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Review Article

IS MASTICATORY FORCE AT MOLAR REGION ANALOGICAL TO STAPLING MECHANICS AND BOTH BELONGING TO AN UNIDENTIFIED LEVER SYSTEM?

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ABSTRACT

For easy and clear understanding of biomechanics, the inter-relationships of simple machines and musculoskeletal functions have always been attempted and established. The masticatory biomechanics is still under research because there is wide range of findings on masticatory muscles including the lack of complete clarity on their line of actions and lever arms too. As a prospective contribution to advanced research on mastication and management of Temporomandibular joint, there are two innovative concepts discussed in this article; (1) Strong correlation between stapling mechanics and Temporomandibular joint biomechanics at molar region (2) Scope for a new unidentified lever system named as fourth class lever. The principal intent of this article is to share these two innovative concepts to be explored further for practical applications in the field of Physical therapy, Dentistry and Engineering.

KEYWORDS: Stapling mechanics, Mastication at molar region, unidentified lever system.

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INTRODUCTION

The functions of some simple machines and the three identified lever systems are commonly correlated for better understanding of musculoskeletal biomechanics. It appears that the stapling mechanics and the masticatory act at the molar region are similar, that may also belong to an unidentified lever system. Chewing or Occlusion, in a dental context is the phenomenon of interaction of mandible and maxillary teeth, bones, and muscles and this process is also called as mastication and the force acting during this process is known as masticatory force or biting force.[1] Bite force is an important variable to investigate oral function related to occlusal factor, dentition, dentures, and treatment with implants, orthognathic surgery, temporo-mandibular disorders and neuromuscular changes.[2] It was also observed that the biting force was higher in the posterior pairs of teeth and comparatively lower in the anterior pairs.[3]

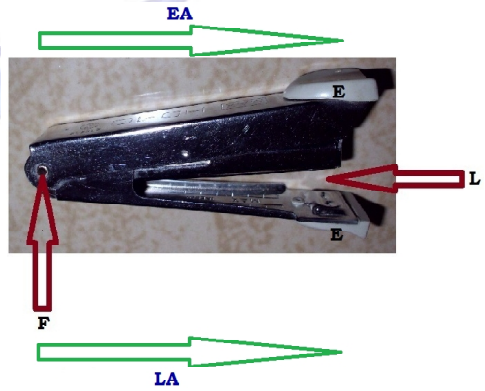
The anatomy and biomechanics of Tempo-romandibular joint (TMJ) is elaborately discussed in various textbooks for Physical Therapists which makes it obvious the role of Physical Therapists in some aspects pertinent to Dentistry. Exercise therapy has long been used in the treatment of TMJ disorders and

therapeutic exercise interventions are prescribed to address specific TMJ impairments and to improve the function of the TMJ and craniomandibular system.[4] The lack of clarity in some aspects of TMJ functions and the demand for detailed researches in the management of TMJ disorders have also been reported. There is a clear need for well-designed controlled trials examining physical therapy interventions for TMJ disorders.[5] The line of action of masticatory muscles is still not clear and the lever action advocates do not always agree on how to analyze the chewing apparatus.[6] Various such literatures indicate the requirement for further better understanding of the TMJ and the masticatory functions. As a prospective contribution to this requirement, there are two innovative concepts discussed in this article; (1) Strong correlation between stapling mechanics and Temporomandibular joint biomechanics at molar region (2) Scope for a new unidentified lever system named as fourth class lever. The principal intent of this article is to share these two innovative concepts to be explored further for practical applications in the field of Physical therapy, Dentistry and Engineering.

Mechanical-Biomechanical analysis and interpretations

Staplers are used in putting together various sheets of paper. Photograph 1 shows a simple stapler version that can be operated chiefly between thumb and index finger as shown in Photograph 2 but it may also demand the auxiliary role of other fingers based on the thickness of sheets to be stapled as shown in Photograph 3. The force requirement is directly proportional to the thickness of the sheets placed at the stapling ends. To understand the lever system of the stapler, the three accredited lever systems should be recalled at this juncture - Figure 1a, 1b, 1c & 1d. The relative locations of the applied force, the resistance, and the fulcrum or axis of rotation determine lever classifications.[7] Lever arm is used to describe the distance from the axis to the point at which a force is applied to the lever, hence effort arm (EA) refers to the lever arm of effort force and resistance arm (RA) refers to the lever arm of the resistance.[8] Resistance arm is also named as load arm (LA) by some authors.[9] All these three lever systems usually possess unequal lengths of effort arm (EA) and load arm (LA) but the first class lever system of some machines like see-saw possess equal lengths of EA and LA- Figure 1a. Mechanical advantage is the ratio of the effort arm to the load arm, thus it is directly proportional to EA and inversely proportional to LA. A lever system is said to be 100% mechanically efficient if the leverage of EA and LA are equal whilst EA>LA can increase the mechanical efficiency beyond 100% (still depending on the load) and EA<LA can decrease the mechanical efficiency below 100%. If we closely examine the stapler (Photograph-1), it possesses a unique feature as shown in Figure-2 with equal leverages of EA & LA on the same side that is quite different from all the three accredited lever systems. The points of application of efforts by the thumb and index finger are in line with the point at which the load gets placed. Not only that, the line joining the points of effort and the point of load also tends to intersect the stapler perpendicularly (Photograph 4 & 5).

Photograph 1: F- Fulcrum of the stapler, E - Effort applying points for the thumb and the index finger, L- place for Load (sheets of paper) at the stapling ends, EA - Effort arm, LA - Load arm.



Photograph 2: Role of the thumb and the index finger when only few sheets of paper are to be stapled.

Photograph 3: Auxiliary role of other fingers when many sheets of paper are to be stapled.

Fig. 1: (a) First class lever with equal lever arms (b) Second class lever (c) Third class lever (d) First class lever with unequal lever arms. F- Fulcrum, E - Effort, EA - Effort arm, L- Load, LA - Load arm.

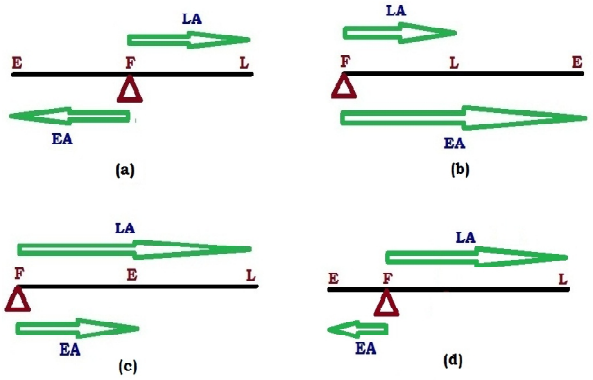


Fig. 2: Effort arm = Load arm, but different from the functions of first class lever shown in Figure 1a.

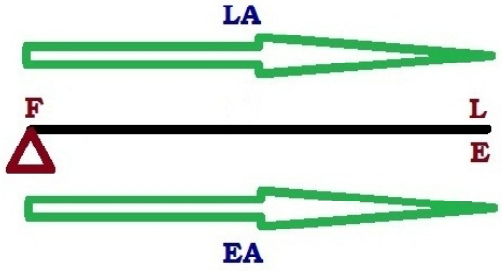


Fig. 3a,3b,3c: Schematically shows the of molar region, maxilla, mandible, Temporomandibular joint (TMJ).

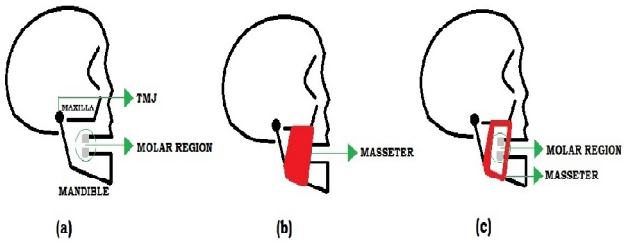
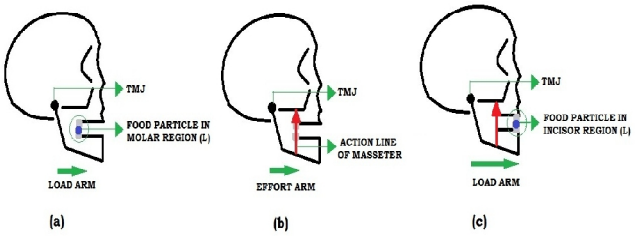
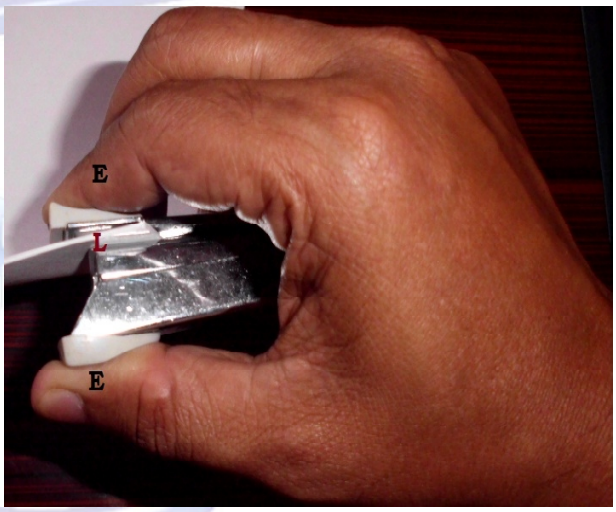


Fig. 4a,4b,4c: 4a & 4b schematically shows the equal leverages of load arm and effort arm of the Masseter that should be matched with Figure-2. Also to be noted is the action line of Masseter perpendicular to mandible. 4c schematically shows the increased load arm as the food particle is placed in the incisor region while the effort arm of the Masseter remains unchanged (Third class lever with unequal lever arms)



Photograph 4: The sheets of paper (L) and the place where the efforts (E) are applied.



Photograph 5: The line joining load (L) and the points of efforts (E) looks perpendicularly intersecting the stapler.

All these interpretations of stapling mechanics should be compared with TMJ function at molar region. The TMJ is one of the most complex, delicate and highly used joints in a human body.[10] Mandibular elevation predominantly helps in mastication at different distances from Temporomanibular joint for different purposes

with the bite forces ranging from very soft to highly forceful. Measuring maximum bite force is an attempt to quantify the force that mandible elevator muscles can make.[11] The role of the Masseter muscle in the mastication is well established. The masseter muscle closes the mouth and is the main muscle used in mastication.[12] The Masseter is a powerful muscle of mastication that elevates mandible.[13] Mansour and Reynik (1975) interpret the behavior of the mandible as a lever system and noticed load & effort on the same side with mechanical advantage at the more posterior portion (molar region).[14] All these literature reviews aptly corresponds with the intended biomechanical analysis at molar region chiefly using the Masseter muscle.

Lever systems of mandible and variations in the length of the load arm have been shown schematically in sagittal view (Figure-3).The location of the food substance from the TMJ determines the length of the load arm which in turn determines the masticatory force requirements. The length of the effort arm and the masticatory force are inversely proportional and also belong to third class lever system. Biting force is inversely varying to the distance of tooth pair from the temporomandibular joint.[3] Also at molar region, better mechanical advantage was noticed by Mansour and Reynik.[14]

Apart from all these foundation knowledge, it is also possible that the concentration of effort taken by Masetter (E) and the food substance (L) in the molar region may be at equal distance from the TMJ with the action line of Masseter perpendicularly intersecting the mandible. If such biomechanical arrangement is naturally possible, then the function of TMJ at molar region will be an unidentified lever system analogical to stapling mechanics (Figure 2,3&4). Hence, the major difference of this unidentified lever system is the presence of load and effort on the same side with equal lever arms or leverages and the line of action of Masseter perpendicular to the mandible lever. The anatomical location of Masseter in the molar region, as shown in various textbooks and search engines, increases the chance of this line of action of Masseter and unidentified lever system with 100% mechanical advantage as long as the Masseter effort (E) can overcome the resistance of the food (L) masticated at the molar region but this has to be experimented because the researches on chewing apparatus and masticatory muscles are still ongoing. The external morphology of the masseter muscle does not match that described in anatomical atlases and textbooks.[15] Studies have reported differences in the morphological disposition of the human masseter muscle stating variations in course and orientation.[16] Thickness and the strength of the masseter correlated significantly with facial morphology.[17] The variations in the structural disposition of the deep and superficial fibres during mastication have been described by some authors.[18] Many difficulties will have to be overcome if the goal of the TMJ research is to develop systems aimed at predicting the TMJ loading and stress analysis during mandibular movements during normal or abnormal neuromuscular control.[19] The mean biting force at molars were found to be the highest as compared to central incisors, lateral incisors, canine and premolar regions.[3] A finer gradation of force and contraction speeds is possible in masticatory muscles than in limb and in trunk muscles.[20] The motor unit territories are small and restricted to specific areas in animal and human masseter and such an organization permits the differential control of separate muscle portions and also the production of internal force vectors with different directions and magnitudes in muscles with broad attachment areas and heterogeneous skeletal lever arms, resulting in differential mechanical actions.[21]

CONCLUSION

TMJ kinetics and masticatory functions can be further researched on the basis of this mechanical-biomechanical analysis and interpretations. Masseter as a whole or certain portion of Masseter with or without possible role of any other masticatory muscles may be linked to this stapling mechanics at the molar region. A simple extra-oral and intra-oral palpation of Masseter contraction during a biting action also confirms tremendous anterior motion of this muscle towards the molar region (in fact the posterior motion of this muscle also can be felt at the

same time during an extra-oral palpation), perhaps to enhance its sagittal plane dimension and perpendicular orientation to the mandible. Stapling mechanics analogy to understand the TMJ biomechanics at molar region can be emphasized in the learning systems of Physical Therapists and Dentists. The new views about the features of an unidentified lever system with equal lever arms on the same side can also be seriously taken in to consideration for consensus, practical applications and accreditation as 'fourth class lever'.

Conflicts of interest: None

REFERENCES

1. Bakke M. Bite Force and Occlusion. Seminars in Orthodontics, 12:120-26, 2006.
2. A Vander Bilt, A Tekamp., H Van der Glas and J Abbink. Bite force and electromyography during maximum unilateral and bilateral clenching. European Journal of Oral Sciences. 2008;116:217-222.
3. B K Biswas S Bag & S Pal. Biomechanical analysis of normal and implanted tooth using biting force measurement. International Journal of Engineering and Applied Sciences 2013;4(2) ISSN 2305-8269.
4. Hertling D, Dussault L. The Temporomandibular joint. In: Hall CM, Brody LT, eds. Therapeutic Exercise: Moving Toward Function. Philadelphia, Pa: Lippincott Williams & Wilkins; 499– 520, 1999.
5. Margaret L McNeely,Susan Armijo Olivo and David J Magee. A Systematic Review of the Effectiveness of Physical Therapy Interventions for Temporomandibular Disorders, Physical Therapy 2006;86(5):710-725.
6. Lin Wang. Biomechanical analysis in Human masticatory system. Applied mechanics and materials 2013;249-250:1294-1300.
7. Susan J Hall, Basic Biomechanics, Chapter-13, Equilibrium and Human movement, Brown & Bench mark, 1991.
8. Cynthia C Norkin and Pamela K Levangie, Joint structure and function, Chapter 1, Page-33, Jaypee Brothers, 2nd Edition).
9. John Low and Ann Reed, Basic Biomechanics explained, Chapter 5, Page-82, Butterwort Heineman, 1996.
10. Alomar X, Medrano J, Cabratosa J, Clavero J, Lorente M, Serra I, Monill J, Salvador A, Anatomy of the temporomandibular joint. Seminars in Ultrasound, CT, and MRI 2007;28:170-183.
11. L J Pereira M.B Gavião, L R Bonjardim, P M Castelo and S Andrade Ada. Ultrasonography and electromyography of masticatory muscles in a group of adolescents with signs and symptoms of TMD. Journal of Clinical Pediatric Dentistry 2006;30:314-319.
12. Hylander W. L. An experimental analysis of temporomandibular joint reaction force in macaques. American Journal of Physical Anthropology 1979;51:433-456.
13. Drake R, Vogl AW, Mitchell A, Grays Anatomy for Students, 927, 2009.
14. Mansour and Reynik. In vivo occlusal forces and moments. I. Forces measured in terminal hinge position and associated moments, J Dent Res. 1975;54(1):114-20.
15. Ju-Young Lee, Jeong-Nam Kim, Ja-Young Yoo, Kyung-Seok Hu, Hee-Jin Kim, Wu-Chul Song and Ki-Seok Koh, Topographic anatomy of the masseter muscle focusing on the tendinous digitations, Clinical Anatomy 2012;25(7):889–892.
16. Goto TK, Langenbach ER, Hannam AG. Length changes in the human masseter muscle after jaw movement. Anat Records 2001;262(3):293-300.
17. Weijs WA, Hillen B. Correlation between cross-sectional area of jaw muscles and craniofacial size and shape. American journal of physical Anthropology 1986;70:423-431.
18. Newton JP, Abel E W, Robertson E M, Yemm R. Changes in human masseter and medial pterygoid muscles with age: a study by computed tomography. Gerodontics. 1987;3:151–154.
19. E.Tanaka, J.H.Koolstra, Biomechanics of the Temporomandibular joint. J Dent Res. 2008;87(11):989-991.
20. T.M.J.J Van Eijden, S.J.J. Turkawsk. Morphology and Physiology of Masticatory Muscle Motor Units, T.M.G.J. Sage publications 2001;12:76.
21. Van Eijden TMGJ, Klok EM, Weijs WA, Koolstra JH. Mechanical capabilities of the human jaw muscles studied with a mathematical model, Arch Oral Biol. 1988;33:819-826.

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