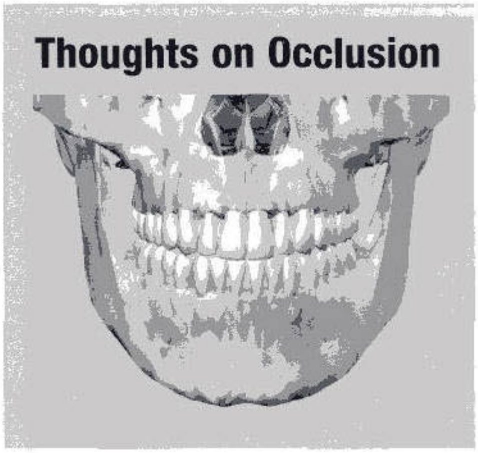


# Digital Laser Scans Used in Morphometric Analysis of Human Skulls To Demonstrate Dental Occlusal Function III

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## Supposition/Thesis

Melvin Moss posited the "Functional Matrix" in several papers in the 1970's. In Dental Clinics of North America, he clearly described the functional relationship between muscles and the joints they operate (1). He described the adaptation of the boney matrix to the dynamics and strength of muscle function.

This concept is applied to the dynamics of motion and bony architecture of the TMJ. Zola (2) described a functional guiding plane on the medial wall of the glenoid fossa to which he gave his name — Zola's tubercle.

The basic supposition of this research is that the motion of the

**Mathematical Solution**

• This unit rotation vector is defined via vector math

$$\vec{N}_{P1} = \vec{P}_1 \times \vec{N}_1$$

$$\vec{N}_{P2} = \vec{P}_2 \times \vec{N}_2$$

$$\vec{E}_R = \frac{\vec{N}_{P1} \times \vec{N}_{P2}}{\left|\vec{N}_{P1} \times \vec{N}_{P2}\right|}$$

**Figure 1.**

**Mathematical Solution**

• The opposite TMJ trajectory is then determined from

$$\begin{bmatrix} \cos\Phi + E_{Rx}^2(1-\cos\Phi) & E_{Rx}E_{Ry}(1-\cos\Phi) + E_{Rz}\sin\Phi & E_{Rx}E_{Rz}(1-\cos\Phi) - E_{Ry}\sin\Phi \\ E_{Rx}E_{Ry}(1-\cos\Phi) - E_{Rz}\sin\Phi & \cos\Phi + E_{Ry}^2(1-\cos\Phi) & E_{Ry}E_{Rz}(1-\cos\Phi) + E_{Rx}\sin\Phi \\ E_{Rx}E_{Rz}(1-\cos\Phi) + E_{Ry}\sin\Phi & E_{Ry}E_{Rz}(1-\cos\Phi) - E_{Rx}\sin\Phi & \cos\Phi + E_{Rz}^2(1-\cos\Phi) \end{bmatrix} \begin{Bmatrix} P_{TMJ} \\ P_{TMJ} \\ P_{TMJ} \end{Bmatrix}$$

The equation accounts for variation in skull size.

The above equation defines the TMJ trajectory for any rotation of $\Phi$ about the pivot TMJ.

APPLIED STRUCTURAL DYNAMICS

**Figure 2.**

mandible in chewing function is controlled by the strength of the major muscles of mastication, the guide planes of the contacting teeth and the angle of guidance in the TM joint, more specifically, Zola's tubercle. The contact of the teeth in forceful use (mastication and/or bruxism ) moderates and coordinates the power of muscle contraction and these combined forces influence the pressure within the gliding TM joint which effects modification of the boney surfaces, through adaptive change, to be in harmony with the guiding teeth.

In two previous papers, techniques of measurement, data collection and data confirmation were described. Using the supposition presented and the data from physical examination of human dry specimen skulls (digital laser scans) a mathematical formula to solve the complex relationships of contact and function was commissioned from two professional mathematicians.

The intent of this study and *mathematical analysis was to con*firm the supposition through analysis of collected data.

Two separate problems had to be solved and the results specifically related to prove the supposition. These analytical and mathematical processes are too complex to describe in this paper but the equations representing the mathe-

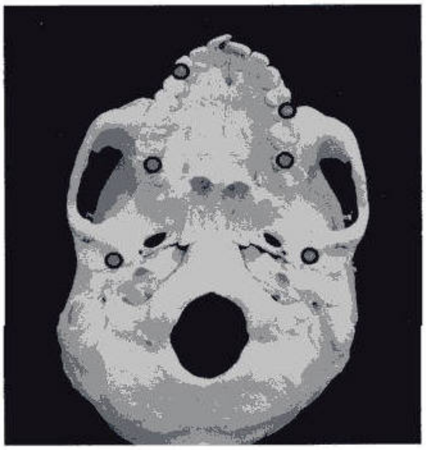


Figure 4A. Photo of base of skull A4, confirming plot points from computer on anatomical speciman.

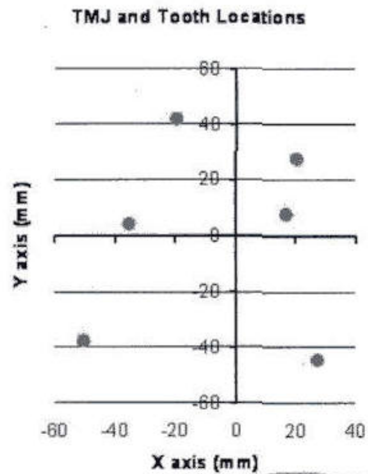
**Skull Sample A4**

Plane Position

| A4 | X | Y | Z |
|---|---|---|---|
| RMTJ LL | -50.34775 | -37.76561 | -798.26581 |
| T1 LL | -35.16550 | 4.25373 | -779.68672 |
| T13 LL | 20.65940 | 27.50095 | -783.46022 |
| LTMJ RL | 26.99338 | -44.60614 | -806.75571 |
| T15 RL | 16.89250 | 7.81952 | -780.42099 |
| T6 RL | -19.82746 | 41.88641 | -786.32453 |

Normal Vector

| A4 | X | Y | Z |
|---|---|---|---|
| RMTJ LL | -0.83308 | -0.28306 | 0.47523 |
| T1 LL | -0.47662 | -0.19843 | 0.85643 |
| T13 LL | -0.21055 | -0.43375 | 0.87609 |
| LTMJ RL | 0.73967 | -0.42754 | 0.51971 |
| T15 RL | 0.22335 | 0.15752 | 0.96193 |
| T6 RL | 0.08111 | -0.12739 | 0.98853 |

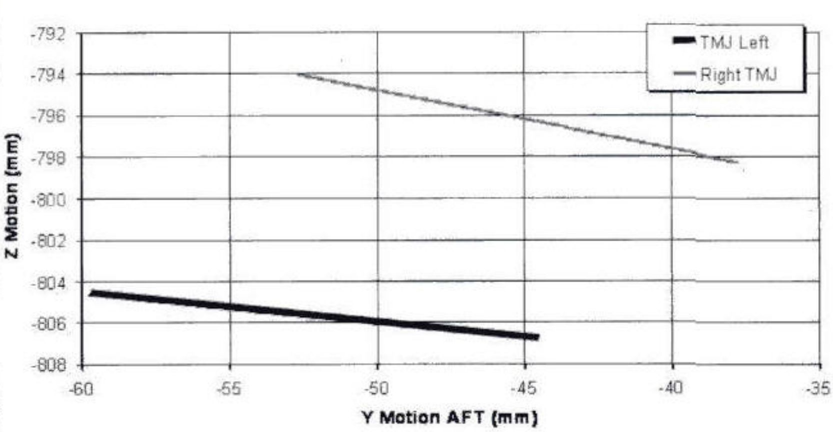



APPLIED STRUCTURAL DYNAMICS

Figure 3. Scan data and initial computer plot of wear facet areas.

**Skull Sample A4**

- **Trajectories are in coordinate system defined by input data**




APPLIED STRUCTURAL DYNAMICS

Figure 4B. TMJ trajectories as resolved mathematically.

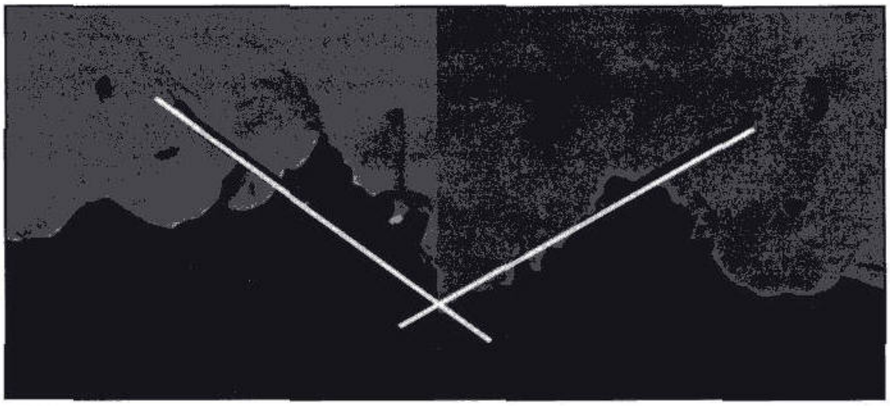


Figure 5. TMJ trajectories, anatomical demonstration. Note that the right guide angle is steeper than the left as solved mathematically.

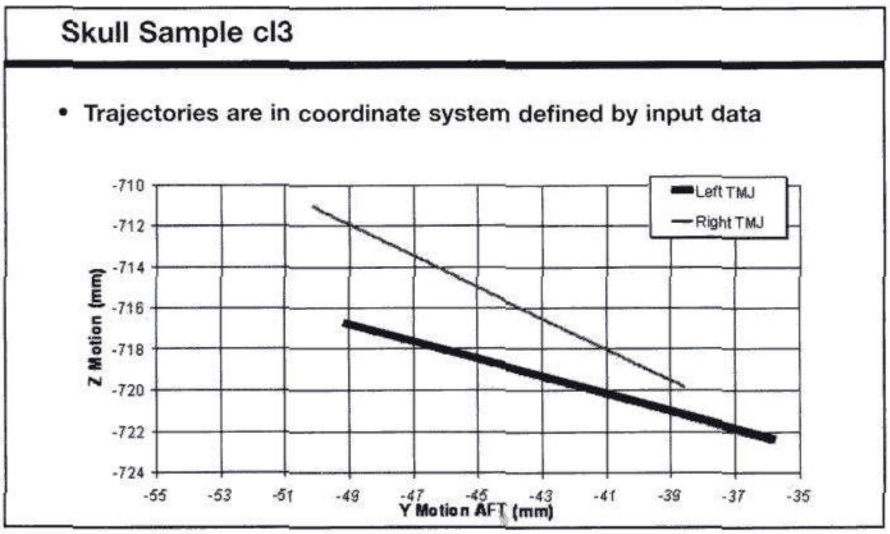



Figure 6. Mathematical solution for Medial guide angles in Skull Cl3.

Applied Structural Dynamics

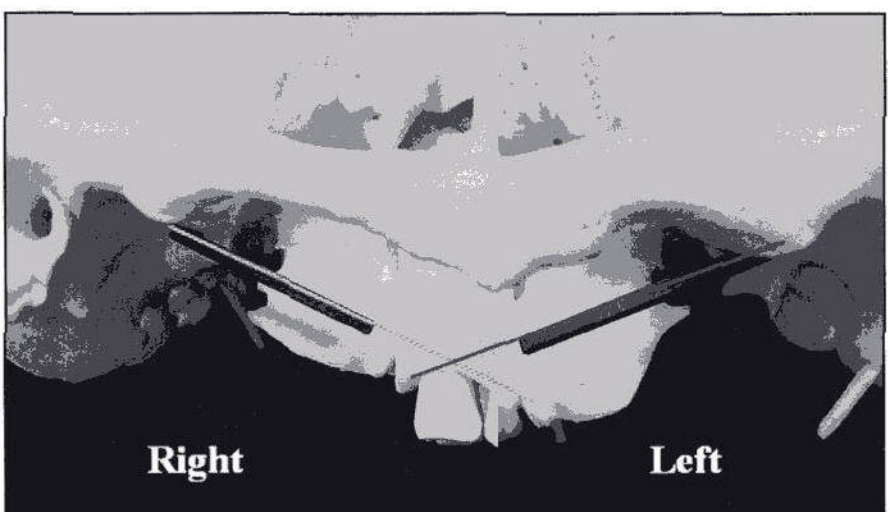



Figure 7. Note the right guide angle is steeper than the left as solved mathematically.

matical solutions are shown in Figures 1 and 2. The results expressed in graphic and photographic form are represented in Figures 3–7.

Using the aforementioned formulae, a mathematical model was constructed to solve for any one of three missing guide planes given the other two. In this initial study, the givens were tooth contacts on opposite sides of the dental arch and the solution was made for the TMJ guidance plane. The accuracy of the mathematical model was calculated at .99611, an error factor of .088102 percent (less than 0.1%), and the solution for the guide angle of Zola's tubercle was consistent with the analog model.

Initial conclusions that can be drawn from this study:

1. There are cross arch tooth contacts which guide the motion of the mandible.
2. The tooth contacts modify muscle function — speed, trajectory and power.
3. TMJ boney surfaces adapt to this muscle function to guide the jaw in harmony with the guidance of the teeth in forceful use of the masticatory system.

## References

1. Moss Melvin L, Dent Clin North Am, A Functional Cranial Analysis of Centric Relation, 1975;19(3):431-442
2. Zola A and Rothschild E A. Posterior condyle positions in unimpeded jaw movements, J Pros Dent 1962; 11(5):873-881.