EAN '92 30th Conference of Experimental Stress Analysis
30. konference o experimentální analýze napětí
2. - 5. 6. 1992 ČVUT Praha Czechoslovakia

DISTRIBUTION OF FORCES IN MANDIBULAR MUSCLES

DISTRIBUCE SIL VE SVALECH DOLNÍ ČELISTI

Petrtýl M., Cais S., Petrovičová B.

Práce zkoumá rozdělení sil ve žvýkacích svalech dolní čelisti při symetrickém a asymetrickém kousání potravy. Znalost rozdělení sil ve svalech je důležitá nejen ve stomatologické protetice, ale i v chirurgii obličejového skeletu, jakož i v dětské stomatologii při poruše kloubního výběžku.

Keywords: chewing muscles, mandibular joints, stress, malfunction

The present paper investigates the distribution of forces in the chewing muscles of the lower jaw. Symmetric and asymmetric patterns of food mastication are included in the case of correct physiological functioning of the muscles and typical malfunctions of the lower jaw with reduced force action in some muscles. Knowledge of the values and distribution of forces (resulting from occlusion) is essential not only for the selection of a suitable denture in dentistry, but also in facial skeleton surgery and in infant stomatology when treating defects of the arthritic process.

Mechanical stimulii are very important for the skeleton's development and permanent regeneration. Paramount is the force action in the muscles attached to appropriate locations and parts of the facial skeleton. If, for example, the arthritic process of the lower jaw is damaged in infancy, the mechanical action upon the lower jaw of the muscles diverges from the physiological optimum. The progressive evolution of deformations results in

damaged geometrical configuration of the whole lowerjaw. The extent of these deformations may even bring about the loss of symmetry of the whole facial skeleton. The geometrical assymetry of the skeleton may be accompanied by the assymetry of forces in the individual muscles. The present paper attempts to contribute to a better understanding of the biomechanical side of the problem and to provide necessary underlying data for the therapy.

Methodology of the work

Selected as a mechanical model of the system consisting of the mandible, the mandibular joint and the chewing muscles is the perfectly rigid balcony girder which is supported by an ideal cylindrical hinge and suspended on Hookean elastic bars. The system has one degree of freedom since the girder can only turn about the lateral axis which passes through the centers of the mandibular joints.

We remark that the actual behaviour of the muscles is more complex than that of the Hookean elastic bars and that the chosen model does not account for the isotonic and isometric actions of the muscles. Nevertheless, we can expect that the model would reflect the essential features of reality at least in a qualitative manner, i.e. it would provide plausible information on the distribution of the maximum forces acting upon the lower jaw.

The model and the orientation of the axes are sketched in Fig.1. The muscles are denoted as S1, S2,..., S5 on the left-hand side, and as $\overline{S1}$, $\overline{S2}$, $\overline{S3}$, ... $\overline{S5}$ on the right-hand side, in the following order:

S1,$\overline{S1}$ ... m. masseter (pars superficialis)

S2,$\overline{S2}$ ... m. masseter (pars profunda)

S3,$\overline{S3}$ ... m. temporalis

S4,$\overline{S4}$ ... m. pterygoideus medialis

S5,$\overline{S5}$ ... m. pterygoideus lateralis

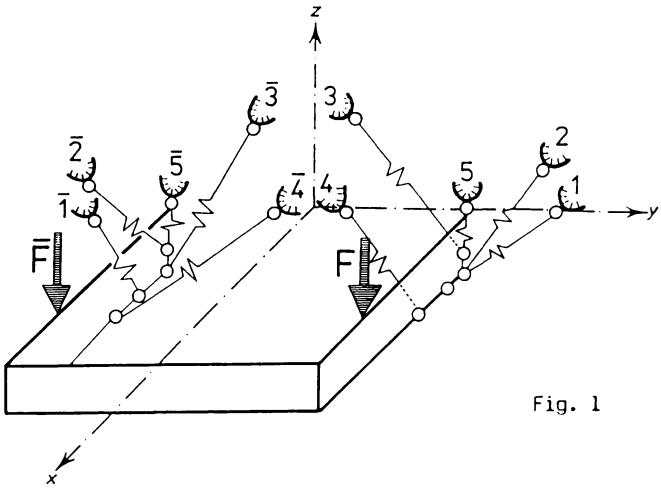

Fig. 1

We assume that the stiffnesses of the elastic bars are proportional to te cross-section areas of the muscles. These areas were determined in the Institute of Anatomy of the Medical Faculty, Charles University, Prague, as the mean values resulting from measurements which were carried out on three individuals.

These loading patterns were considered in analysis:

I. $F = \bar{F} = 300$ N on the second molar on the left and on the right (Fig.2);
II. $2F = 2 \times 300$ N on the first incissors (Fig.3);
III. $F = 300$ N on the second molar on the left (assymetric loading);
IV. $F = 300$ N on the right.

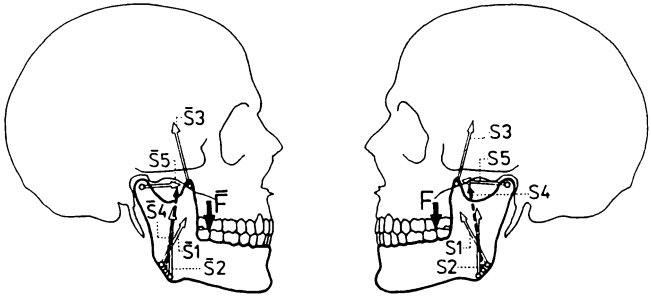

Fig.2

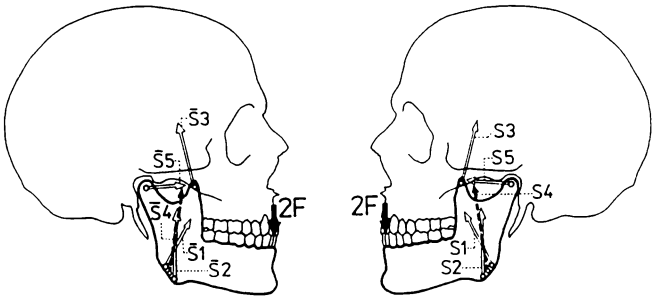

Fig.3

The effects of these loadings were investigated in the case of

a) the complete system of muscles, and

b) the muscular system with various defects.

The mechanical problem was formulated in terms of the matrix structural analysis. The forces in the muscles were determined from the condition of the equilibrium of the moments about the lateral axis **y**, the remaining equilibrium conditions provided the reactions in the mandibular joints. A FORTRAN programme was implemented on the ICL 4-72 computer. The programme permits changes in both the anatomic data (the characteristics of the muscles and the jaws) and the physiological data (position and value of forces on occlusion).

Conclusions

Exerting equivalent forces, whiich are active on food mastication at the locations of the left and right molars, the most loaded stressed muscle is the m. masseter (pars superficialis), followed by m. masseter (pars profunda) and m. temporalis.

Petrtýl M.,doc.Ing.DrSc., Cais S.,Doc.Ing.CSc., Petrovičová B.,Ing.CSc.
Department of Structural Analysis, Faculty of Civil Engineering, Czech Technical University in Prague,
Thákurova 7, 166 29 Prague 6