KINEMATIC ANALYSIS OF JAW MOVEMENTS

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Keywords: mandible, muscle, movements, kinematics

Abstract: The jaw can be moved directly forward or backward; up and down, a pure hinge motion; a rotary movement on a vertical axis through one of the condyles; and rotation on a transverse axis passing from side to side through the mandibular or inferior dental foramina. To simulate the movement of the mandible can be achieved using a kinematics analysis of upper joints. The kinematics analysis of the mechanism is to determine the parameters of position, velocity and acceleration corresponding to all elements.

The mandible has four basic movements. The jaw can be moved directly forward or backward; up and down, a pure hinge motion; a rotary movement on a vertical axis through one of the condyles; and rotation on a transverse axis passing from side to side through the mandibular or inferior dental foramina.

Movement can be decomposed and studied in the three reference planes: frontal, sagittal and horizontal.

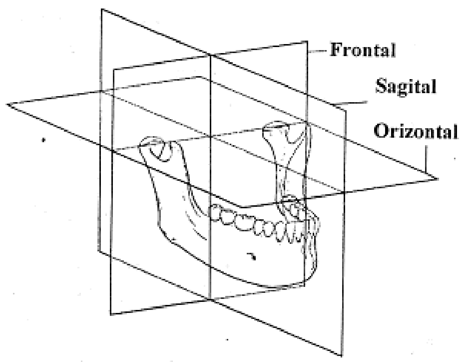


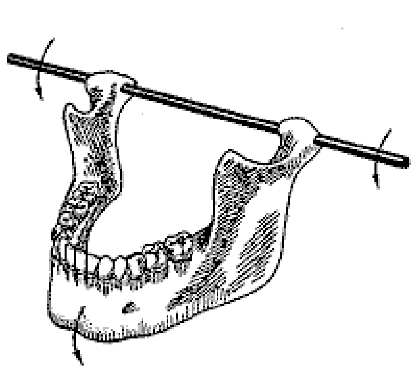
Figure 1: The reference planes to limit the movements of the mandible

The mandible movements you make can be classified into: basic movements, movements composed of fundamental movements and functional movements.

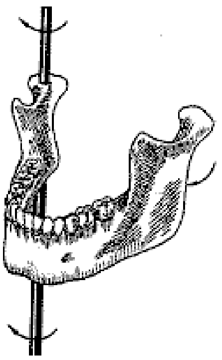
The incremental movements are the translational and rotational movements, which can run in joint cavities, synchronous and asynchronous. The rotation movement is performed at the main axis of rotation of the temporomandibular joint (is the horizontal axis passing through the two poles of the medial condyle Fig. 3-a), and rotation can be run around a vertical axis (Fig. 3-b) or sagittal (Fig. 3-c) - the lateral excursion. The operation involved more jaw muscle groups.

Thus, the lifting movement of the jaw (mouth closed), the essential role it has masseter muscle, temporal muscle and pterigoidieni helped. Braking is done with muscle movement: posterior digastric, digastric and sternohyoid previously.

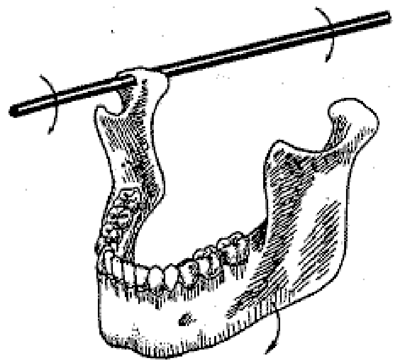
Rotation around the temporomandibular jaw joint, called the medical literature and hinge motion is carried around an imaginary axis called bicondilian shaft, passing through two of the mandibular condyle. It is estimated that the rotation is ideally produces an opening angle of 12^0 and possesses all the properties of speed and acceleration distribution for fixed axis rotation. In this beach, angular velocity ω is expected to be constant. Rotation movement of the mandible occurs naturally and is easy to put out.



a) around the horizontal axis



b)around the vertical axis



c)around the sagittal axis

Figure 2: Rotational movements of the mandible. Movement of the hinge is on masseter muscle, temporal, internal and external pterygoid

To simulate the movement of the mandible can be achieved using a kinematics analysis of upper joints. Figure 3 shows the two profiles (of the mandible and skull) in contact at point *C*. The kinematics analysis of the mechanism is to determine the parameters of position, velocity and acceleration corresponding to all elements. To determine these parameters calculation procedures are used, prepared for each module. For this purpose, it is necessary to determine the components of the mechanism module which simulates jaw movement.

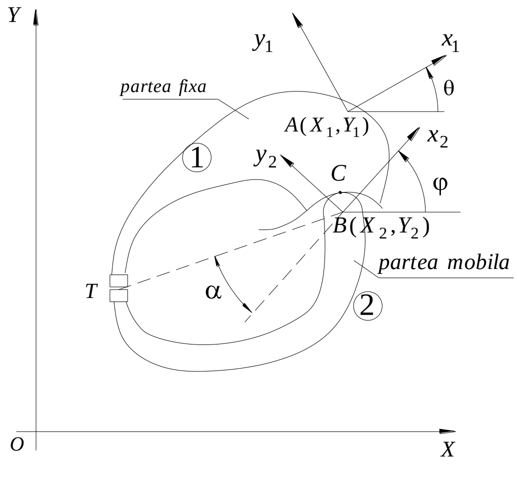


Figure 3: Representation the masticator apparatus using kinematics couplings

To obtain analytical expressions of the equations of a parametric profile 1 measurement on the skull to determine the numerical values of these coordinates, then by the method of least squares, determine the analytical expression of the function that best approximates these coordinates.

The laws of motion of the two profiles are given by roots movements and systems of axes Ax_1y_1 and Bx_2y_2, and rotations of these systems to XOY fixed axis system, namely:

- the law of motion of a profile

$$X_1 = XA = const; \quad Y_1 = YA = const; \quad \theta = const; \tag{1}$$

- the law of motion of the profile 2 (the law of motion of the mandible).

$$\begin{cases} X_2 = XB(t); \\ Y_2 = YB(t); \\ \varphi = \varphi(t); \end{cases} \tag{2}$$

Parametric equations of curves of the two sections of fulltime guidelines are:

- the parametric equations of a profile 1 (you chose a 5-degree polynomial, you can choose and other equations)

$$\begin{cases} x_1 = x_1; \\ y_1 = a_0 + a_1x_1 + a_2x_1^2 + a_3x_1^3 + a_4x_1^4 + a_5x_1^5; \end{cases} \tag{3}$$

- the parametric equations of the profile 2 are:

$$\begin{cases} x_2 = R\cos(\nu); \\ y_2 = R\sin(\nu); \end{cases} \tag{4}$$

where: ν is the parameter generation crupper (it was considered an arc centred on point B)

The condition of contact between the two sections of fulltime 1 and 2, XOY fixed system is given by:

$$\begin{aligned} X_{10} &= X_{20} = X_C; \\ Y_{10} &= Y_{20} = Y_C, \end{aligned} \tag{5}$$

where:

$$\begin{aligned} X_{10}(x_1,t) &= XA + x_1\cos\theta - y_1\sin\theta; \\ Y_{10}(x_1,t) &= YA + x_1\sin\theta + y_1\cos\theta, \end{aligned} \tag{6}$$

the transformation of the coordinates of a point fixed system XOY of the mobile system Ax_1y_1 and

$$X_{20}(\nu,t) = XB + R\cos(\nu)\cos(\varphi) - R\sin(\nu)\sin(\varphi);$$
$$Y_{20}(\nu,t) = XB + R\sin(\nu)\sin(\varphi) + R\cos(\nu)\cos(\varphi); \qquad (7)$$

the transformation of the coordinates of a point fixed system XOY of mobile system Bx_2y_2.

The tangency condition at the same fixed system XOY is:

$$\frac{\frac{\partial Y_{10}}{\partial x_1}}{\frac{\partial X_{10}}{\partial x_1}} = \frac{\frac{\partial Y_{20}}{\partial \nu}}{\frac{\partial X_{20}}{\partial \nu}}, \qquad (8)$$

where:

$$\frac{\partial X_{10}}{\partial x_1} = \cos(\theta) - \frac{dy_1}{dx_1}\sin(\theta);$$
$$\frac{\partial Y_{10}}{\partial x_1} = \sin\theta + \frac{dy_1}{dx1}\cos(\theta); \qquad (9)$$
$$\frac{\partial X_{20}}{\partial \nu} = -R\sin(\nu)\cos(\varphi) - r\cos(\nu)\sin(\varphi);$$
$$\frac{\partial Y_{20}}{\partial \nu} = -R\sin(\nu)\sin(\varphi) + \frac{dy_2}{d\nu}\cos(\varphi). \qquad (10)$$

After substitution in (8) yields:

$$\nu = \theta - \varphi + \mathrm{arctag}\left(\frac{-1}{\frac{dy_1}{dx_1}}\right) + \pi. \qquad (11)$$

The parameter ν is introduced in the relations equations (7) and the resulting coordinates of point *B*

$$X_{20} = XB + R\cos(\theta - \varphi + \arctan\left(\frac{-1}{\frac{dy}{dx_1}}\right) + \pi)\cdot\cos(\varphi) - R\sin(\theta - \varphi + \arctan\left(\frac{-1}{\frac{dy}{dx_1}}\right) + \pi)\cdot\sin(\varphi);$$

$$Y_{20} = XB + R\sin(\theta - \varphi + \arctan\left(\frac{-1}{\frac{dy}{dx_1}}\right) + \pi)\cdot\sin(\varphi) + R\cos(\theta - \varphi + \arctan\left(\frac{-1}{\frac{dy}{dx_1}}\right) + \pi)\cdot\cos(\varphi),$$

(12)

which is the origin of the mobile system Bx_2y_2 in the coordinate system *XOY*. By modifying the values of the angle φ, the position of the reinsurance determine the coordinates of point B and the parameter φ can be determined using nonlinear system T of equations consisting of equations (5) and (8).

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