

# Medial Mandibular Flexure: A Review of Concepts and Consequences

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## ABSTRACT

Mandible is a long bone which is bent in the form of a 'U' or bow, supported and articulated with the cranium by means of muscles and ligaments. These muscles, tendons and ligaments attached to the mandible exert force, which causes change in the shape of the mandible at different levels of movement of the jaws. A medial flexure of mandible occurs during wide opening of mouth with the amount of flexure depending on the degree of jaw movement. This mandibular flexure, though minimal, has a profound influence on cross-arch restorations and patients with subperiosteal implants. This article describes the various facts and consequences of mandibular flexure.

**Keywords:** Mandibular flexure, Muscles of mastication, Cross-arch restoration, Mandible, Implants.

## INTRODUCTION

The term flexure refers to “the quality or state of being flexed.” Medial mandibular flexure (MMF) is a functional elastic deformation characterized by medial convergence of hemimandibles in jaw opening and protrusion movements.<sup>38</sup> Lateral pterygoid muscle is the main muscle responsible for mandibular flexure towards the midline, because of its anatomical location, which is favorable for that kind of movement. The other muscles liable for flexure are the mylohyoid, platysma and superior constrictor muscles of pharynx.<sup>1</sup> Electromyographic studies have also revealed that muscle activities are extremely complex and interrelated in the processes of opening and closing.<sup>2</sup> Nonetheless, Weinmann and Sicher suggest that the bending force is exerted mainly by the lateral pterygoid muscles.<sup>3</sup>

Medial mandibular flexure (Fig.1) could lead to challenging problems with both conventional and implant-supported prostheses, when treatment planning includes rigid bilateral connection in the posterior region of the mandible. Previous clinical and experimental studies reported possible association of medial mandibular flexure with increased stress in dental prostheses and abutments, poor fit of fixed and partial removable prostheses, impression distortion and pain during function, fracture of screws and implants, loosening of cemented prostheses and fracture of porcelain.

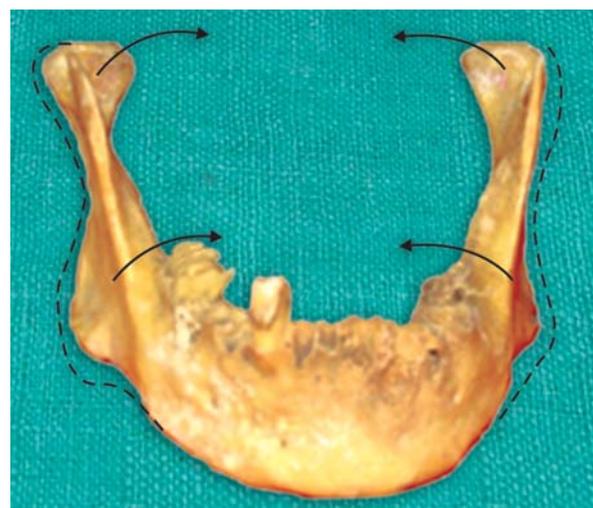


Fig. 1: Medial mandibular flexure

## REVIEW OF LITERATURE

It often occurs that the mandibular rigidly connected long span bridges that cross the midline supported by natural abutments or implants become loose or get dislodged after a period of usage. The reasons for these failures are various. However, few researchers have shown the influence of the mandibular elastic deformation on the abutments, and their possibility of producing a distortion and dislodgement force between the abutment and prosthesis. Various methods were reported by several investigators to evaluate the amount of

mandibular flexure occurring as a consequence of jaw movements.<sup>1,5,6</sup>

Picton in 1962<sup>4</sup> confirmed a contralateral tooth movement during chewing and open clench exercises, which implied that distortion of the mandible would be the cause of such movement between adjacent posterior teeth.

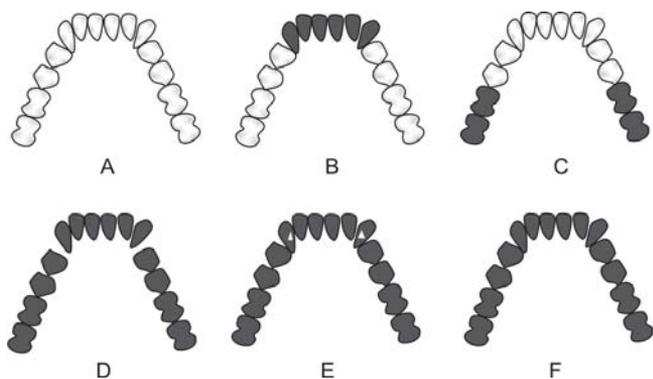
Osborne J and Tomlien HR<sup>1</sup> in 1964 in an *in vivo* study concluded that there is a reduction in the width of mandibular arch during forced opening and protrusion, demonstrated that the amount of flexure is more related to opening.

Ragli and Kelly in 1967<sup>5</sup> used elastomeric impressions as the basis for their measurements. They explained the changes in width at impressions made at various levels of opening of the mandible.

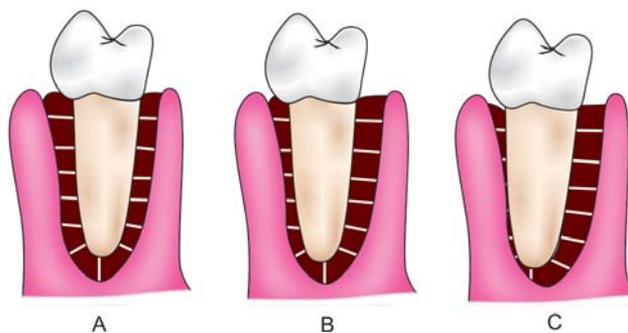
Burch and Borchers in the year 1970<sup>7</sup> demonstrated a change in the mandibular width during function using an intraoral strip of untempered beryllium-copper spring steel and recorded the changes demonstrated on a polygraph. They found an average decrease in the width of the mandible by 0.61 mm, while Novak in 1972<sup>8</sup> found the flexure range to be between 0.3 and 1.0 mm.

Other than mouth opening, flexure could also occur due to other physical properties of mandible and musculature like bone density, muscle strength or by age.<sup>9</sup> It has been established by several investigators that mandibular flexure occurs towards the midline and it affects both fixed prosthesis and natural teeth or implant.<sup>10</sup>

Fishman in 1976<sup>11,12</sup> developed different types of splints for full arch rehabilitation and noted the effect of these splints on mandibular flexure (Figs 2A to F). He concluded that mandibular flexure will be reduced in most of the splinted cases and also showed that the periodontal space around natural teeth obliterated (Figs 3A to C). This indicates that if mandibular flexure is reduced, the stresses will develop around the teeth, because the splinted teeth will not move but mandible will try to flex in its original manner. Inhibition of mandibular flexure apparently increases as more teeth are splinted and more rigid attachments are used.



**Figs 2A to F:** (A) Control, (B) anterior splint, (C) posterior splint, (D) anterior and posterior splints, (E) splint with precision attachment, (F) full mandibular splint



**Figs 3A to C:** (A) Available periodontal attachment space at rest, (B) mandibular flexure not exceeding periodontal attachment space, (C) splinted teeth resisting mandibular flexure which exceeds the periodontal attachment space

While Beecher RM in 1977<sup>13</sup> suggested that corporal rotation occurs only during the power strokes of mastication, in which its occurrence was demonstrated during opening and closing of the jaws. Its magnitude, however, is correlated poorly with symphyseal height. Omar R and Nise MD in 1981<sup>14</sup> reported that flexure of mandible is even present with muscular activity alone and demonstrated that clenching exerted not only occlusal load but also mandibular flexure. Gates NG and Nicholls JI in 1981<sup>15</sup> evaluated the width changes of the mandibular arch at various mandibular positions and manipulations and concluded that:

- The width of the mandible is influenced by intrinsic and extrinsic forces
- Maximal opening, protrusion and biting forces cause the mandible to decrease in arch width
- A horizontal retruding force on the mandible for centric relation records caused an increase in arch width
- The amount of mandibular arch width change during impression making could be minimized by preventing any protrusive movement and/or opening beyond 20 mm.

Hylander in 1984<sup>16,17</sup> postulated five patterns of jaw deformation in the primate mandible, which included symphyseal bending associated with medial convergence, dorsoventral shear, corporal rotation and anteroposterior shear.

Bradley Fischman in 1990<sup>18,19</sup> explained the existence of rotational aspect of mandible and its flexure by means of a photographic comparison. He also explained the importance of these movements in relation to anatomic considerations, periodontal therapy, restorative dentistry and implant supported prosthesis. His conclusions stated that:

- Impressions should be made with the patient's mouth in a partially closed unstrained mandibular position.
- Short spans should be used whenever possible in fixed prosthesis.
- Large spans of porcelain should be avoided and
- Posterior mandibular osseointegrated implants should be freestanding, associated with short prosthetic spans, or related to tooth abutments via stress breakers where compromises in implant size or bone quality demand.

Hobkirk JA and Schwab in 1991<sup>20</sup> found a relative displacement between implants of up to 420 microns and force transmission between linker implants of up to 16 N with jaw movements. They noted that the forces were much less in lateral excursion than in opening and protrusion movements.

McCartney JW in 1992<sup>21</sup> suggested that posterior implants could be subjected to stress-induced microdamage to the bone-implant interface in cantilever situations due to mandibular flexure but the use of posterior abutments for support of the cantilever without connection reduced the potential hazard of stress-induced microdamage.

Ueda R in 1992<sup>22</sup> reported that there was no significant difference in lateral pterygoid activity between maximum opening and protrusion which implied that lateral pterygoid is not solely responsible for mandibular distortion during jaw movement.

Korioth TWP and Hannam AG in 1994<sup>23</sup> did finite element analysis of five clenching tasks, which included intercuspal position, left group function, left group function with balancing contact, incisal clenching and right molar clenching. Under conditions of static equilibrium and within the limitations of the current modeling approach, the human jaw deformed elastically during symmetrical and asymmetrical clenching tasks. This deformation was rendered as complex and included the rotational distortion of the corpora around their axes. In addition, the jaw also deformed parasagittally and transversely, however, the degree of distortion depended on each clenching task.

Horiuchi M et al in 1997<sup>24</sup> measured the relative position between two biointegrated implants during opening and protrusive movement of the jaws and mandibular distortion was evaluated as the change in the relative positions of the implant. The conclusions drawn from the study suggested a deviation of distal implant to the lingual side relative to the mesial implant and the deviation with protrusive movement was larger than that for opening movement. The relative displacement of the two implants during maximum opening and protrusion ranged from 8 to 25  $\mu\text{m}$  and 10 to 37  $\mu\text{m}$  respectively, which confirms the buccolingual flexure of the mandible.

Loth SR and Henneberg M in 1998<sup>25-27</sup> have suggested that the mandibular ramus posterior flexure (MRPF) had a high sex discriminating effectiveness. Flexure appears to be a male developmental trait because it only manifests consistently after adolescence. In most females, the posterior border of the ramus retained the straight juvenile shape. If flexure was noted, it was found to occur either at a higher point near the neck of the condyle or lower in association with the gonial prominence or eversion.

Hobkirk and Havthovlas in 1998<sup>28</sup> hypothesized that functional mandibular deformation influences force distribution in the jaws/implant or superstructure complex.

The following conclusions were drawn:

- Force distribution in the mandibular implant host complex may be unevenly distributed about the median sagittal plane as a result of jaw symmetry.
- The use of larger number of implants to support a fixed superstructure resulted in pronounced leverage effects, particularly around the midline.
- Smaller number of implants was associated with more localized patterns of force distribution.
- A mismatch of the dorsoventral shears characteristic of superstructure and jaw may increase posterior tensile forces associated with unilateral loading.

A comparison of implant abutment stresses for idealized superstructure with different cross-sectional shapes and material properties during a simulated, complex biting task was evaluated by Korioth and Johann 1999.<sup>29</sup> They used different types of beams as superstructure models which had similar surface areas of 12 mm. The lowest principal stresses were obtained using a superstructure with a rectangular shaped beam oriented vertically. Superstructure material with a lower MOE seems not only to increase the implant abutment stresses overall but also to slightly reduce the tensile stress on the most anterior implants.

Misch CE in 1999<sup>30</sup> has stated that when posterior rigid fixed implants were splinted to each other in a cross-arch restoration; they were subjected to considerable buccolingual force on opening due to mandibular flexure. The flexure also introduced lateral stresses to the implants, causing bone loss around implants, loss of implant fixation, unretained restorations, material fracture and discomfort on mouth opening. It was concluded that fixed implants should be avoided in the mandible and the use of nonrigid connectors anteriorly was emphasized with splitting of the restorations as two or more independent prosthesis.

Hind H et al in 2000<sup>31,32</sup> measured the medial convergence, dorsoventral shear, and corporal rotation in the human mandible and concluded that:

- Mandibular deformation occurs immediately on opening
- Jaw opening and lateral excursion causes the mandible to deform in three directions—medial convergence, corporal rotation and dorsoventral shear.
- All three patterns of jaw deformation occurred concurrently.

Chen DC et al in 2000<sup>33</sup> investigated the mandibular deformation during mouth opening, and searched for contributing factors related to this phenomenon. It was concluded that:

- Jaw movements from rest position to maximum opening resulted in mandibular narrowing of up to 437  $\mu\text{m}$  with wide variations between subjects.
- During mouth opening, dimensional change of mandible seemed to be greater in female subjects. However, the disparity between females and males was not statistically significant.

- Some proposed factors, including symphyseal width, area, bone density and lower gonial angle were closely related to mandibular deformation on mouth opening.

The results support a multifactorial model of mandibular deformation on mouth opening by using a backward variable elimination method.

Jiang T and Ai M in 2002<sup>34</sup> suggested that when subjects clenched on the canines (unilaterally or bilaterally) or on bilateral second molars, no mandibular deformation was found, whereas when the subjects clenched on unilateral second molars, the mandibular arch on the nonpivot side moved upward and inward and straight line distances between the right and left measurement points decreased by 0.2 mm. The magnitude of deformation was smaller than the depressible limit of periodontal membrane. This suggested a negligible influence of mandibular deformation on the connected prosthesis in case of natural root supported long span bridge but should probably be considered in the case of an implant supported bridge.

In the year 2003, Yamily Pacz et al<sup>35</sup> designed a split frame implant prosthesis to compensate for mandibular flexure. When an edentulous mandible is restored with implant-supported prosthesis connected by a metal bar and retained with screw, mandibular flexure may cause screw loosening and needless stress and strain on the prosthesis and implant. To overcome this problem, separation of the hybrid prosthesis in the midline is done to relieve the stress and strain thereby improving the longevity of the prosthesis has been increased with the split framework.

A finite element study of the effect of mandibular flexure and stress build up on osseointegrated implants was evaluated by Fernando Zarone in the year 2003.<sup>36</sup> A significant amount of stress was noted in the more distal implants and the superstructure at the symphysis as a consequence of mandibular functional flexure. The analysis of the stress distribution generated by the different restorative patterns suggested that a division of the superstructure at the level of the symphysis significantly restored the natural functional flexure of the mandible.<sup>36,37</sup>

Shinkai RSA et al in 2004<sup>38</sup> evaluated the intra- and interrater reliability of a digital image method for linear measurement of medial mandibular flexure in dentate subjects and concluded that digital image method had excellent intrarater and good interrater reliability. This method would be useful in identification of subjects with excessive medial mandibular flexure.

Canabarro SA, Shinkai RSA in 2006<sup>39</sup> evaluated the association among medial mandibular flexure, maximum occlusal force, gender, weight, height and body mass index, and investigated whether subjects with high maximum occlusal force exhibited large medial mandibular flexure values, but the result from the study did not support this hypotheses.

Misch CE in 2008<sup>40</sup> stated that in complete subperiosteal implants, pain upon opening was noted in 25% of the patients at the suture removal appointment when a rigid bar was connected from molar to molar region. When the connecting bar was cut into two sections between the foramina, the pain upon opening was eliminated immediately. This clinical observation does not mean the other 75% of patients did not have flexure of the mandibular arch upon opening. The observation does demonstrate, however, that flexure may be relevant to postoperative complication.

## SUMMARY

It has been viewed by various authors that the mandible yields to the functional requirements of an individual initiated by the stretching of ligaments and tendons in unison with the change in position of the muscles. This physiological phenomena can, however, have a deleterious effect on cross-arch restorations like fixed partial dentures, implant-supported prosthesis or even conventional complete dentures. The incorporation of stress and strain in these prosthesis could be minimized by reducing the mandibular arch width change during impression making by preventing any protrusive movement and/or opening beyond 20 mm, the fabrication of split frame implant prosthesis or separation of a hybrid mandibular denture at the midline, modifications can be done to articulators to allow for mandibular resilience and the use of posterior abutments for support of the cantilever without an anterior connection reduces the potential hazard of a stress induced microdamage.

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