Stereotactic Brain Biopsy

frame-based versus frameless neuronavigation-assisted technique

AZIENDA OSPEDALIERO UNIVERSITARIA PISANA

Firenze 07/04/2018

Dr Andrea Peluso

Introduction

Growing understanding of biological and biomolecular characteristics of brain lesions confirms the necessity of the most complete histopathological diagnostic data

At the same time modern neurosurgical practice promotes reduction of invasiveness and patient's discomfort

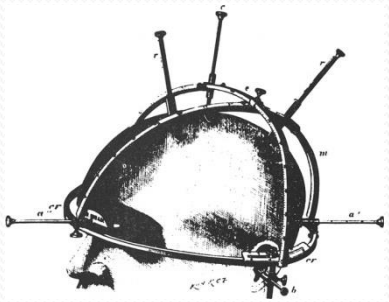
Despite diffusion of high magnetic fields and complex imaging diagnostic, brain biopsy has still a role for unresectable brain lesions

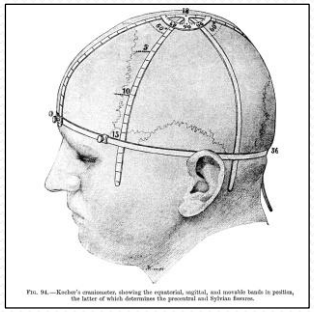
Progressive implementation of neuronavigation technologies allowed diffusion of frameless bioptic techniques

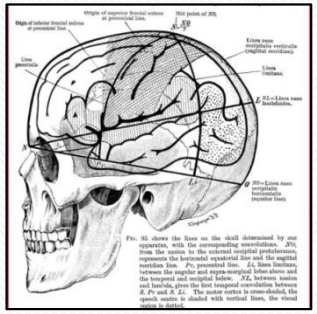
As the last evolution of brain biopsy, a better understanding of their potentials and limits is needed, compared to standardized stereotactic procedures

Historical Background

Zernov 1889: encephalometer

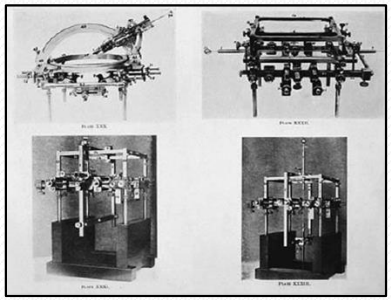


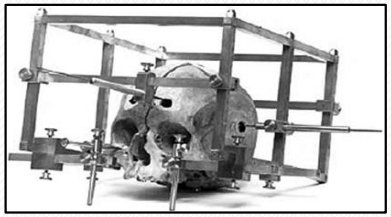


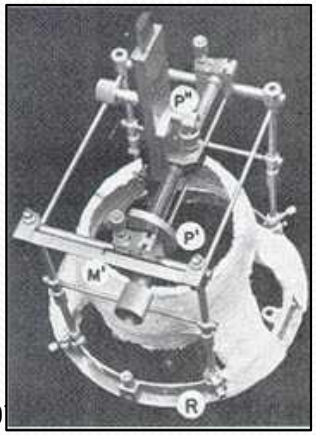


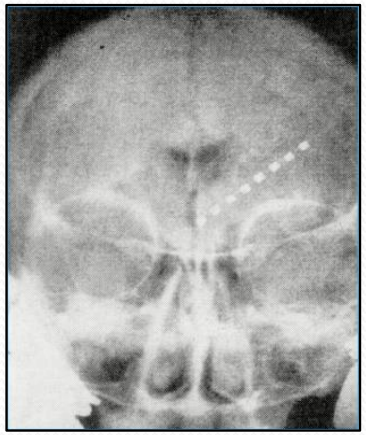
Craniometric school 1890 – 1910
Broca, Wilson, Kroenline, Kholer, Kocher

Horsley and Clarke 1908: stereotaxis





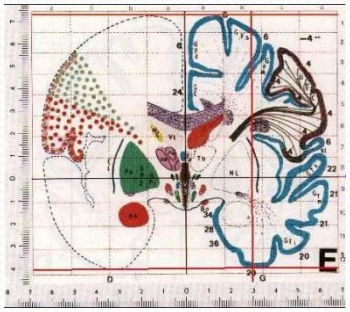




Spiegel and Wycis 1947: individual reference points

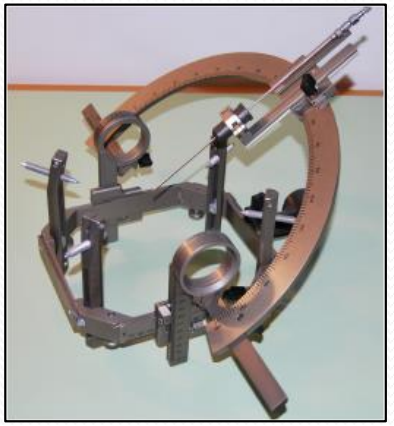
Historical Background

Talairach 1949: AC-PC, Stereotactic atlas



1949 Leksell: arc-radius system, stereotactic arc

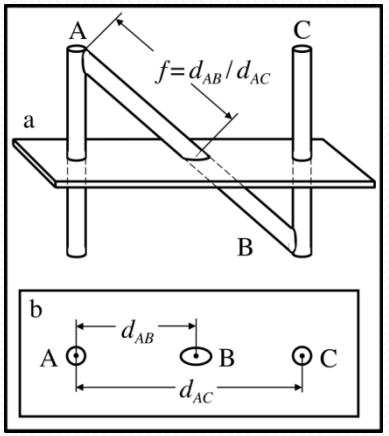
Radiosurgery



1950 – 1960 Riechert-Wolff, Narabayashi, Todd-Wells

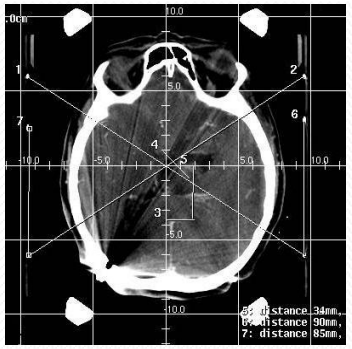
‘70 Computerized Tomography: direct target identification on tomographic images
New applications

1978 Brown: N-localizer and Cosman-Roberts-Wells

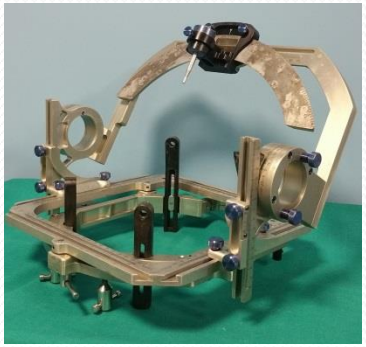


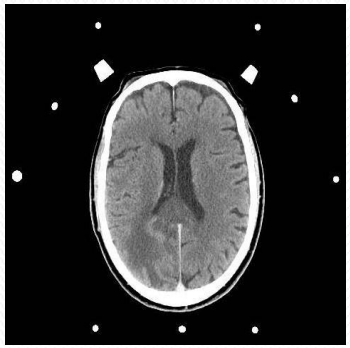
Stereotactic devices

Leksell stereotactic frame



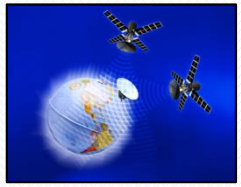
Cosman-Roberts-Wells stereotactic frame



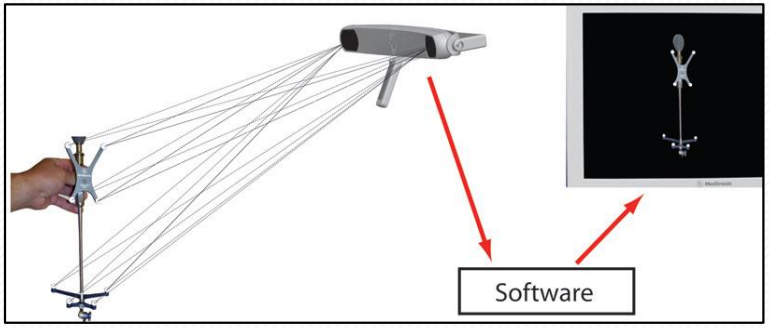


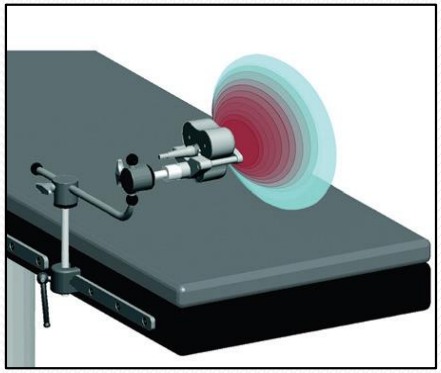
Neuronavigation

- **Merging of radiologic virtual space and patient's anatomical physical space**
- **Tracing of navigable instruments, their position and orientation**
- **Continuous updating of instruments position in the anatomical space**



Infrared optic system





Electromagnetic system

Role of cerebral biopsy

Reliability of brain biopsy

- Diagnostic yield 88,8 – 100%
- Diagnostic accuracy 57 – 89%

High Grade Gliomas

Assessment of biomolecular characteristics for definition of prognosis in unresectable lesions

Low Grade Gliomas

Increasingly limited role: contraindications or unresectability

Risk of downgrading and undertreatment

Targeting supporting techniques (PET, spectroscopy, perfusion study)

Other cerebral lesions

Limited role for brain metastasis

Diagnostic definition in cerebral lymphoma

Clinical study

Since 2014 introduction of neuronavigation-assisted technique at our department

Frameless neuronavigation techniques advantages

- Unnecessary centering CTscan
- Reduced discomfort due to stereotactic frame
- No rigid head fixation with EM procedure
- Easier anesthesiologic management

Aim of the study:

- Assessment of reliability of the procedure in terms of diagnostic yield and safeness compared to standard stereotactic procedures
- Identification of possible limits and advantages
- Comparison with literature data

Materials and methods

141 bioptic procedures, July 2011 – May 2017

Presumed oncologic lesions indefinable by clinical and radiological data

Indications:

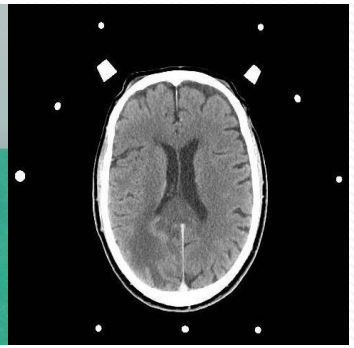
- Deep cerebral lesions
- Direct functional areas involvement
- Multiple lesions
- Major comorbidities
- Patient's refusal to resective surgery

Neuroradiologic evaluation and assisted targeting

Materials and methods

Conventional stereotactic procedure

Leksell/Cosman-Roberts-Wells frame



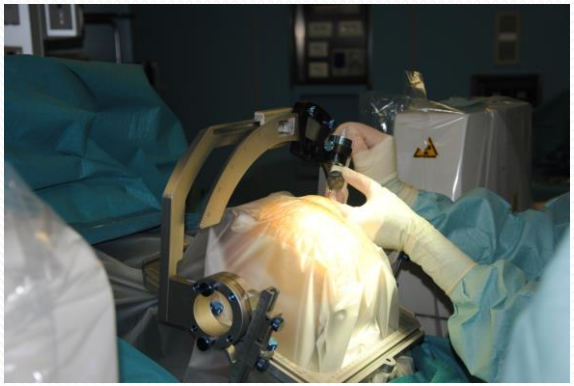
mounting: **Probe Carrier Anterior or Posterior (Trunion Rings are in the left-to-right position)**

A-P	Lateral	Vertical	Ring Angle	Arc Angle
-15.0 mm	**-9.7 mm**	**-21.1 mm**	**61.2 A °**	**14.9 L °**

Frame positioning

Centering CT scan

Coordinates determination



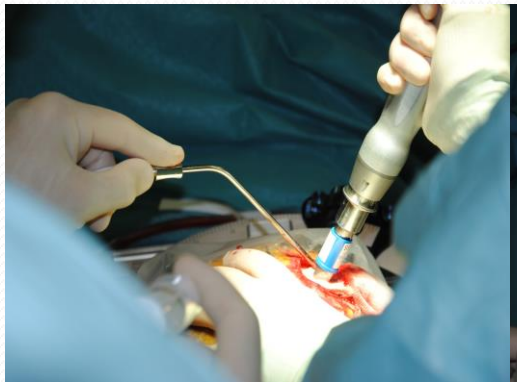
Semisitting position

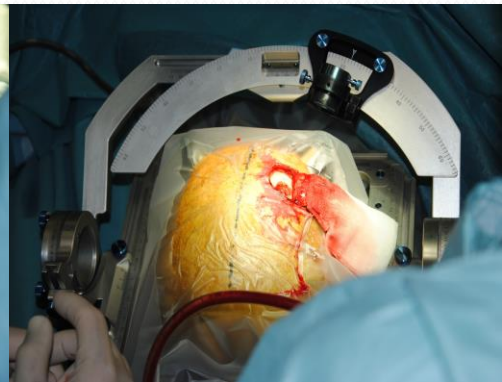
Set up of stereotactic arc

Burr-hole, durotomy

Insertion of biopsy needle and sampling

Closure procedure and frame removal

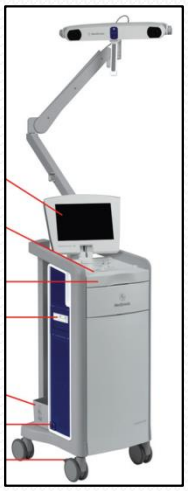


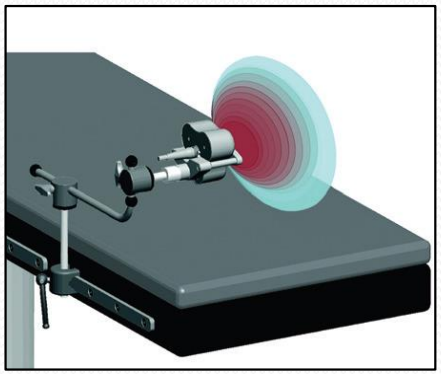


Materials and methods

Navigation-assisted technique

StealthStation AxiEM Medtronic





EM stylet

J Neurosurg Pediatrics 2:430–434, 2008

The use of noninvasive electromagnetic neuronavigation for slit ventricle syndrome and complex hydrocephalus in a pediatric population

Clinical article

Simon Clark, Ph.D.,[1,2] Meharpal Sangra, M.R.C.S.,[1] Caroline Hayhurst, M.R.C.S.,[2] Jothi Kandasamy, M.R.C.S.,[2] Michael Jenkinson, Ph.D.,[2] Maggie Lee, M.R.C.S.,[2] and Conor Mallucci, F.R.C.S.(SN)[1,2]

OPERATIVE TECHNIQUES

Syed S. Azeem, M.D.
Department of Neurological Surgery, Loyola University Medical Center, Maywood, Illinois

T. C. Origitano, M.D., Ph.D.
Department of Neurological Surgery, Loyola University Medical Center, Maywood, Illinois

Ventricular Catheter Placement with a Frameless Neuronavigational System: A 1-year Experience

JNS

TECHNICAL NOTE

Neuronavigated percutaneous approach to the sphenopalatine ganglion

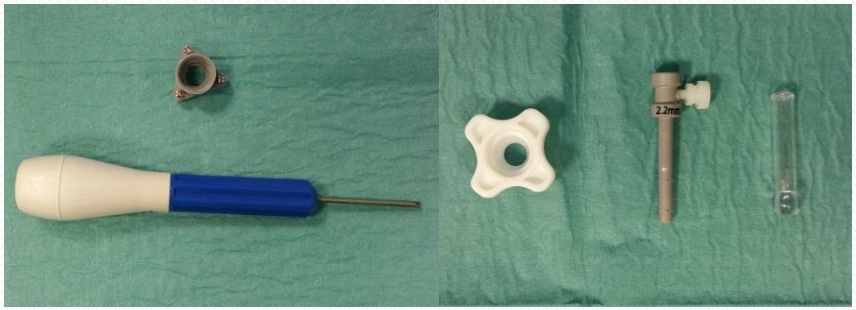
Nicola Benedetto, MD, PhD, and Paolo Perrini, MD, PhD

Neurosurgical Department, Azienda Ospedaliero Universitaria Pisana-AOUP, Pisa, Italy

Materials and methods

Navigation-assisted technique

Trajectory Guide Kit

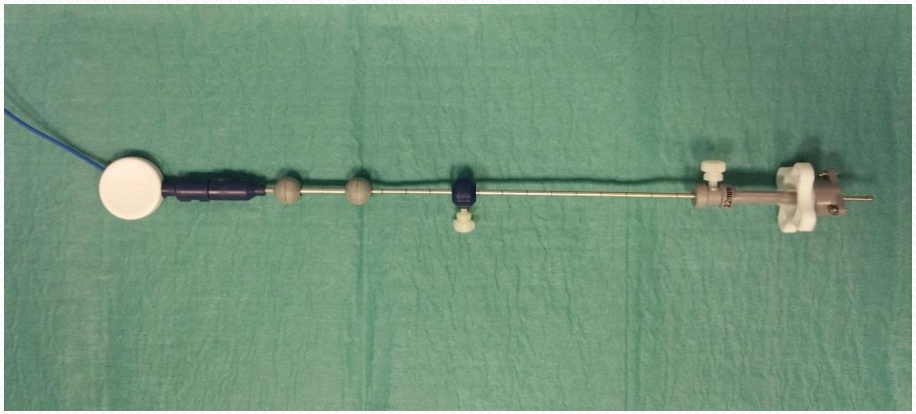


TUMOR *Instrumentation Assessment*

Stuart E. Harrisson, MRCS
David Shooman, MRCS
Paul L. Grundy, MD, FRCS

Department of Neurosurgery, Wessex Neurological Centre, Southampton University Hospitals Trust, Southampton, United Kingdom

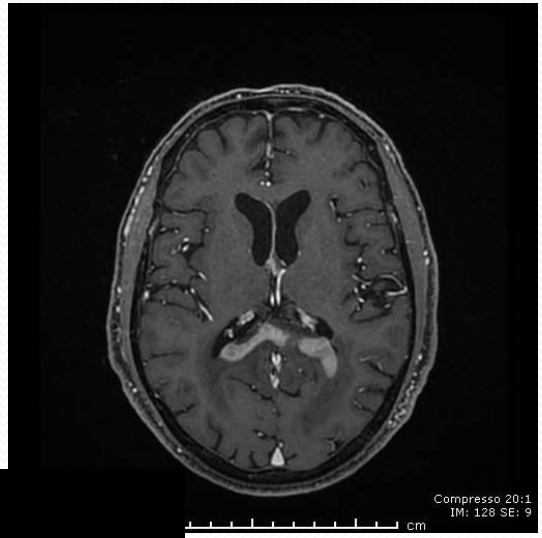
A Prospective Study of the Safety and Efficacy of Frameless, Pinless Electromagnetic Image-Guided Biopsy of Cerebral Lesions

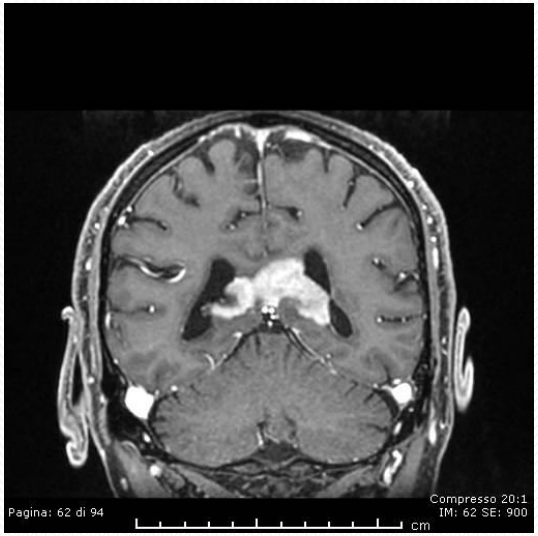


Materials and methods

Clinical case

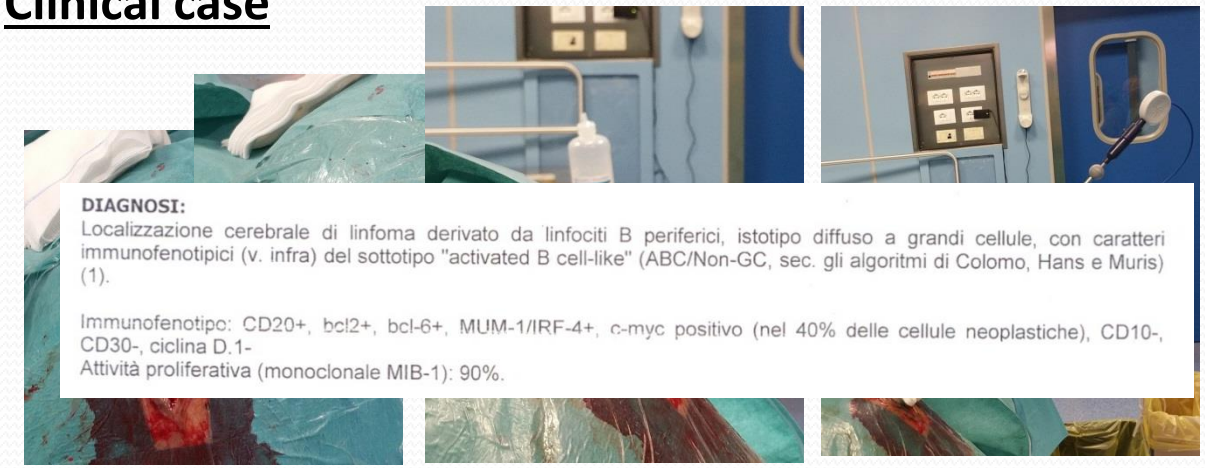
MM, male, 72yo
Confusion and right visual field deficit





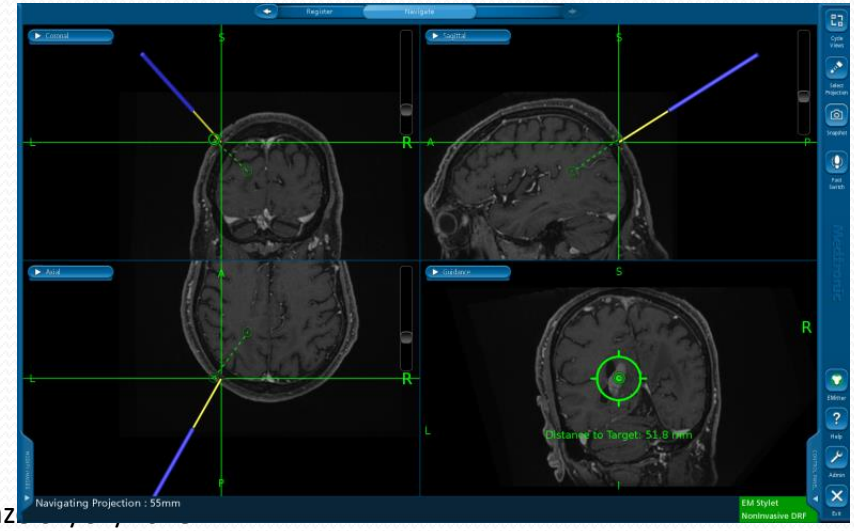
Materials and methods

Clinical case



DIAGNOSI:
Localizzazione cerebrale di linfoma derivato da linfociti B periferici, istotipo diffuso a grandi cellule, con caratteri immunofenotipici (v. infra) del sottotipo "activated B cell-like" (ABC/Non-GC, sec. gli algoritmi di Colomo, Hans e Muris) (1).

Immunofenotipo: CD20+, bcl2+, bcl-6+, MUM-1/IRF-4+, c-myc positivo (nel 40% delle cellule neoplastiche), CD10-, CD30-, ciclina D.1-
Attività proliferativa (monoclonale MIB-1): 90%.



Firenz

Patients population

Demographic data

141 patients
Mean age 65 (24 – 84)
F:M=72:68
Two groups

- *Frame*
- *Frameless*

	Frameless		Frame		TOT	
	N° (%)	Age (mean/SD)	N° (%)	Age (mean/SD)	N° (%)	Age (mean/SD)
F	17 (53,1)	61,47/9,95	55 (50,5)	66,76/12,31	72 (51,1)	65,51/11,94
M	15 (46,9)	64,0/10,37	54 (49,5)	64,61/12,12	69 (48,9)	64,48/11,69
TOT	32 (100)	63,0/10,1	109 (100)	66,0/12,20	141 (100)	65,0/11,79

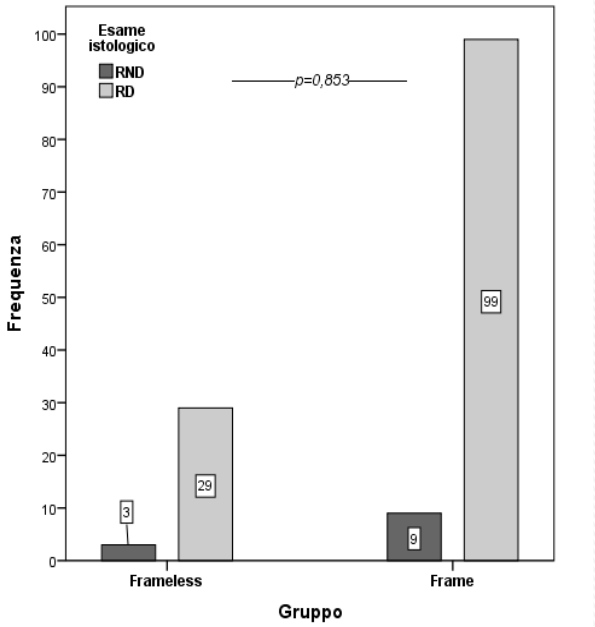
Lesions location

Location	**N° (%)**
Corpus callosum	45 (31,91)
Internal capsule/White matter	30 (21,28)
Diencephalum (Thalamus/Basal ganglia)	20 (14,18)
Multiple	17 (12,07)
Lobar/multilobar	16 (11,34)
Insula	13 (9,22)
TOT	141 (100)

Diagnostic Yield

Results

Histologic diagnosis	Frame (%)	Frameless (%)	TOT (%)
High Grade Glioma	52 (48,15)	20 (62,5)	72 (51,43)
Low Grade Glioma	27 (25)	0	27 (19,29)
Lymphoma	11 (10,18)	7 (21,87)	18 (12,86)
Metastasis	3 (2,78)	1 (3,13)	4 (2,86)
Progressive Multifocal Leukoencephalopathy	3 (2,78)	0	3 (2,14)
Infection	2 (1,85)	0	2 (1,43)
PNET	0	1 (3,13)	1 (0,71)
Granulomatous vasculitis	1 (0,93)	0	1 (0,71)
Non diagnostic	9 (8,33)	3 (9,37)	12 (8,57)
TOT	108 (100)	32 (100)	140 (100)



Non diagnostic

Necrotic material	**3**
Aspecific inflammatory infiltrate	**3**
Inadequate/Insufficient sampling	**6**

Frame	91,67%
Frameless	90,63%

Diagnostic Yield

Discussion

Range

Frame 83,4 – 95%

Frameless 88,8 – 100%

Study	Frame (%)	Frameless (%)
Dorward and coll.	95	100
McGirt/Woodworth and coll.	91	89
Smith e coll.	90	90
Dammers e coll.	89,6	88,8
Lobao e coll.	83,4	91,7
Nishihara e coll.	94,9	97,4
Lu e coll.	95,2	89,4
Harrisson e coll.	-	96,7

In a meta-analysis of 7471 biopsies Hall and coll. report a diagnostic yield of 91%

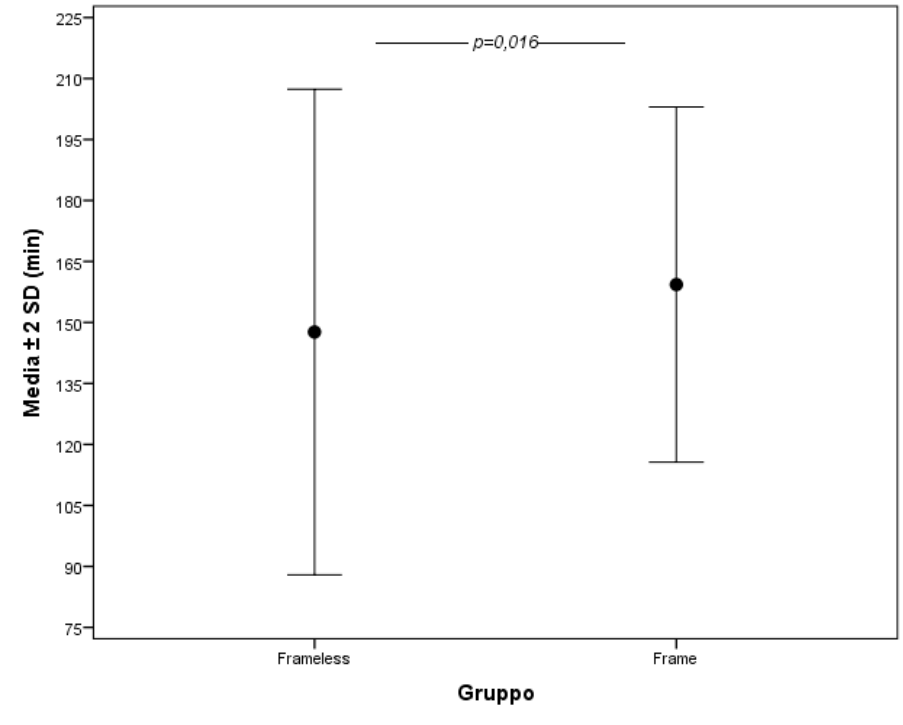
The absence of normal brain tissue samples lays in favor of limits in targeting rather than in the technique itself

Operating Room Times

Results

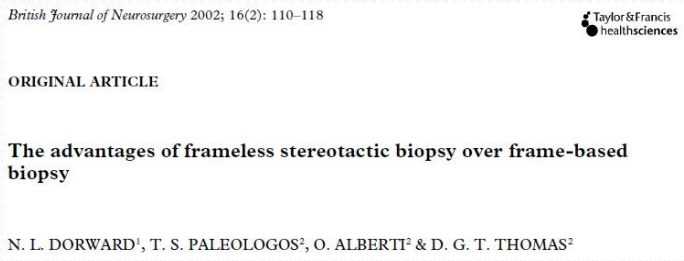
Additions to surgical time

Frame	Frame positioning and centering CT scan
Frameless	Anesthesiologic assistance and neuronavigation tracing



Operating Room Times

Discussion



British Journal of Neurosurgery 2002; 16(2): 110–118

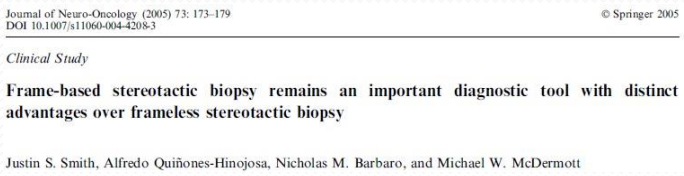
Taylor & Francis healthsciences

ORIGINAL ARTICLE

The advantages of frameless stereotactic biopsy over frame-based biopsy

N. L. DORWARD[1], T. S. PALEOLOGOS[2], O. ALBERTI[2] & D. G. T. THOMAS[2]

Dorward and coll. Frameless technique



Journal of Neuro-Oncology (2005) 73: 173–179
DOI 10.1007/s11060-004-4208-3

© Springer 2005

Clinical Study

Frame-based stereotactic biopsy remains an important diagnostic tool with distinct advantages over frameless stereotactic biopsy

Justin S. Smith, Alfredo Quiñones-Hinojosa, Nicholas M. Barbaro, and Michael W. McDermott

Smith and coll. Frame-based technique

Important reduction of patient's discomfort

Compatibility with various anesthesiologic regimens

Complications

Clinical/neurological complications

Transient disphasia
Postoperative seizure
Worsening of hemiparesis
Neurologic deterioration with rescue surgery

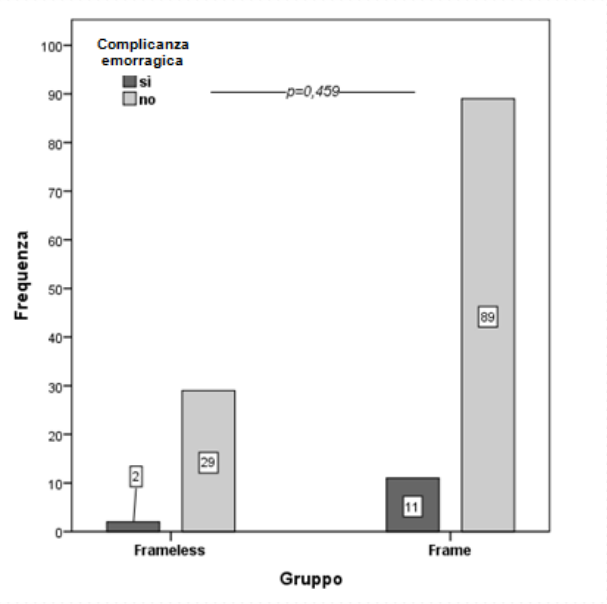
Hemorrhagic/radiological complications

Hemorrhage considered significant if >500mm^3 on postoperative CT scan

Intralesional
Intraparenchimal

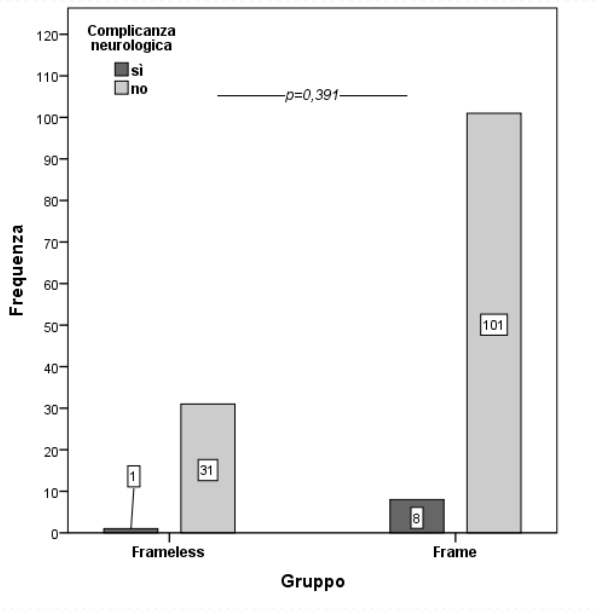
Morbidity and mortality

Results



Clinical/neurological

Frame	7,3%
Frameless	3,12%



Hemorrhagic/radiological

Frame	11%
Frameless	6,45%

Total morbidity		**Long time morbidity**		**Mortality**	
Frame	14,68%	Frame	3,67%	Frame	0,92%
Frameless	9,37%	Frameless	0%	Frameless	0%

Morbidity and mortality

Discussion

Variable definition of morbidity

Frame 4 – 20,6%

Frameless 1 – 19,6%

Long-time morbidity 5 – 5,3%

Study	Frame (%)	Frameless (%)
Dorward and coll.	8,8	6,6
McGirt/Woodworth and coll.	13	15
Smith e coll.	4	1
Dammers e coll.	12,4	11,6
Lobao e coll.	9,8	13,8
Lu e coll.	20,6	19,6
Harrisson e coll.	-	4,7

Study	Frame (%)	Frameless (%)
Dorward and coll.	1,6	1,6
McGirt/Woodworth and coll.	1	1
Smith e coll.	0	1
Dammers e coll.	4	3,7
Lobao e coll.	1,9	2,7
Nishihara e coll.	0	0
Harrisson e coll.	-	2,7

Range

Frame 0 – 4%

Frameless 0 – 3,7%

Conclusions

The frameless neuronavigation assisted brain biopsy is a reliable technique in terms of diagnostic yield and clinical-radiological outcome

Technological and methodological evolutions are improving diagnostic reliability

Our data are comparable with literature and confirm that this technique is not inferior to standardized frame-based stereotactic procedures

Furthermore it seems a more tolerable and time-saving procedure

Prospective randomized studies are needed to completely assess reliability, with particular reference to small deep lesions

Thank you for your attention

Servizio Sanitario della Toscana

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Firenze 07/04/2018

Dr Andrea Peluso