	280	263	269

Table 4 : Demographic characteristics retrospective population

Traumatic brain injury patients have on average longer stays in intensive care unit and show on average lower initial mean scores on the FIM, Berg, LAST, apple test and WAIS subtest.

For the prospective analysis we found a 22,9 (p=0.024) point difference post cranioplasty on FIM in the brain injury group compared to the vascular group. This amounts to an additional 48% improvement in FIM following cranioplasty. Whereas, the average gain for both groups after controlling linear trend and individual fixed effect is only of 2,2 (p=0,752). This progression is further enhanced by the fact that the baseline FIM is on average 4 points lower (p=0.834) in the TBI group.

The results combining the prospective and retrospective data, showed a differential of the means of FIM TBI versus vascular group of 1,778 (p=0.812). However the progression on the FIM score post surgery, of all patients after controlling for a linear trend and individual fixed effect is 14,04 (p=0,014), so 18% more.

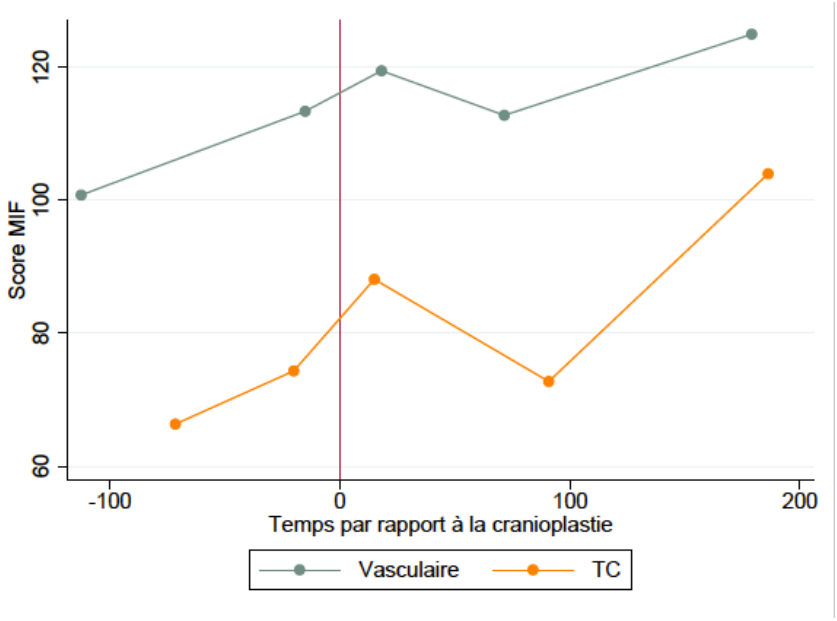


Figure 3 : Average FIM score in relation to time away from cranioplasty. Vascular versus TBI. Prospective data.

Figure 3 : Average FIM score in relation to time away from cranioplasty. Vascular versus TBI. Prospective and retrospective data.

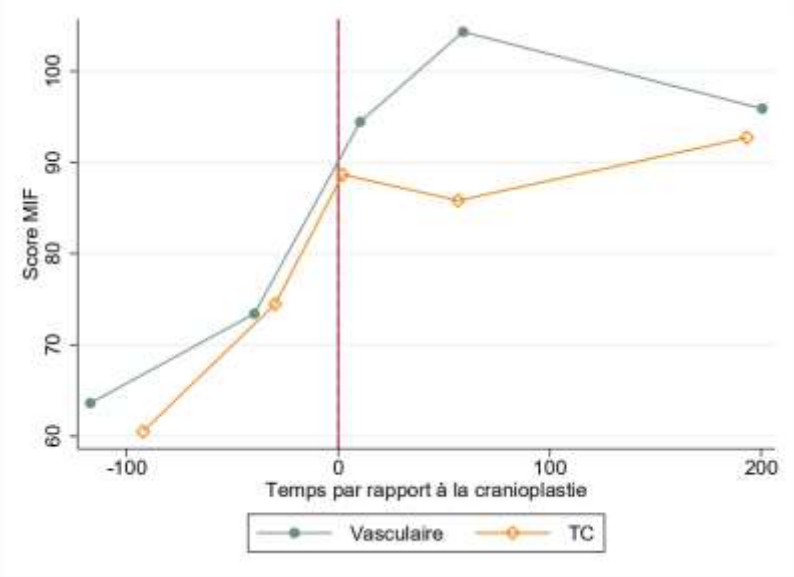
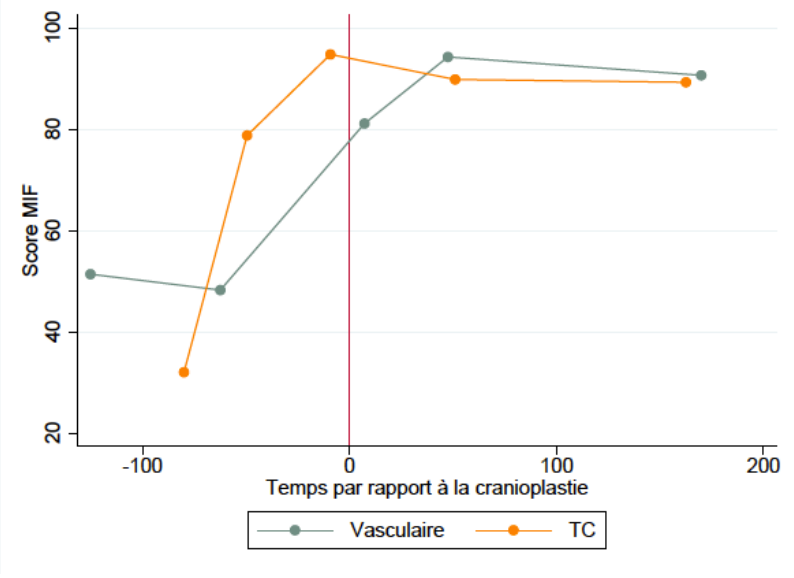


Figure 4 : Average FIM score in relation to time away from cranioplasty. Vascular versus TBI. Retrospective data.



The BERG analysis shows a progression of 6,571 points (p=0,202) attributable to cranioplasty, all patients mixed after controlling for a linear trend and individual fixed effect. The BERG increase of 0,1 (p=0,002) points more for the TBI group is negligible. The average initial BERG was 2 points less for the TBI group than for the vascular group.

Analysis of gait speed showed an increase of 0,22 step/sec (p=0,379) post cranioplasty for both groups. The increase in walking speed is of 0,002 (p=0,076) step/sec more in the TBI group than in the vascular group.

Figure 6 : Average Berg score in relation to time away from cranioplasty. Vascular versus TBI.

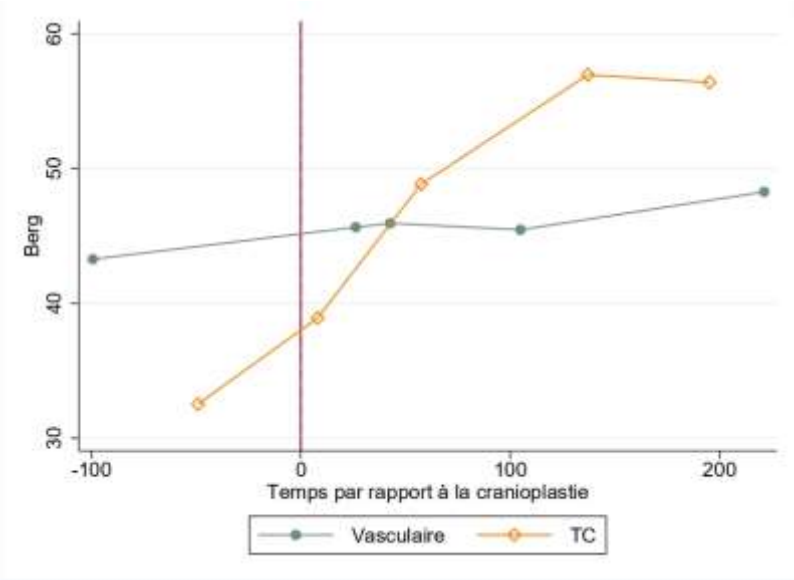
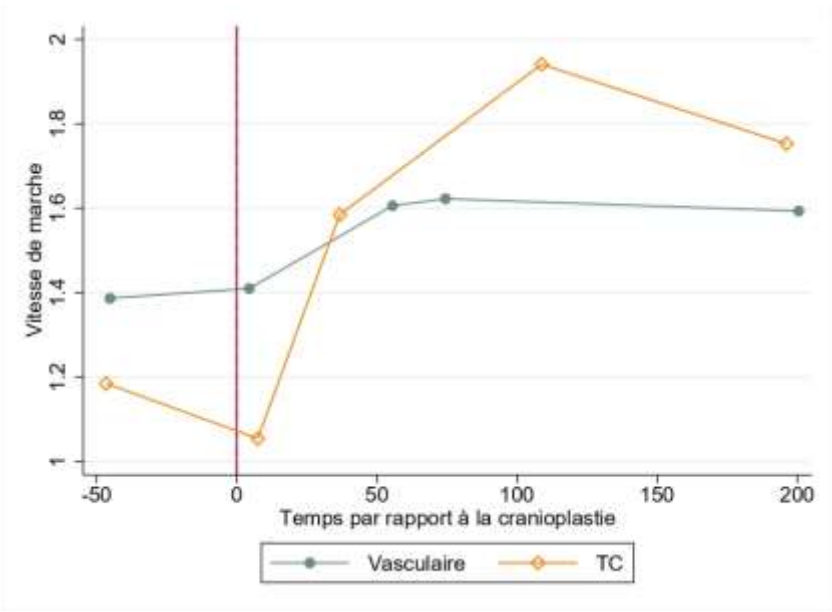


Figure 7 : Average walking speed in relation to time away from cranioplasty. Vascular versus TBI.



The walking range shows an average elevation of 67,3 m (p=0,376) due to cranioplasty, all groups combined. The TBI gets slightly higher score results (0,239m) than the vascular group; without significance (p=0,582).

The Fugl meyer's statistic analysis shows a negative relation to cranioplasty as it is lowered from -0,397 points (p=0,885) for mixed groups after controlling for linear trend and fixed effects. There is a negligible superiority for the vascular group.

Figure 8 : Average walking perimeter in relation to time away from cranioplasty. Vascular versus TBI.

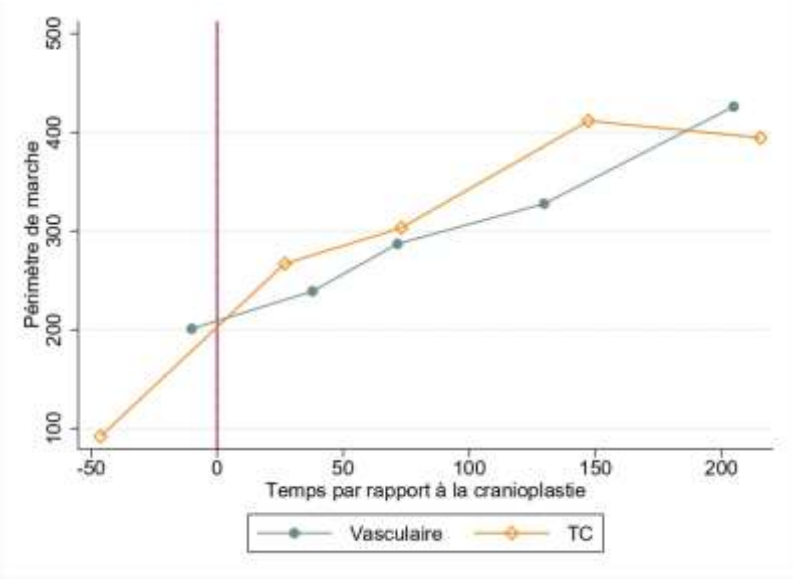
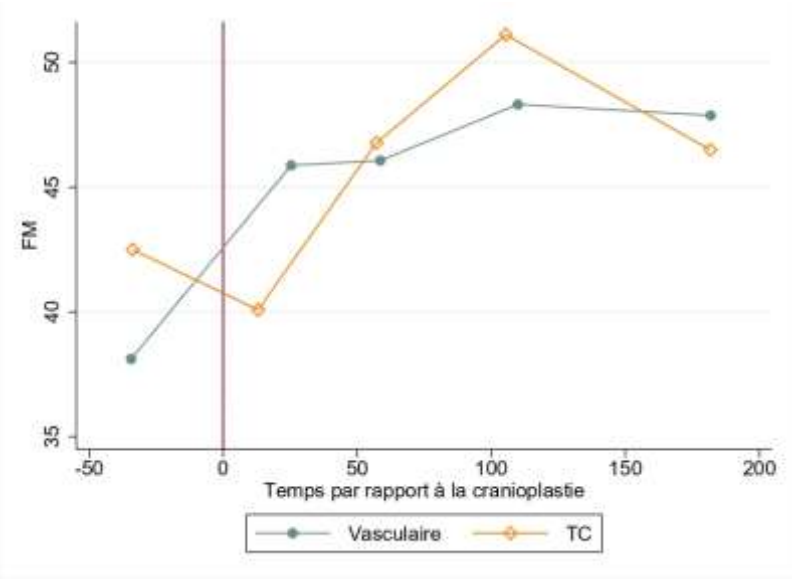


Figure 9 : Average Fugl Meyer score in relation to time away from cranioplasty. Vascular versus TBI



The LAST score shows a 0,709 point (p=0,559) elevation post surgery in both groups.

The difference in score between the TBI group and the vascular group is negligible.

The apple test shows an average regression of the number of errors of 3,145 (0,550) for both groups in post cranioplasty. The decrease is slightly more present, but non significant in the TBI group.

Figure 10 : Avereage LAST score, in relation to time away from cranioplasty. Vascular versus TBI.

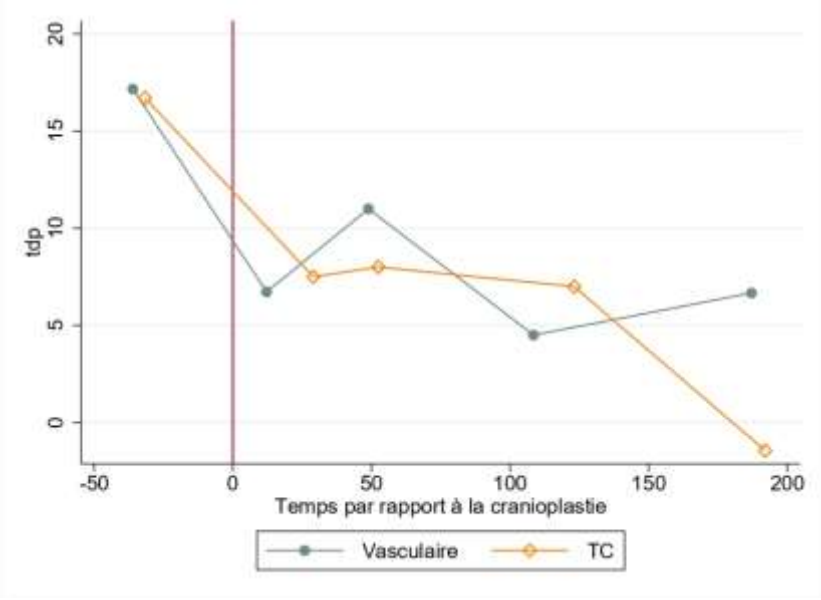
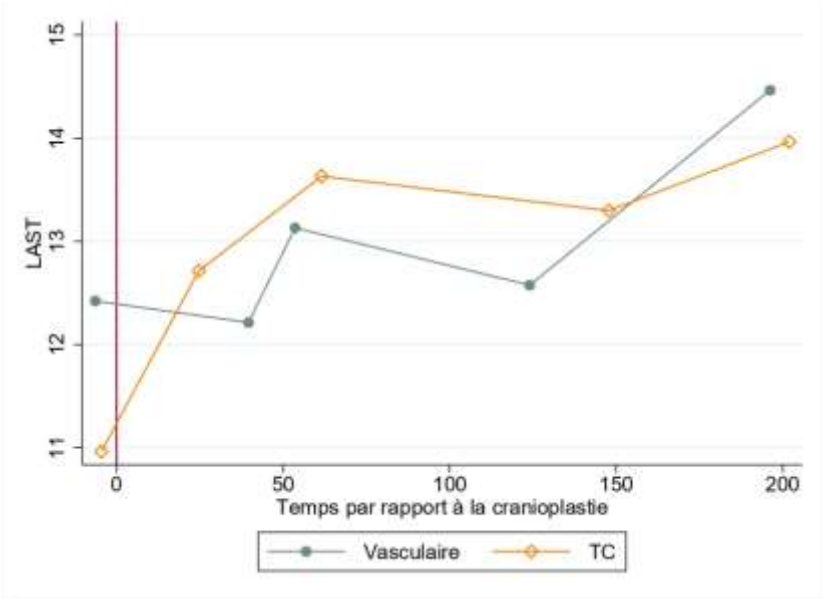
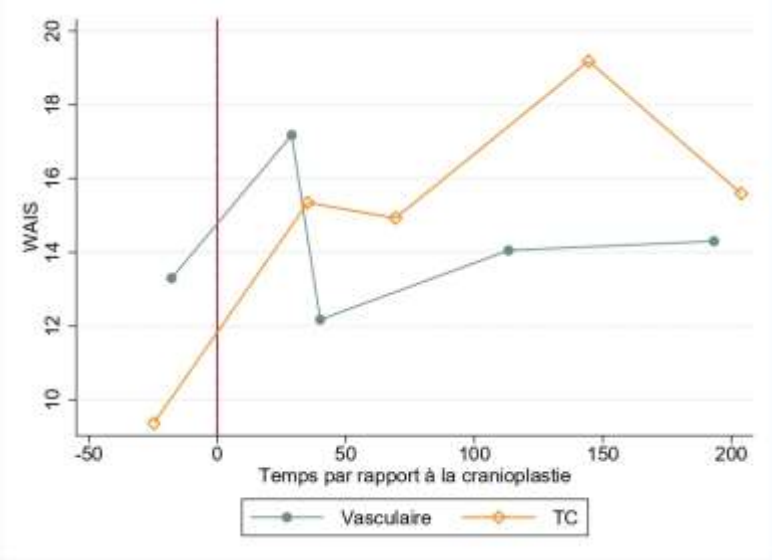


Figure 11 : Average number of errors at the apple test, in relation to time away from cranioplasty. Vascular versus TBI.



The WAIS subtest shows an increase of 2,733 (p=0,345) points linked to the intervention. The difference in TBI versus stroke evolution is 0,0348 (p=0,128).

Figure 12 : Average WAIS score in relation to time away from cranioplasty. Vascular versus TBI:



In total, for all patients vascular and traumatic, we found a positive effect of cranioplasty on the patients' autonomy evolution. We show a significant difference in the evolution of the FIM for the traumatic brain injury patients compared to the vascular group, even though the initial FIM of TBI patients was lower preoperatively. However, this trend is absent when retrospective data are added. No effect on the total length of hospital stay could be shown, neither prospectively nor retrospectively as the difference was, after controlling for age and sexe, of 0,137 (p=0,998) days more for TBI .

The BERG's analysis, as the walking speed, the walking range, the apple test and the WAIS show an interesing improvement for all patients but without being significant. On the contrary the Fugl Meyer score is not improved post-surgery , but without significance.

The Berg's analysis demonstrates a significant difference in favor of the TBI group, but the increase is too small to be taken into account. The walking speed, the walking range, the LAST, the apple test and WAIS improve for all patients, show a very low difference in favour of TBI, without significance.

Prospective + restrospective result FIM				
	Fixed effect		Fixed effect + linear trend	
	Score FIM	Score FIM (log)	Score FIM	Score FIM (log)
TBI + vasc (post cranioplasty	33,39* p=0,000	0,483 p=0,000	14,04 p=0,014	0,184 p=0,036
TBI (post cranioplasty)	-0,369 p=0,963	0,0628 p=0,638	1,778 p=0,812	0,0960 p=0,442
Linear trend			0,116* p=0,000	0,00180* p=0,000
Constant	66,91* p=0,00	4,061* p=0,00	73,83** p=0,00	4,168** p=0,00
observations	116			

Table 5 : FIM result with retrospective and prospective data combined

Prospective results FIM				
	Fixed effect		Linear trend + fixed effect	
	Score FIM	Score FIM (log)	Score FIM	Score FIM (log)
TBI + vasc (post cranioplasty	15,65 p=0 ,002	0,146 p=0,002	2,202 p=0,752	-0,0238 p=0,814
TBI (post cranioplasty)	23,24* p=0,033	0,490* p=0,005	22 ,99* p=0,024	0,487* p=0 ,005
Linear trend			0,0958* p=0,040	0,00121 p=0,090
constant	80,71** p=0,001	4,255* p=0,000	85,28* p=0 ,00	4,312* p=0,00
Observations	50			
Prospective results BERG				
	With fixed effect		Linear trend+ fixed effect	
	Score BERG	Score BERG (log)	Score BERG	Score BERG (log)
TBI + vasc (post cranioplasty)	5,279 p=0,139	0,177 p=0,324	6,571 p=0,202	0,240 p=0,384
TBI (post cranioplasty)	0,0936** p=0,006	0 ,00397* p=0,019	0,100* p=0,002	0,00429* p=0,008
Linear trend			-0,0111 p=0,506	-0.000542 p=0.514
constant	37,45** p=0,00	3,363** p=0,00	36,94** p=0,00	3,338** p=0,00
Observations	36	36	36	36

Table 6 : FIM and BERG results, prospective data

Discussion

The impact of cranioplasty on the prognosis of the brain-injured patients remains a poorly researched phenomenon today. It has been shown, although there is conflicting evidence, that early cranioplasties lead to better prognoses. The only meta-analysis carried out on the subject shows a better prognosis for early cranioplasties, that is within 90 days of craniectomy (9). The delays are longer in our study, with an average of 177 days, what can influence our results.

In all the studies carried out on the subject, the major constraint is to succeed in evaluating a wide variety of disabilities with the same tools. The second constraint is to evaluate only the progression secondary to cranioplasty and to differentiate it from the recovery linked to cerebral plasticity and rehabilitation. Indeed the use of a control group, without surgery, leads to an ethical problem.

The studies performed so far are all level 4 studies (cf table**), with small numbers of patients and very variable observation times, between 72 hours and 9 months following cranioplasty. Almost all show significant improvements in post-cranioplasty, with various evaluation scales (MMS, BREF, BI, FIM, COGNISTAT…). It should be noted that no study takes into account, as we did, the naturally favourable progression linked to the resorption of lesions, brain plasticity and the rehabilitation context, in its results.

We can mention 2 studies which try to evaluate independently the impact of cranioplasty on their results. A prospective study by Stephen Honeybul and associates [17], carried out on 25 craniectomized patients with mixed etiologies. The evaluations are performed close to the intervention in order to measure its effects, 72 hours before the cranioplasty and 7 days after. The patients were evaluated on the FIM and the COGNISTAT scale. They showed a slight improvement on the FIM of 2.1 points IC (0.1-4.3) 95%.
We can also cite the study by N. Jasey and al [18]. It is a cohort study on 26 individuals with brain injury, with a retrospective design and the only one with a randomized control group of craniectomized patients who did not receive cranioplasty during the study period. Their design is interesting as they use a FIM efficiency, corresponding to a weighing of the score on the

number of days of rehabilitation. They show an improvement on the FIM efficiency score but without significance between the two groups. However the FIM are scored at the patients' discharge, so the time of follow up varies greatly.
It is in this context that our study design is interesting. Indeed we carry out a long-term follow up which we believe is essential in an autonomy assessment. But we also care to best assess the effect of cranioplasty itself, without taking into account the favourable progression in the rehabilitation context by the used of a linear trend.

Only one meta analysis has been realised on the subject by J G Malcolm [19]. 8 retrospective observational studies are gathered with 521 patients. The combined results show a significant improvement post-cranioplasty on the barthel index, and the KPS (Karnofsky Performance Scale), the data for the FIM were not significant.

Some studies, as ours, have assessed cognitive functions [20]. It is the case of the Jelcey study in 2013 [21], witch evaluates the effect of cranioplasty on neuropsychological assessments. The results show a positive effect of cranioplasty on executive functions and verbal fluency at 3 months. Again, they do not take into account the possible natural favourable evolution.
We did not find any motor assessments following cranioplasty in the literature, apart from subgroup analysis on FIM or BI motor criteria.

Our study is the first prospective study, which questions the effect of cranioplasty by differentiating the pathologies. The idea comes from a pathophysiological hypothesis. Presently the main physiopathological hypothesis is a deleterious effect of atmospheric pressure on cerebral vascularization, of cranectomized patients [22] [23]. The neurological status improvement of the patients would then be linked to the reversibility of this condition following the cranioplasty surgery.

In this way, the Chibbaro and al (2013) study [24], found an impact of cranioplasty on cerebral hemodynamics, via a perfusion CT and trans-cranial doppler. Post-cranioplasty, cerebral perfusion increased on both the craniectomized and controlateral hemisphere.
Halani and al (2017)[23] , also worked on the topic, in a systematic review, including 205 patients, in 21 studies, with different techniques of evaluation of cerebral perfusion and very variable

time frames. All of them found an improvement of cerebral perfusion on the craniectomized hemisphere and 9 an improvement of contralateral perfusion.

Indeed we can imagine a potentially different effect of the cerebral vascularisation improvement, on traumatic disseminated lesions (diffuse axonal lesions, counter blow lesion), from the generally localized and infarcted vascular expectations. It also seems essential to us to take into account the type of lesion and their mecanism.

We have searched outside the context of cranioplasty, if there were different documented patterns of evolution between these two diseases.

The literature describes a difference in prognosis between stroke and TBI, in favour of TBI, for the recovery of aphasia[25]. We did not find other areas of evolution where a difference was proven[26].

In total, in our study we wanted to perform an exhaustive evaluation of the patients using motor, language and cognitive assessments. Our results are in favour of a better functional evolution for TBI after cranioplasty surgery. Unfortunately, the addition of retrospective data does not confirm the results of the prospective study on FIM. However, this should be qualified by the small number of existing FIMs, and the large interval between evaluations per patient, in the files. The other scales used in this study do not show any significant difference between etiologies. However we are limited by our small number of patients which implies a lack of power. This hypothesis would require a wider recruitment of patients. It should also be taken into account in our results that the pre-cranioplasty FIMs of TBIs are lower than those of vascular patients, thus also leaving more room for improvement.

Our study has several shortcomings that may impact our results. Indeed, we used the same scales in our two groups in order to be able to compare them. However, some of them, such as the Fugl meyer, the apple test or the LAST are only validated for stroke assessment. In addition, the assessment dates were not always perfectly respected, so that not all patients had the same number of assessments per scale. This leads to a loss of accuracy. However, we did not include an assessment of executive behavioural disorders, which are indeed more frequent in brain-injured people and have a strong impact on autonomy.

In a future study it could be interesting to perform an analysis by FIM's subcategory, to explore whitch items progress the most.

Conclusion

In total the effects of cranioplasty remain a subject that has been little explored, and which requires a good level of evidence, taking into account the difficulty of capturing only its significant effects in the progression of patients.

Our hypothesis of a stronger impact for traumatic etiologies is confirmed in this study but only in the prospective analysis with a small number of subjects. And it is only significant in terms of autonomy. We do not observe any significant effects in our motor, language or attentional evaluations.

We obtained apparently worse results than other studies on the subject. However, we chose to use a demanding statistical method with both fixed effects and linear trend, what was never done before. The number of patients is low,

so we lack power. In the future it seems interesting to repeat this protocol with a larger recruitment.

Acronyms

PMR : Physical Medicine and Rehabilitation unit

GOS : Glasgow outcome scale

GCS : Glasgow coma scale

FAB : frontal assesment battery

MMSE : mini mental state examination

T : time

BI : Barthel index

CBF : cerebral blood flow

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Appendix

Walking speed step /sec				
	Fixed effect		Linear trend + fixed effect	
	Score walking speed	Score walking speed (log)	Score walking speed	Score walking speed (log)
TBI + vasc (post cranioplasty)	0,225 p=0,239	0,132 p=0,291	0,225 P=0,379	0,142 p=0,392
TBI (post cranioplasty)	0,0027 p=0 ,071	0,0011 p=0,158	0,0028 p=0,076	0,0012 p=0,187
Linear trend			-0.00000907 p=0,994	-0.000112 p=0,876
Constant	1.243* p=0,000	0.285** p=0,006	1.243** p=0,00	0.282 p=0,014
Observations	35			
Walking perimeter				
	Fixed effect		Linear trend + fixed effect	
	Score	Score (log)	Score	Score (log)
TBI + vasc (post cranioplasty)	101,1 p=0,29	0,702 p=0,129	67,30 p=0,376	0,671 p=0,254
TBI (post cranioplasty)	0,740* p=0,038	0,00204 p=0,195	0,239 p=0,582	0.00163 p=0,558
Linear trend			0,607 p=0,110	0.0005 p=0,829
constant	182,7 p=0,001	4,927 p=0,00	191,5 p=0,002	4,936 p=0,00
observations	30			

Fugl Meyer				
	Fixed effect		Linear trend + fixed effect	
	Score	Score (log)	Score	Score (log)
TBI + vasc (post cranioplasty)	3,085 p=0,249	0,111 p=0,344	-0,397 p=0,885	-0,0258 p=0,791
TBI (post cranioplasty)	0 ,0298 p=0 ,192	0.000674 p= 0.397	-0.00722 p= 0.790	-0.00121 p=0.131
Linear trend			0.0461 p=0.070	0.00224 p=0.004
constant	41,27 p=0,0	3,776 p=0,0	42,76 p=0,00	3.837 p=0,00
observations	31			
Apple test				
	Fixed effect		Linear trend + fixed effect	
	Score	Score (log)	Score	Score (log)
TBI + vasc (post cranioplasty)	-6,147 p=0 ,299	-0,542 p=0,220	-3,145 p=0,550	-0 ,235 p=0,712
TBI (post cranioplasty)	-0,0574 p=0,220	-0.00898 p=0,086	-0.0466 p=0,430	-0.00654 p=0,328
Linear trend			-0.0146 p=0,747	-0.00353 p=0,583
constant	13,67* p=0,004	2,586* p=0,000	13,48* p=0,007	2.531* p=0,00
observations	25			

WAIS subtest				
	Fixed effect		Linear trend + fixed effect	
	Score	Score (log)	Score	Score (log)
TBI + vasc (post cranioplasty)	1,588 p=0,467	0,217 p=0,267	2,733 p=0,345	0,326 p=0,238
TBI (post cranioplasty)	0,0248 p=0,203	0,00183 p=0,252	0,0348 p=0,128	0.0027 p=0,165
Linear trend			-0,0142 p=0,432	-0.0013 p=0,388
constant	12,55 p=0,000	2,405 p=0,00	12,33 p=000	2,385 p=000
observations	20			

LAST				
	Linear trend		Linear trend + fixed effect	
	Score	Score (log)	Score	Score (log)
TBI + vasc (post cranioplasty)	1,257 p=0,125	0,187 p=0,152	0,709 p=0,559	0,169 p=0,398
TBI (post cranioplasty)	0,0054 p=0,309	0,0009 p=0,335	0,0007 p=0,943	0,0007 p=0,635
Linear trend			0,00598 p=0,561	0,0001 p=0,876
constant	11,71 p=0,00	2,318 p=0,00	11,89 p=0,00	2,324 p=0,00
observations	28			

Table 7 : Results for walking speed, walking perimeter, fugl meyer, Berg score, apple test, WAIS and LAST, prospective data

References for neurological improvement after cranioplasty						
Reference	Methodology	Number of patients	Etiologies	Outcome	Assesment time (before/after)	Result
Stelling 2011	Case series retrospective	23	TBI	GCS	Immediately	NS
Jelcic & al 2013	Case series prospective	5	TBI	Neuropsychological test set	J-7 J+84	S : fluency, working memory, attention
Chibaro & al 2013	Case series multicenter	24	TBI	GOS, FAB, MMSE Transcranial doppler	J-7 J+28 J+68	S : brain perfusion J28
N. Jasey 2017	Retrospective cohort study, 2 groups	26	mixte	[(FIM™ discharge – FIM™admission)/ number of days in rehabilitation]	#	FIM™ efficiency increased following cranioplasty without significance
H.Muramatsu 2007	Retrospective case series	7	stroke	BI Recovery grade of hemiplegia	monthly	S : recovery grade of hemiplegia
Paredes & al 2015	Prospective case series	55	TBI	NIHSS BI	J-3 J+3	14,5% : 2pt NIHSS gain 1,8% :>5pt BI
Di stefano & al 2016	Prospective case series	29	mixte	Neuropsychological tests	J-120 J-30 J+30 J+180	S : all field

Reference	Methodology	Number of patients	Etiologies	Outcome	Assesment time (before/after)	Result
Honeybul & al 2013	Prospective case series	25	mixte	FIM GOGNISTAT	J-3 J+7	Mean FIM score improvement : 2.1 points, 95% IC (0.1 – 4.3), p = 0.049
J G Malcolm	Meta analysis	551 (8 studies)	mixte	FIM, BI, KPS, GCS, GOS	variable	S : KPS and BI Better outcome <90days/>90 days
Mah & Kass 2016	Prospective case series	22	mixte	CBF, GOS,MMSE	J0 J+28 J+168	S : CBF MMSE (+3 pt)

Table 8 : References to existing literature on the effect of cranioplasty

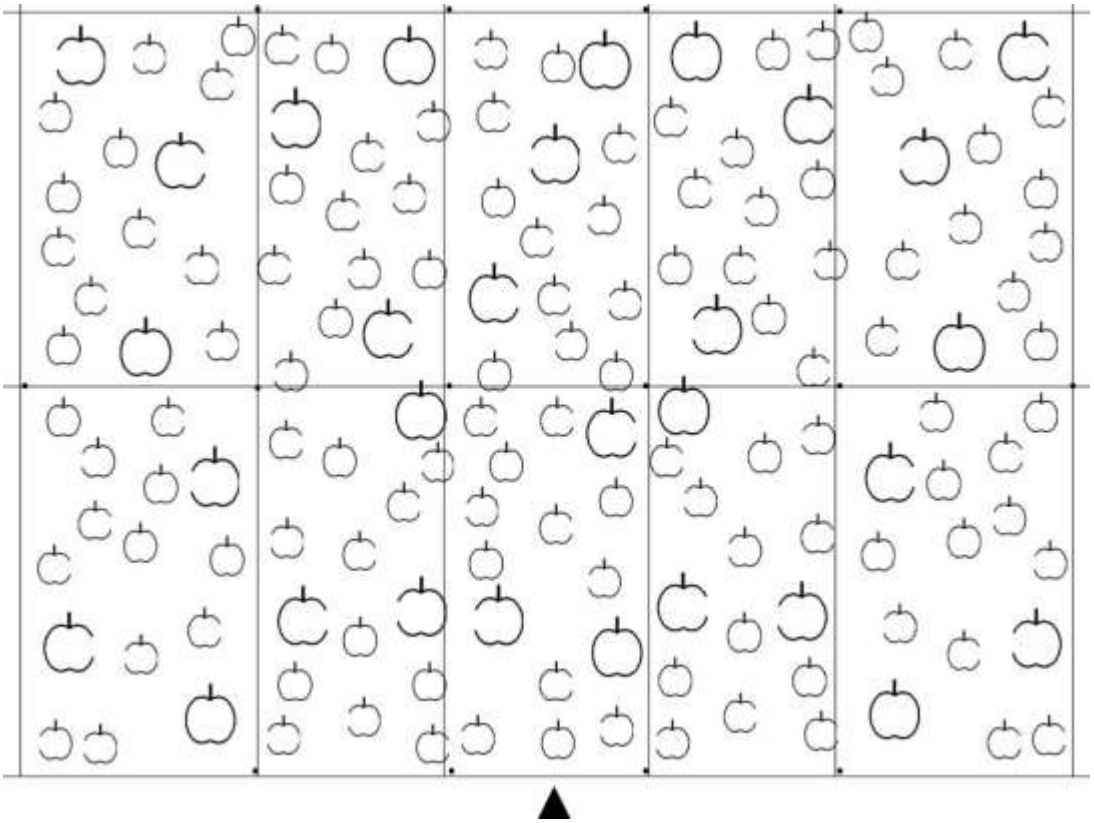

Figure 13 : Apple cancellation sheet

BERG BALANCE TESTS AND RATING SCALE

Patient Name _____
Date _____
Location _____
Rater _____

ITEM DESCRIPTION SCORE (0-4) Sitting to standing_____Standing unsupported_____Sitting unsupported_____Standing to sitting_____Transfers_____Standing with eyes closed _____ Standing with feet together_____Reaching forward with outstretched arm_____Retrieving object from floor_____Turning to look behind_____Turning 360 degrees_____Placing alternate foot on stool_____Standing with one foot in front_____Standing on one foot_____TOTAL _____

GENERAL INSTRUCTIONS
Please demonstrate each task and/or give instructions as written. When scoring, please record the lowest response category that applies for each item.

In most items, the subject is asked to maintain a given position for a specific time. Progressively more points are deducted if the time or distance requirements are not met, if the subject's performance warrants supervision, or if the subject touches an external support or receives assistance from the examiner. Subjects should understand that they must maintain their balance while attempting the tasks. The choices of which leg to stand on or how far to reach are left to the subject. Poor judgment will adversely influence the performance and the scoring.

Equipment required for testing are a stopwatch or watch with a second hand, and a ruler or other indicator of 2, 5 and 10 inches (5, 12 and 25 cm). Chairs used during testing should be of reasonable height. Either a step or a stool (of average step height) may be used for item #12.

1. SITTING TO STANDING
INSTRUCTIONS: Please stand up. Try not to use your hands for support.
( ) 4 able to stand without using hands and stabilize independently
( ) 3 able to stand independently using hands
( ) 2 able to stand using hands after several tries
( ) 1 needs minimal aid to stand or to stabilize
( ) 0 needs moderate or maximal assist to stand

2. STANDING UNSUPPORTED
INSTRUCTIONS: Please stand for two minutes without holding.
( ) 4 able to stand safely 2 minutes
( ) 3 able to stand 2 minutes with supervision
( ) 2 able to stand 30 seconds unsupported
( ) 1 needs several tries to stand 30 seconds unsupported
( ) 0 unable to stand 30 seconds unassisted

If a subject is able to stand 2 minutes unsupported, score full points for sitting unsupported. Proceed to item #4.

3. SITTING WITH BACK UNSUPPORTED BUT FEET SUPPORTED ON FLOOR OR ON A STOOL

INSTRUCTIONS: Please sit with arms folded for 2 minutes.
( ) 4 able to sit safely and securely 2 minutes
( ) 3 able to sit 2 minutes under supervision
( ) 2 able to sit 30 seconds
( ) 1 able to sit 10 seconds
( ) 0 unable to sit without support 10 seconds

4. STANDING TO SITTING

INSTRUCTIONS: Please sit down.
( ) 4 sits safely with minimal use of hands
( ) 3 controls descent by using hands
( ) 2 uses back of legs against chair to control descent
( ) 1 sits independently but has uncontrolled descent
( ) 0 needs assistance to sit

5. TRANSFERS

INSTRUCTIONS: Arrange chairs(s) for a pivot transfer. Ask subject to transfer one way toward a seat with armrests and one way toward a seat without armrests. You may use two chairs (one with and one without armrests) or a bed and a chair.
( ) 4 able to transfer safely with minor use of hands
( ) 3 able to transfer safely definite need of hands
( ) 2 able to transfer with verbal cueing and/or supervision
( ) 1 needs one person to assist
( ) 0 needs two people to assist or supervise to be safe

6. STANDING UNSUPPORTED WITH EYES CLOSED

INSTRUCTIONS: Please close your eyes and stand still for 10 seconds.
( ) 4 able to stand 10 seconds safely
( ) 3 able to stand 10 seconds with supervision
( ) 2 able to stand 3 seconds
( ) 1 unable to keep eyes closed 3 seconds but stays steady
( ) 0 needs help to keep from falling

7. STANDING UNSUPPORTED WITH FEET TOGETHER

INSTRUCTIONS: Place your feet together and stand without holding.
( ) 4 able to place feet together independently and stand 1 minute safely
( ) 3 able to place feet together independently and stand for 1 minute with supervision
( ) 2 able to place feet together independently but unable to hold for 30 seconds
( ) 1 needs help to attain position but able to stand 15 seconds with feet together
( ) 0 needs help to attain position and unable to hold for 15 seconds

8. REACHING FORWARD WITH OUTSTRETCHED ARM WHILE STANDING

INSTRUCTIONS: Lift arm to 90 degrees. Stretch out your fingers and reach forward as far as you can. (Examiner places a ruler at end of fingertips when arm is at 90 degrees. Fingers should not touch the ruler while reaching forward. The recorded measure is the distance forward that the finger reaches while the subject is in the most forward lean position. When possible, ask subject to use both arms when reaching to avoid rotation of the trunk.)

( ) 4 can reach forward confidently >25 cm (10 inches)
( ) 3 can reach forward >12 cm safely (5 inches)
( ) 2 can reach forward >5 cm safely (2 inches)
( ) 1 reaches forward but needs supervision
( ) 0 loses balance while trying/requires external support

9. PICK UP OBJECT FROM THE FLOOR FROM A STANDING POSITION

INSTRUCTIONS: Pick up the shoe/slipper which is placed in front of your feet.

( ) 4 able to pick up slipper safely and easily
( ) 3 able to pick up slipper but needs supervision
( ) 2 unable to pick up but reaches 2-5cm (1-2 inches) from slipper and keeps balance independently
( ) 1 unable to pick up and needs supervision while trying
( ) 0 unable to try/needs assist to keep from losing balance or falling

10. TURNING TO LOOK BEHIND OVER LEFT AND RIGHT SHOULDERS WHILE STANDING

INSTRUCTIONS: Turn to look directly behind you over toward left shoulder. Repeat to the right. Examiner may pick an object to look at directly behind the subject to encourage a better twist turn.

( ) 4 looks behind from both sides and weight shifts well
( ) 3 looks behind one side only other side shows less weight shift
( ) 2 turns sideways only but maintains balance
( ) 1 needs supervision when turning
( ) 0 needs assist to keep from losing balance or falling

11. TURN 360 DEGREES

INSTRUCTIONS: Turn completely around in a full circle. Pause. Then turn a full circle in the other direction.

( ) 4 able to turn 360 degrees safely in 4 seconds or less
( ) 3 able to turn 360 degrees safely one side only in 4 seconds or less
( ) 2 able to turn 360 degrees safely but slowly
( ) 1 needs close supervision or verbal cueing
( ) 0 needs assistance while turning

12. PLACING ALTERNATE FOOT ON STEP OR STOOL WHILE STANDING UNSUPPORTED

INSTRUCTIONS: Place each foot alternately on the step/stool. Continue until each foot has touched the step/stool four times.

( ) 4 able to stand independently and safely and complete 8 steps in 20 seconds
( ) 3 able to stand independently and complete 8 steps in >20 seconds
( ) 2 able to complete 4 steps without aid with supervision
( ) 1 able to complete >2 steps needs minimal assist
( ) 0 needs assistance to keep from falling/unable to try

13. STANDING UNSUPPORTED ONE FOOT IN FRONT

INSTRUCTIONS: (DEMONSTRATE TO SUBJECT) Place one foot directly in front of the other. If you feel that you cannot place your foot directly in front, try to step far enough ahead that the heel of your forward foot is ahead of the toes of the other foot. (To score 3 points, the length of the step should exceed the length of the other foot and the width of the stance should approximate the subject's normal stride width)

( ) 4 able to place foot tandem independently and hold 30 seconds

( ) 3 able to place foot ahead of other independently and hold 30 seconds ( ) 2

able to take small step independently and hold 30 seconds

( ) 1 needs help to step but can hold 15 seconds( ) 0

loses balance while stepping or standing

14. STANDING ON ONE LEG

INSTRUCTIONS: Stand on one leg as long as you can without holding. ( ) 4

able to lift leg independently and hold >10 seconds

( ) 3 able to lift leg independently and hold 5-10 seconds

( ) 2 able to lift leg independently and hold = or >3 seconds

( ) 1 tries to lift leg unable to hold 3 seconds but remains standing independently ( ) 0

unable to try or needs assist to prevent fall

TOTAL SCORE (Maximum = 56: _____

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FUGL-MEYER ASSESSMENT **ID:**

UPPER EXTREMITY (FMA-UE)

Assessment of sensorimotor function **Examiner**:

Fugl-Meyer AR, Jaasko L, Leyman I, Olsson S, Steglind S: The post-stroke hemiplegic patient. A method for evaluation of physical performance. Scand J Rehabil Med 1975, 7:13-31.

A. UPPER EXTREMITY, sitting position					
I. Reflex activity			**none**	**can be elicited**	
Flexors: biceps and finger flexors (at least one) **Extensors**: triceps			0 0	2 2	
		Subtotal I (max 4)			
II. Volitional movement within synergies, without gravitational help			**none**	**partial**	**full**
Flexor synergy: Hand from contralateral knee to ipsilateral ear. From extensor synergy (shoulder adduction/ internal rotation, elbow extension, forearm pronation) to flexor synergy (shoulder abduction/ external rotation, elbow flexion, forearm supination). **Extensor synergy:** Hand from ipsilateral ear to the contralateral knee	Shoulder Elbow Forearm	retraction elevation abduction (90°) external rotation flexion supination	0 0 0 0 0 0	1 1 1 1 1 1	2 2 2 2 2 2
	Shoulder Elbow Forearm	adduction/internal rotation extension pronation	0 0 0	1 1 1	2 2 2
		Subtotal II (max 18)			
III. Volitional movement mixing synergies, without compensation			**none**	**partial**	**full**
Hand to lumbar spine hand on lap		cannot perform or hand in front of ant-sup iliac spine hand behind ant-sup iliac spine (without compensation) hand to lumbar spine (without compensation)	0	1	2
Shoulder flexion 0°- 90° elbow at 0° pronation-supination 0°		immediate abduction or elbow flexion abduction or elbow flexion during movement flexion 90°, no shoulder abduction or elbow flexion	0	1	2
Pronation-supination elbow at 90° shoulder at 0°		no pronation/supination, starting position impossible limited pronation/supination, maintains starting position full pronation/supination, maintains starting position	0	1	2
		Subtotal III (max 6)			
IV. Volitional movement with little or no synergy			**none**	**partial**	**full**
Shoulder abduction 0 - 90° elbow at 0° forearm neutral		immediate supination or elbow flexion supination or elbow flexion during movement abduction 90°, maintains extension and pronation	0	1	2
Shoulder flexion 90° - 180° elbow at 0° pronation-supination 0°		immediate abduction or elbow flexion abduction or elbow flexion during movement flexion 180°, no shoulder abduction or elbow flexion	0	1	2
Pronation/supination elbow at 0° shoulder at 30°- 90° flexion		no pronation/supination, starting position impossible limited pronation/supination, maintains start position full pronation/supination, maintains starting position	0	1	2
		Subtotal IV (max 6)			
V. Normal reflex activity assessed only if full score of 6 points is achieved in part IV; compare with the unaffected side			**hyper**	**lively**	**normal**
Biceps, triceps, finger flexors		2 of 3 reflexes markedly hyperactive 1 reflex markedly hyperactive or at least 2 reflexes lively maximum of 1 reflex lively, none hyperactive	0	1	2
		Subtotal V (max 2)			
		Total A (max 36)			

B. WRIST support may be provided at the elbow to take or hold the starting position, no support at wrist, check the passive range of motion prior testing		**none**	**partial**	**full**
Stability at 15° dorsiflexion elbow at 90°, forearm pronatedshoulder at 0°	less than 15° active dorsiflexion dorsiflexion 15°, no resistance tolerated maintains dorsiflexion against resistance	0	1	2
Repeated dorsifexion / volar flexion elbow at 90°, forearm pronated shoulder at 0°, slight finger flexion	cannot perform volitionally limited active range of motion full active range of motion, smoothly	0	1	2
Stability at 15° dorsiflexion elbow at 0°, forearm pronated slight shoulder flexion/abduction	less than 15° active dorsiflexion dorsiflexion 15°, no resistance tolerated maintains dorsiflexion against resistance	0	1	2
Repeated dorsifexion / volar flexion elbow at 0°, forearm pronated slight shoulder flexion/abduction	cannot perform volitionally limited active range of motion full active range of motion, smoothly	0	1	2
Circumduction elbow at 90°, forearm pronated shoulder at 0°	cannot perform volitionally jerky movement or incomplete complete and smooth circumduction	0	1	2
	Total B (max 10)			

C. HAND support may be provided at the elbow to keep 90° flexion, no support atthe wrist, compare with unaffected hand, the objects are interposed, active grasp		**none**	**partial**	**full**
Mass flexion from full active or passive extension		0	1	2
Mass extension from full active or passive flexion		0	1	2
GRASP				
a. Hook grasp flexion in PIP and DIP (digits II-V), extension in MCP II-V	cannot be performed can hold position but weak maintains position against resistance	0	1	2
b. Thumb adduction 1-st CMC, MCP, IP at 0°, scrap of paper between thumb and 2-nd MCP joint	cannot be performed can hold paper but not against tug can hold paper against a tug	0	1	2
c. Pincer grasp, opposition pulpa of the thumb against the pulpa of2-nd finger, pencil, tug upward	cannot be performed can hold pencil but not against tugcan hold pencil against a tug	0	1	2
d. Cylinder grasp cylinder shaped object (small can) tug upward, opposition of thumb and fingers	cannot be performed can hold cylinder but not against tug can hold cylinder against a tug	0	1	2
e. Spherical grasp fingers in abduction/flexion, thumb opposed, tennis ball, tug away	cannot be performed can hold ball but not against tug can hold ball against a tug	0	1	2
	Total C (max 14)			

D. COORDINATION/SPEED, sitting, after one trial with both arms, eyes closed, tip of the index finger from knee to nose, 5 times as fast as possible		**marked**	**slight**	**none**
Tremor		0	1	2
Dysmetria	pronounced or unsystematic slight and systematic no dysmetria	0	1	2
		≥ 6s	**2 - 5s**	**< 2s**
Time start and end with the hand on the knee	6 or more seconds slower than unaffected side 2-5 seconds slower than unaffected side less than 2 seconds difference	0	1	2
	Total D (max 6)			

TOTAL A-D (max 66)	

H. SENSATION, upper extremity eyes closed, compared with the unaffected side		**anesthesia**	**hypoesthesia ordysesthesia**	**normal**
Light touch	upper arm, forearm palmary surface of the hand	0 0	1 1	2 2
		less than 3/4correct or absence	**3/4 correct or considerable difference**	**correct 100%, little or no difference**
Position small alterations in the position	shouder elbow wrist thumb (IP-joint)	0 0 0 0	1 1 1 1	2 2 2 2
			Total H (max12)	

I. PASSIVE JOINT MOTION, upper extremity,sitting position, compare with the unaffected side				**J. JOINT PAIN** during passive motion, upper extremity		
	only few degrees (less than 10° inshoulder)	decreased	normal	pronounced pain during movement or very markedpain at the end of the movement	some pain	no pain
Shoulder						
Flexion (0° - 180°)	0	1	2	0	1	2
Abduction (0°-90°)	0	1	2	0	1	2
External rotation	0	1	2	0	1	2
Internal rotation	0	1	2	0	1	2
Elbow						
Flexion	0	1	2	0	1	2
Extension	0	1	2	0	1	2
Forearm						
Pronation	0	1	2	0	1	2
Supination	0	1	2	0	1	2
Wrist						
Flexion	0	1	2	0	1	2
Extension	0	1	2	0	1	2
Fingers						
Flexion	0	1	2	0	1	2
Extension	0	1	2	0	1	2
Total (max 24)				**Total** (max 24)		

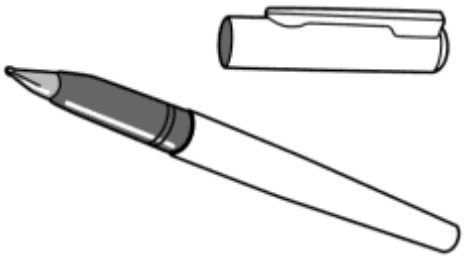
A. UPPER EXTREMITY	/36
B. WRIST	/10
C. HAND	/14
D. COORDINATION / SPEED	/ 6
TOTAL A-D (motor function)	/66

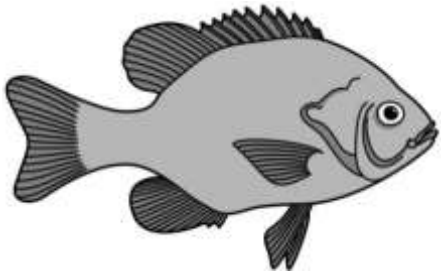
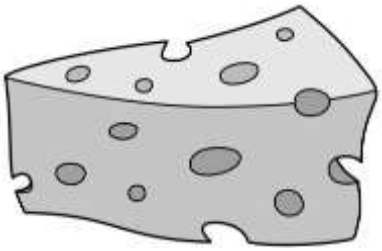
H. SENSATION	/12
I. PASSIVE JOINT MOTION	/24
J. JOINT PAIN	/24

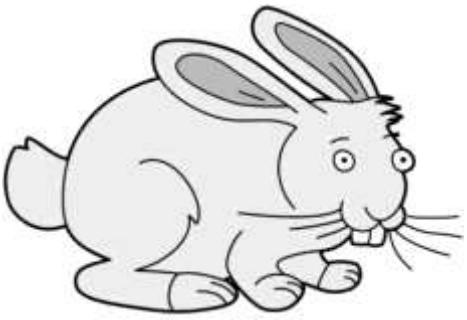
Language Screening Test
LAST-a

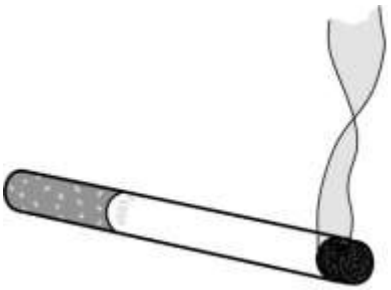
date : ___/___/_____

Expression index		SCORE	
Naming	Phone	/1	
	Pineapple	/1	
	Pen	/1	
	Crocodile	/1	
	Fork	/1	
	Naming Score		***/5***
Repetition	Mathematics	/1	
	The postman brings a letter to my neighbour	/1	
	Repetition Score		***/2***
Automatic Speech	Count from 1 to 10	/1	
	Automatic speech Score		***/1***
Expression index Score			**/8**

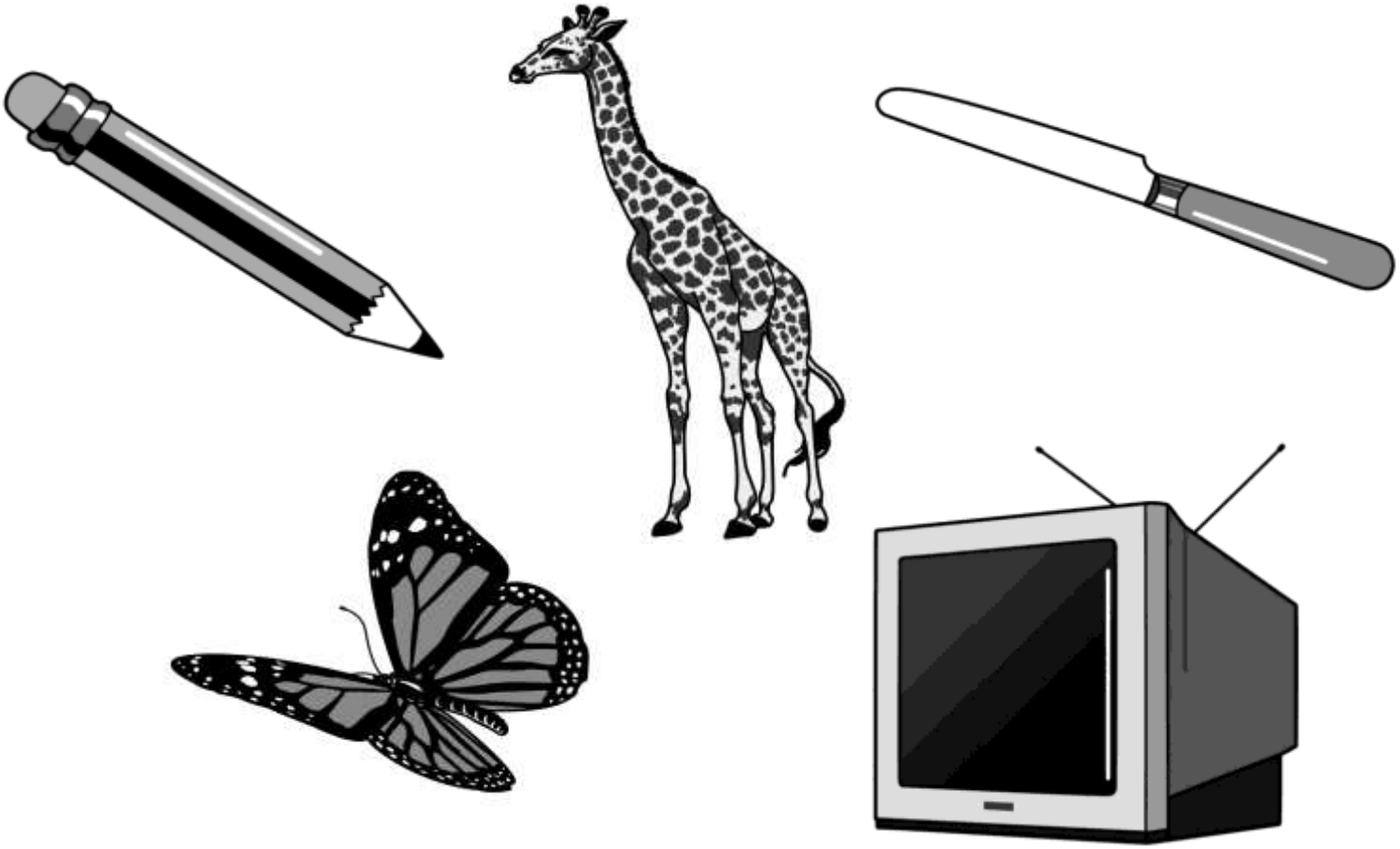





Receptive index		Score	
Picture recognition	Rabbit	/1	
	Spoon	/1	
	Cigarette	/1	
	Eye	/1	
	Picture recognition score		/4
Verbal instructions	« Point at the ceiling »	/1	
	« Don't take the drinking-glass but the pen »	/1	
	« Put a hand on your head, then a finger on your nose »	/1	
	Verbal instruction score		***/2***
Receptive index score			***/7***
LAST TOTAL SCORE		**/15**	

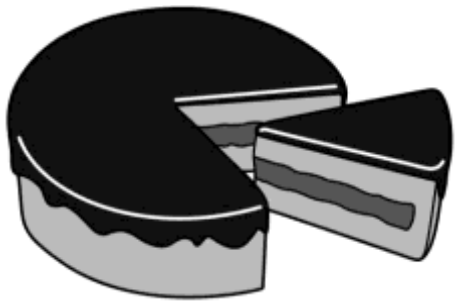


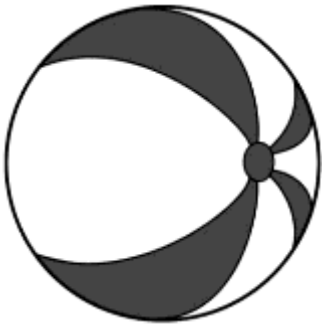
Language Screening Test
LAST-b

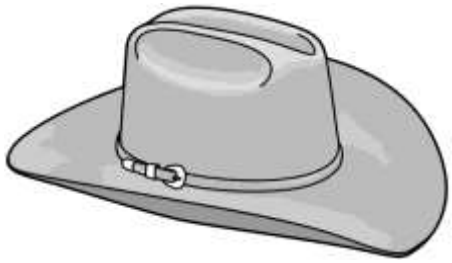
Date : ___/___/_____

Expression index		SCORE	
Naming	Pencil	/1	
	Television	/1	
	Giraffe	/1	
	Knife	/1	
	Butterfly	/1	
	Naming Score		***/5***
Repetition	Literature	/1	
	Vacationers would like strawberry ice-cream	/1	
	Repetition Score		***/2***
Automatic Speech	Count from 1 to 10	/1	
	Automatic speech Score		***/1***
Expression index Score			**/8**

Receptive index		Score	
Picture recognition	Hat	/1	
	Hand	/1	
	Car	/1	
	Tomato	/1	
	Picture recognition score		/4
Verbal instructions	« Point at the floor »	/1	
	« Don't take the leaf but the key »	/1	
	« Touch one of your ears with one finger, then your forehead with two fingers »	/1	
	Verbal instruction score		***/2***
Receptive index score			***/7***
LAST TOTAL SCORE		**/15**	







NOM : GUILLOUZOUIC LE CORFF PRENOM : Lola

Titre de Thèse : THE INFLUENCE OF CRANIOPLASTYON THE IMPROVEMENT OF FUNCTIONAL IMPAIRMENTS : TRAUMATIC BRAIN INJURY VERSUS VASCULAR CAUSES

RESUME (10 lignes)

Cet article a pour objet la cranioplastie, acte chirurgical qui survient après une craniectomie décompressive afin de protéger l'encéphale et restituer le forme du scalp. La littérature scientifique, ainsi que notre approche empirique du sujet laisse à penser que la repose du volet a des conséquences positives sur le fonctionnement cérébral et influent sur le pronostic neurologique des patients craniectomisés. Notre hypothèse est que l'effet de la cranioplastie est essentiellement présent dans les étiologies traumatiques. Afin de la démontrer, nous avons mené une étude prospective, sur 9 patients, et rétrospective, sur 22 patients, chacune subdivisée entre les étiologies traumatiques et vasculaires. Le critère principal d'évaluation, une échelle fonctionnelle la MIF, a montré une évolution positive en post-opératoire chez tous les patients, et significativement supérieur chez les traumatisés craniens. Toutefois l'ajout des données rétrospectives vient infirmer cette tendance pour ces derniers. D'autre part les données des critères secondaires ne viennent pas appuyer le résultat positif du critère principal de façon significative, malgré le fait qu'elles soient positives.

MOTS-CLES

CRANIOPLASTIE, CRANIECTOMIE, TRAUMATISES CRANIENS, ACCIDENT VASCULAIRE, MIF