Introduction

- Posture: static relative position of different body parts with respect to each other

Ageing
Neurological
Visual
Vestibular
Orthopedic disorders

Postural instability
Introduction

Principle Sensory systems in Balance mechanism:

1. Somatosensory
2. Visual
3. Vestibular system
BALANCE

- Graviceptors
- Vision
- Vestibular organ
- Proprioception
- Gaze stabilization
- Orientation and navigation
- Balanced locomotion
- Autonomic function
- Circadian rhythm
- CNS
POSTUROGRAPHY

• Objective techniques used to quantify postural control in upright stance in individuals
• Most sensitive technology for balance evaluation*
• Functional measure
• Isolates functional contributions of sensory inputs

POSTUROGRAPHY

STATIC
Subjects maintain stance in a relatively unperturbed state (usually quiet stance on a fixed support surface).

DYNAMIC
Experimentally induced balance perturbations
COMPUTERISED STATIC POSTUROGRAPHY
Neurocom balance Master

NeuroCom®
Balance Manager® System

- Clinical Module
- Settings
- Data Analysis
- Instructions for Use

REMOVE WEIGHT FROM PLATFORM AND SELECT TARGET MODULE.

- System Init
- File Utilities
- Turn Off System
- Exit to Desktop

Balance Master (5.9)
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Static Posturography

- Modified Clinical Test of Sensory Interaction and Balance
- Limits of Stability
- Rythmic Weight Shift
Modified Clinical Test of Sensory Interaction and Balance

NeuroCom® Balance Manager® System

PATIENT INFORMATION

Last Name: Bhaduria
First Name: Ankit
ID: (Leave blank for auto-ID) ATID00040
MI: 
Height(cm): 170
Date of Birth: 12 6 2001

Referral Source: Not Specified
Diagnosis: Not Specified
Comments: 

Raw Data File Name: C:\BCenter\DATA\FD40.DRX

Press ESC key or click here to exit
Modified Clinical Test of Sensory Interaction and Balance

Modified CTSIB

Align medial malleolus to center horizontal line and lateral calcaneous to 'T' line.

Click on Start button to begin test.
mCTSI B test conditions

EO-Firm

EC-Firm

EO-Foam

EC-Foam
mCTSiB test
mCTSB - Results

Mean COG Sway Velocity

<table>
<thead>
<tr>
<th>Condition</th>
<th>deg/sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm-EO</td>
<td>0.3</td>
</tr>
<tr>
<td>Firm-EC</td>
<td>0.4</td>
</tr>
<tr>
<td>Foam-EO</td>
<td>0.6</td>
</tr>
<tr>
<td>Foam-EC</td>
<td>1.6</td>
</tr>
<tr>
<td>Comp</td>
<td>0.7</td>
</tr>
</tbody>
</table>

COG Alignment:
- Firm-EO
- Foam-EO
- Firm-EC
- Foam-EC

Left Back, 30% LOS @ 237.3 degree
mCTSI B - Results
Limits of Stability

Align medial malleolus to center horizontal line and lateral calcaneous to ‘T’ line.

Direction: Forward

Click on Start button to begin test.

Start | Next Test | Select Cursor | Assessment Menu | Main Menu

Keep Cursor in Center Target, Click on A Mouse Button to Score.
Limits of Stability
LOS - Results

Limits Of Stability

<table>
<thead>
<tr>
<th>Transition</th>
<th>RT (sec)</th>
<th>MVL (deg/sec)</th>
<th>EPE (%)</th>
<th>MXE (%)</th>
<th>DCL (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (F)</td>
<td>0.26</td>
<td>1.3</td>
<td>43</td>
<td>52</td>
<td>63</td>
</tr>
<tr>
<td>2 (RF)</td>
<td>1.19</td>
<td>2.9</td>
<td>62</td>
<td>79</td>
<td>86</td>
</tr>
<tr>
<td>3 (R)</td>
<td>1.04</td>
<td>3.5</td>
<td>49</td>
<td>84</td>
<td>65</td>
</tr>
<tr>
<td>4 (RB)</td>
<td>0.52</td>
<td>2.4</td>
<td>58</td>
<td>58</td>
<td>53</td>
</tr>
<tr>
<td>5 (B)</td>
<td>0.25</td>
<td>1.3</td>
<td>37</td>
<td>37</td>
<td>23</td>
</tr>
<tr>
<td>6 (LB)</td>
<td>0.72</td>
<td>2.3</td>
<td>62</td>
<td>83</td>
<td>57</td>
</tr>
<tr>
<td>7 (L)</td>
<td>0.54</td>
<td>2.8</td>
<td>53</td>
<td>82</td>
<td>87</td>
</tr>
<tr>
<td>8 (LF)</td>
<td>0.50</td>
<td>2.9</td>
<td>32</td>
<td>55</td>
<td>61</td>
</tr>
</tbody>
</table>

Reaction Time (RT) | Movement Velocity (MVL) | Endpoint & Max Excursions (EPE & MXE) | Directional Control (DCL)
Rhythmic Weight Shift

• Ability to move COG between 2 targets
Rhythmic Weight Shift
Rhythmic Weight Shift

**Left/Right**
- SLOW (3sec/3trans)
- MODERATE (2sec/3trans)
- FAST (1sec/3trans)

**Front/Back**
- SLOW (3sec/3trans)
- MODERATE (2sec/3trans)
- FAST (1sec/3trans)

**On-Axis Velocity**
- deg/sec
- Slow: 3, Mod: 4.8, Fast: 7.9, Comp: 5.2

**Directional Control (DCL)**
- %
- Slow: 80, Mod: 87, Fast: 84, Comp: 64

**On-Axis Velocity**
- deg/sec
- Slow: 2.4, Mod: 4.1, Fast: 7.8, Comp: 4.8

**Directional Control (DCL)**
- %
- Slow: 72, Mod: 49, Fast: 76, Comp: 66
Unilateral Stance
DYNAMIC POSTUROGRAPHY
DEFINITION: AAOHNS & AAN

- Isolation and quantification of orientation inputs from visual, vestibular and somatosensory systems.
- Isolation and quantification of central integrating mechanisms for selecting functionally appropriate orientation sense(s).
- Isolation and quantification of functionally appropriate movement strategy(s).
- Isolation and quantification of motor output mechanisms for generating timely and effective postural movements.
Dynamic Posturography

- Sensory Organisation Test
- Limits of Stability
- Adaptation Test
- Motor Co-ordination Test
Sensory Organization Test

- Objectively identifies the abnormalities in use of sensory systems
- Assessed in 6 test conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Vision</th>
<th>Surface</th>
<th>Visual surrounding</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Eyes open</td>
<td>Stable</td>
<td>Stable</td>
</tr>
<tr>
<td>2</td>
<td>Eyes closed</td>
<td>Stable</td>
<td>Stable</td>
</tr>
<tr>
<td>3</td>
<td>Eyes open</td>
<td>Stable</td>
<td>Sway Referenced</td>
</tr>
<tr>
<td>4</td>
<td>Eyes open</td>
<td>Sway Referenced</td>
<td>Stable</td>
</tr>
<tr>
<td>5</td>
<td>Eyes closed</td>
<td>Sway Referenced</td>
<td>Stable</td>
</tr>
<tr>
<td>6</td>
<td>Eyes open</td>
<td>Sway Referenced</td>
<td>Sway Referenced</td>
</tr>
</tbody>
</table>
Sensory Organization Test

Condition 1
Normal Vision
Fixed Support

Condition 2
Absent Vision
Fixed Support

Condition 3
Sway-Referenced Vision
Fixed Support

Condition 4
Normal Vision
Sway-Referenced Support

Condition 5
Absent Vision
Sway-Referenced Support

Condition 6
Sway-Referenced Vision
Sway-Referenced Support
SOT - Results

Individual trials isolate the effective use of each sensory system under each environmental condition.

Composite score identifies the presence of a balance control problem.

Summarizes the overall function of the three systems and the ability to resolve conflicting sensory inputs.

Is the patient appropriately aligned to midline?

Is the strategy selected appropriate for the amount of balance stability present?
Motor Control Test

• Assesses the ability of motor system to counter the small unexpected external disturbance.
Adaptation test

• Assesses patient’s ability to modify motor reactions and minimize sway when the support moves unpredictably in the Toes up/down direction.

• Simulates daily life conditions (uneven surface)

• Slow toes up/down rotations

• 8 deg/s
Applications

• Objective assessment of balance
• Preference of system used for balance
• Identification of neurological disorders
• Rehabilitation programme
• Non-organic Postural instability
• Monitoring recovery
• Documentation
• Specificity of over 90%*

DEPARTMENTAL STUDIES IN RELATION TO POSTUROGRAPHY
ASSESMNT OF BALANCE BY POSTUROGRAPHY – A
COMPARATIVE STUDY IN PRE AND POST OPERATIVE PATIENTS
UNDERGOING CANAL WALL UP AND CANAL WALL DOWN
MASTOIDECTOMY
Scheme of study

- Patient presents to ENT OPD
- Diagnosed as a case of COM squamous based on history and clinical examination
- Pre op static posturography
- Undergoes CWU/CWD procedures
- Computerised static posturography done at end of $1^{st}$, $3^{rd}$ and $6^{th}$ month post op
## Pre-operative MSW

<table>
<thead>
<tr>
<th>GROUP</th>
<th>N</th>
<th>MEAN SWAY VELOCITY</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MEAN</td>
<td>SD</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>CWU</td>
<td>25</td>
<td>2.076</td>
<td>0.1631</td>
</tr>
<tr>
<td>CWD</td>
<td>25</td>
<td>2.188</td>
<td>0.1032</td>
</tr>
</tbody>
</table>
## Pre & Post operative MSW

<table>
<thead>
<tr>
<th>GRP</th>
<th>Pre op MSW Mean</th>
<th>Post op Mean Sway Velocity</th>
<th>1 Month</th>
<th>3 Month</th>
<th>6 Month</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>CWU</td>
<td>2.076</td>
<td></td>
<td>2.54</td>
<td>0.18</td>
<td>2.21</td>
</tr>
<tr>
<td>CWD</td>
<td>2.188</td>
<td></td>
<td>2.67</td>
<td>0.15</td>
<td>2.38</td>
</tr>
<tr>
<td>P-value</td>
<td>0.056</td>
<td></td>
<td>0.013</td>
<td></td>
<td>0.0001</td>
</tr>
</tbody>
</table>
Conclusions

• Pre-operative occult vestibular dysfunction in COM patients undergoing CWU/CWD mastoidectomy.

• More vestibular dysfunction in COM patients undergoing CWD surgery both pre & post operatively.

• The vestibular function gets compensated in course of 06 months.
A STUDY TO COMPARE POST OPERATIVE VESTIBULAR DEFICIT IN PATIENTS OF OTOSCLEROSIS HAVING UNDERGONE SMALL FENESTRA STAPEDOTOMY BY CONVENTIONAL AND LASER ASSISTED TECHNIQUE.
Scheme of study

- Patient presents to ENT OPD with complaint of hearing loss
- Clinical evaluation, Audiometry, Tympanometry, HRCT temporal bone
- Pre op static posturography
- Undergoes Stapedotomy
- Computerised static posturography done at end of 1st and 4th week post op
## Group 1: Conventional

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; week</th>
<th>4&lt;sup&gt;th&lt;/sup&gt; week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean sway velocity (deg/s)</td>
<td>0.713</td>
<td>0.938</td>
<td>0.763</td>
</tr>
<tr>
<td>p value</td>
<td>0.000</td>
<td>0.003</td>
<td></td>
</tr>
<tr>
<td>VSS-sf-V score (0-32)</td>
<td>0.250</td>
<td>1.525</td>
<td>0.350</td>
</tr>
<tr>
<td>p value</td>
<td>0.000</td>
<td>0.102</td>
<td></td>
</tr>
</tbody>
</table>

Comparison of pre and post op sway velocity and VSS-sf-V in Conventional group (Wilcoxon Signed Rank Test)
## Group 2: Laser

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; week</th>
<th>4&lt;sup&gt;th&lt;/sup&gt; week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean sway velocity (deg/s)</td>
<td>0.703</td>
<td>0.940</td>
<td>0.703</td>
</tr>
<tr>
<td>p value</td>
<td>0.000</td>
<td>0.798</td>
<td></td>
</tr>
<tr>
<td>VSS-sf-V score (0-32)</td>
<td>0.225</td>
<td>1.750</td>
<td>0.400</td>
</tr>
<tr>
<td>p value</td>
<td>0.000</td>
<td>0.106</td>
<td></td>
</tr>
</tbody>
</table>

Comparison of pre and post op sway velocity and VSS-sf-V in Laser group (Wilcoxon Signed Rank Test)
Conventional vs Laser

Variations of mean sway velocities with time

<table>
<thead>
<tr>
<th></th>
<th>Pre op</th>
<th>1st week</th>
<th>4th week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>0.7125</td>
<td>0.9375</td>
<td>0.7625</td>
</tr>
<tr>
<td>Laser</td>
<td>0.7025</td>
<td>0.9400</td>
<td>0.7030</td>
</tr>
<tr>
<td>p value</td>
<td>0.905</td>
<td>0.883</td>
<td>0.045</td>
</tr>
</tbody>
</table>

Comparison of mean sway velocity between two groups (Mann Whitney U test)
Conclusions

• Stapedotomy by conventional and CO2 Laser assisted technique results in vestibular dysfunction post-surgery.
• Vestibular dys recovers to pre-op levels by the end of 1\textsuperscript{st} month after sx in pts undergoing CO2 Laser assisted stapedotomy while it remains higher than pre-op levels in pts undergoing conventional stapedotomy.
• The use of CO2 Laser- faster recovery of vestibular function.
• The use of CO2 Laser can hence be recommended in Stapedotomy.
A study to evaluate the effect of otitis media with effusion on vestibular system in children
A child presents with history suggestive of OME

Otoscopic Examination

Diagnosed as case of Otitis Media with Effusion

Subject selected according to inclusion and exclusion criteria

Consent taken from parents

Subject tested with Static Posturography pre operatively

Subject undergoes Myringotomy and Grommet Insertion

Subject is tested again with static posturography after 3 months post surgery

Data collection and Analysis
A STUDY TO EVALUATE VESTIBULAR FUNCTION USING STATIC POSTUROGRAPHY IN PATIENTS WITH CHRONIC OTITIS MEDIA (MUCOSAL) ACTIVE UNDERGOING CORTICAL MASTOIDECTOMY WITH OR WITHOUT OSSICULOPLASTY.
STUDY DESIGN

• An observational comparative analytical cohort
• 2 yrs
• To evaluate the effect of COM (mucosal) active on vestibular system by static posturography.
• Assess the change in vestibular function after cortical mastoidectomy with or without ossiculoplasty 3 months post op.
OTHER APPLICATIONS
Posturography in PD

• Detecting quantum of postural instability
• Identification of patients with a risk of recurrent falls in PD*
• Monitoring of any deterioration of posture control
• Monitoring response to exercise therapies specifically addressing balance dysfunction**


Progressive Supranuclear Palsy & PD

PSP pts:
• SOT Score - significantly worse
• Total LOS time and path sway - significantly prolonged
• Levodopa administration – no improvement

Vestibular Disorders

• Diagnosis in conjunction with other tests.
• Detect balance problems in the elderly and start preventative balance training.*
• Assessment and monitoring of individualized vestibular rehabilitation therapy in peripheral vestibular disorders.**


BPPV

• Management: CRM
• Some patients – residual postural instability
• Vestibular rehabilitation exercises using dynamic posturography
• Helpful adjunct to the treatment


Zhang DG et al. Clinical value of dynamic posturography in the evaluation and rehabilitation of vestibular function of patients with benign paroxysmal positional vertigo. *Zhonghua Er Bi Yan Hou Tou Jing Wai Ke Za Zhi.* 2010 Sep;45(9):732-6
Risk of falls in elderly

• 206 Patients
• < 65 yrs
• SOT
• Multi-fallers:
  - Visual input occlusion- more sway
  - Distorted visual and somatosensory inputs- recurrent falls with no postural adaptation.
• Posturography more sensitive than clinical balance tests (Timed 'Up & Go' test, One-Leg Balance, Sit-to-Stand-test).

Buatois S. Posturography and risk of recurrent falls in healthy non-institutionalized persons aged over 65. Gerontology. 2006;52(6):345-52
STROKE

- Reestablishment of balance function.
- Biofeedback to patients regarding the locus of their center of force (COF) or center of pressure (COP), as well as training protocols to enhance stance symmetry, steadiness, and dynamic stability.
- CDP training program - a systematic, objective method to reduce fall risk with improved overground performance of balance tasks in an individual with chronic stroke.

Non organic imbalance

• Substandard performance on sensory tests 1 & 2.
• Better performance on a more difficult test (ST 5 & 6): this was determined using the formulae
  \[ \text{Score} = [(\text{Score1} - \text{Norm1}) + (\text{Score2} - \text{Norm2})] - [(\text{Score5} - \text{Norm5}) + (\text{Score6} - \text{Norm6})]. \]
• Regular periodicity of sway
• Large amplitude AP sway that exceed 5° without falls on ST 4, 5, and 6
• Large amplitude lateral sway that exceed 1.25° without falls on ST 4, 5, and 6
• Excessive inter-trial variability
• Inconsistent motor responses to small and large translational perturbations
Non organic imbalance
mCTSIB - Results
Psychogenic imbalance

- Regular periodicity of sway
- Circular sway
- Inconsistent motor Response

SPACEFLIGHTS

• Recovery of CDP to baseline as a criterion for return to duty after long-duration (space station) spaceflights.
Limitations

• Test of postural control as a whole
• Lack of topographic specificity
• Sensitivity of 61% to 89%
THANK YOU
Conventional vs Laser

Variations of VSS-SF-v with time

Comparison of VSS-sf-V between two groups (Mann Whitney U test)