

# Outcomes of increased occlusal vertical dimension on the stomatognathic system: A systematic review.

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## Abstract

**Objective:** To review the outcomes of increasing occlusal vertical dimension (OVD) on the stomatognathic system including temporomandibular joint (TMJ) and masticatory muscles.

**Materials and Methods:** A search in PubMed and MEDLINE was conducted in which the keywords 'occlusal vertical dimension', 'altered vertical dimension', 'increasing vertical dimension', 'rehabilitation', 'adverse effects', 'temporomandibular joint', 'masticatory muscles' and 'stomatognathic system' were included. Literature search was further supplemented with a manual search of peer-reviewed journals and reference lists of selected articles.

**Results:** A total of 50 articles were initially retrieved, but only 13 of them met the specific inclusion criteria. The results of the studies regarding the effects of increasing OVD were screened for the following 4 subcategories: on TMJ, on masticatory muscles, on function and esthetics, and on implant-supported restorations.

**Conclusion:** Considering the limitations of this review, it could be concluded that since the stomatognathic system adapts well, OVD can be safely increased up to 5 mm whenever indicated.

## INTRODUCTION

Occlusal vertical dimension (OVD) is defined as the distance between two points measured in maxilla and mandible when teeth are in maximum intercuspation<sup>1</sup>. This distance is usually measured between nasal tip and gnathion<sup>2</sup>.

According to Matsumoto's classification<sup>3</sup>, OVD can be divided into 3 classes:

**Class I:** The OVD is maintained by tooth contact; this situation extends from complete dental arches to the most extreme situation where only two antagonistic teeth are in contact.

**Class II:** Despite the presence of teeth, none of them come in contact with their antagonist; thus, the OVD cannot be maintained because there is no inter-arch

contact.

**Class III:** Occlusal contact is totally absent as one of the arches is completely edentulous<sup>3</sup>.

OVD is increased or altered in full occlusal rehabilitations for gaining space for the planned restorations<sup>4</sup>. This loss of prosthetic space is frequently caused by tooth wear. Gradual wear of tooth surface is a physiological process<sup>5</sup>, unlike excessive occlusal wear which is pathological<sup>6</sup>. In many cases, loss of OVD is compensated by tooth eruption and alveolar bone growth<sup>7</sup>. Nevertheless, in case of lost OVD, full rehabilitation should be carried out to restore the physiological one.

It is suggested that any alteration in OVD during restorative procedures is deemed unsafe to the stomatognathic system. In fact, some authors assert that expected consequences of increasing OVD include hyperactivity of masticatory muscles, elevation of bite force, and occurrence of temporomandibular disorders<sup>8</sup>. However, basic uncertainties and erroneous concepts regarding the outcomes of increasing OVD still prevail.

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The aim of this systematic review is to assess the outcomes of an increased OVD on the stomatognathic system.

## MATERIALS AND METHODS

### Review Protocol

Our review aimed to analyze a miscellany of studies investigating the outcomes of increased OVD on the stomatognathic system in adult patients. Prior to the review, the protocol was developed and agreed upon by the investigators. The PICO (Population, Intervention, Control, Outcome) format was used in formulating the research question. Investigated subjects, selected from the adult population, received an OVD increase treatment. No control or comparison group was selected, and the reviewed outcome mainly consisted of reviewing the adverse effects. Consequently, the formulated review question was, ‘What are the outcomes of increasing OVD in adults?’

### Search Strategy

An electronic literature search in PubMed and MEDLINE was conducted to identify articles meeting inclusion criteria. Investigators (RAC, LA, and GD) independently searched and reviewed the titles and abstracts of 50 retrieved articles. Outcomes of the following keywords were combined: ‘occlusal vertical dimension’, ‘altered vertical dimension’, ‘increasing vertical dimension’, ‘rehabilitation’, ‘adverse effects’, ‘temporomandibular joint’, ‘masticatory muscles’, and ‘stomatognathic system’. No publication year filter was applied. The electronic search was supplemented with a manual search of the following journals: Journal of Oral Rehabilitation, Journal of Prosthetic Dentistry, and Quintessence International. Furthermore, the references of each selected article were reviewed for possible inclusion.

### Article Selection

For the purpose of the present systematic review, investigators agreed on including experimental studies that reviewed the effects of increasing OVD as well as literature reviews. Animal studies were also considered for review. All articles published before the year 2000 were excluded. Observational studies and case reports were excluded as well (Fig. 1).

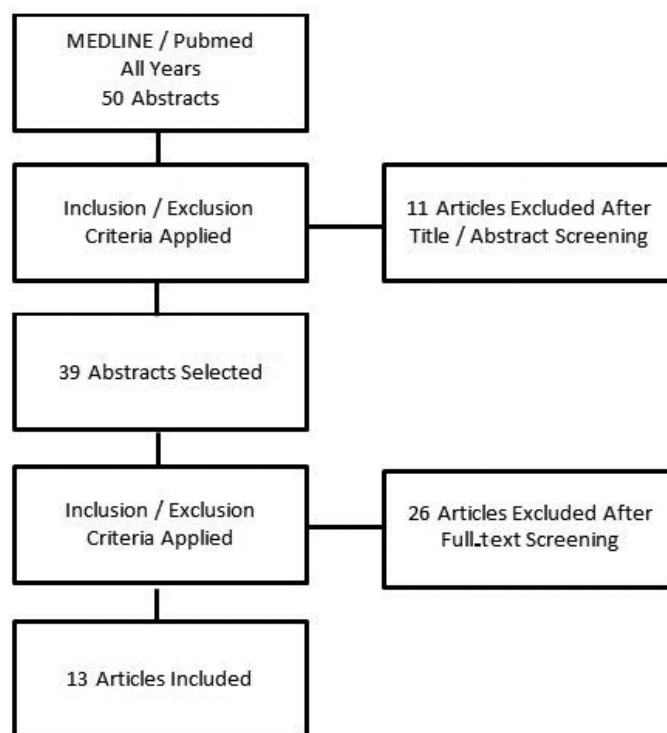


Fig. 1. Flowchart of the selection of studies for our review.

## RESULTS

### 1. Effects of increasing OVD on TMJ

In 2015, Moreno-Hay and Okeson<sup>9</sup> conducted a comprehensive review of the current scientific evidence regarding the effect of altering OVD on producing symptoms of temporomandibular disorders (TMDs); results of the review addressing the effects of increasing OVD did not suggest that increased OVD leads to the development, aggravation, or perpetuation of TMD symptoms. Authors concluded that the stomatognathic system adapts when OVD is increased (< 5 mm) and that further studies are needed in order to better understand the process of adaptation<sup>9</sup>. In some patients, mild transient symptoms of TMD may occur, but they are often self-limiting and without any major consequence.

In a systematic review of 9 studies in which OVD was increased using both fixed and removable methods, Abduo<sup>8</sup> (2012) found that TMD signs and symptoms as well as muscle and joint fatigue had been reported in only one study; the author concluded that, within the limitations of his review, permanent increase of OVD of up to 5 mm, whenever indicated, is a safe and predictable procedure that does not cause any detrimental consequence<sup>8</sup>.

## 2. Effects of increasing OVD on masticatory muscles

Chandu and co-workers<sup>10</sup> (2004) studied the effect of increasing OVD on bite force and masseter electromyography in patients with temporomandibular pain dysfunction disorders (TMPD); they used an interocclusal appliance (IOA) to increase OVD in the test group (TMPD: n = 10) comparing it to a control group (n = 8); they found a decrease in masseter electromyography (EMG) activity during clenching at greater vertical dimensions in patients with TMPD while at-rest EMG activity was greater compared to that of the control group<sup>10</sup>.

In an animal study, Yabushita and associates<sup>11</sup> (2006) investigated the changes in masseter muscle spindle function over periods of 1 day to 8 weeks following OVD increase; thirty-five female albino rats were used; rats were randomly divided into a control group (n = 10) and an increased OVD group (with a 2-mm resin buildup between mandibular and maxillary molars) (n = 25); Results did not show any significant differences among the one-day, two-week, four-week, six-week, and eight-week subgroups in dynamic index (to test the muscle-spindle speed sensitivity) in the control group, while there was a significant decrease of masseter muscle-spindle sensitivity up to 2 weeks after the establishment of an increased OVD condition. Both the dynamic index and the static index (to test the length sensitivity) of masseter muscle spindles were able to recover to their original values in 4 to 6 weeks of increased OVD<sup>11</sup>.

In 2009, Ohnuki and co-workers<sup>12</sup> analyzed the effects of increased OVD on daily activities and fiber-type compositions in jaw muscles; they measured the total duration of daily activity (duty time) in the masseter and digastric muscles of freely moving control group (n=6) and bite-opened rats group (by 3mm) (n=6); they found that bite opening appliance changed EMG activity of masseter and digastric muscles from alternating to overlapping during mastication, without changing the chewing cycle. Authors concluded that increasing the OVD caused muscular hyperactivity in the masseter muscle<sup>12</sup>.

In a study conducted on guinea pigs (2011), Kanayama and associates<sup>13</sup> investigated whether a short-term and reversible increase in OVD, followed by a reduction in OVD to the normal level, resulted

in a time-correlated change in EMG activities of masseter and digastric muscles during chewing; the burst durations of both muscles and chewing rhythm were not significantly affected by the change in OVD during the experimental period. And within the limited recording period of the study, the return of OVD from increased to normal levels did not reverse the increased chewing-related masticatory muscle EMG activity that was induced by the bite-raising treatment<sup>13</sup>.

Terebesi and co-workers<sup>14</sup> (2016) tested 20 healthy subjects to determine if changes in vertical jaw relation induced differential localized recruitment of motor units (MU) in the masseter during biting; the study revealed that small vertical jaw relation changes significantly affected the nature of MU recruitment in the subvolumes of masseter. In addition, EMG activity decreased with raising vertical distance despite the development of a constant bite force<sup>14</sup>.

Nanda and associates<sup>15</sup> (2011) conducted a clinical trial on 10 patients in which they raised OVD with removable splints and measured the EMG of anterior temporalis and masseter muscles prior to the initiation of treatment, immediately after placement of a splint and at subsequent recall visits, with and without the splint; results showed that, after immediate insertion of the splint, an immediate drop in muscle activity was recorded at both postural rest and maximal voluntary clenching. This study advocates using reversible means to increase OVD for a minimum period of 3 months prior to carrying out an irreversible intervention to achieve neuromuscular deprogramming aiming at allowing the muscle to adapt to the new postural position and attain stability in occlusion following splint therapy<sup>15</sup>.

## 3. Effects of increasing OVD on function and esthetics

### - Effects on masticatory function

In the study conducted by Chandu and associates<sup>10</sup> (2004), the effect of clenching was investigated with or without the presence of an inter-occlusal appliance (IOA) on bite force (BF) and masseter EMG in patients with TMPD disorders. As a result, the bite force significantly increased with increasing vertical dimension in healthy subjects<sup>10</sup>.

Olthoff and co-workers<sup>16</sup> (2007) studied the immediate impact of OVD increase on masticatory

performance of dentate individuals, using anatomical maxillary splints. Masticatory performance of the subjects was determined via the use of the chewing test aiming at quantifying the degree of fragmentation of an artificial test food; authors found that masticatory performance was not significantly influenced by anatomical maxillary splints which increased OVD<sup>16</sup>.

MacAvoy and associates<sup>17</sup> (2016) investigated the effects of acute changes in OVD on individual swallowing patterns in 10 volunteers; their investigation demonstrated that as OVD increased, the swallowing duration and the EMG activity of upper and lower lips significantly increased<sup>17</sup>.

Makiguchi and co-workers<sup>18</sup> (2016) conducted a study to investigate the effects of increased OVD on the jaw-opening reflex (JOR) in mature rats; the JOR was recorded from digastric muscle; results showed that an increased OVD affected the latency and amplitude of the JOR, but not its duration. The JOR adapted after 10 weeks of increasing OVD<sup>18</sup>.

#### **- Effects of increasing OVD on esthetics**

Chou and associates<sup>19</sup> (2014) evaluated the effects of increasing OVD of 30 dental students (21-39 years old) with bite splints of 2 mm, 4 mm, 6 mm, and 8 mm thicknesses on the smile's dimension; at second session, the investigators observed an increase in the interlabial gap height, the incisal edge-to-lower lip distance, and the display zone following OVD increase. However, the smile index decreased while the width of the smile and the length of upper lip remained unchanged with an increased OVD<sup>19</sup>.

Orenstein and co-workers<sup>20</sup> (2015) evaluated the effect of increasing OVD on lower face height and on facial esthetics of 20 students with overlays of 2 mm, 3 mm, 4 mm, and 5 mm; results of objective changes in lower face height and the subjective changes in facial esthetics were not statistically significant<sup>20</sup>.

#### **- Effects of increasing OVD on implant-supported restorations**

Ormianer and Palty<sup>21</sup> (2009), in a non-randomized retrospective study, increased OVD of 30 patients who needed either implant- or tooth-supported fixed partial dentures by a range of 3 to 5 mm. A bone loss of 2 mm on buccal aspect of implants was noticed.

There were no other commonly reported mechanical complications such as screw loosening or component fractures; authors concluded that increasing OVD was an acceptable procedure in patients with implant-supported fixed restorations, but precautions should be taken to prevent mechanical problems, peri-implant bone loss, abutment and prosthesis screw loosening, loss of osseointegration, and fractures within the implant-restorative complex<sup>21</sup>.

Abduo and Lyons<sup>22</sup> (2012) found that, despite adaptation of all patients to the increase of OVD, few of them with implant-supported prostheses suffered from prolonged grinding that resolved within 2 to 3 months following the use of an occlusal splint<sup>22</sup>.

## **DISCUSSION**

There is still considerable debate in the literature on treatment modalities used to increase OVD and their effects on stomatognathic system. Throughout decades, it was believed that any alteration of OVD subsequently interferes with the physiology of masticatory system and patient's ability to adapt. Reported consequences of increasing OVD were hyperactivity of masticatory muscles, elevation in occlusal forces, bruxism, and temporomandibular disorders<sup>22</sup>.

In our review, we found that increasing OVD doesn't seem to lead to the development, exacerbation, or perpetuation of TMD symptoms, and that it is relatively safe to increase OVD up to 5 mm without witnessing any detrimental repercussion on TMJ. Both reviews by Moreno-Hay and Okeson<sup>9</sup> (2015) and Abduo and Lyons<sup>22</sup> (2012) concluded that the TMJ adapts to increased OVD. However, these results should be interpreted with caution because of the lack of adequate sample size, control groups, randomization, and long-term follow-up<sup>9,22</sup>.

Literature is filled with controversial results on the effects of increasing OVD on masticatory muscles. In fact, Ohnuki and co-workers<sup>12</sup> (2009), and Kanayama and associates<sup>13</sup> (2011) found that increasing OVD induced an increase in muscle EMG activity while Terebesi and co-workers<sup>14</sup> (2016), and Chandu and associates<sup>10</sup> (2004) found that EMG activity decreased after an OVD increase. The study of Yabushita and co-workers<sup>11</sup> (2006) identified the adaptation of muscle activity 4 to 6 weeks subsequent to OVD increase.

The studies' limitations were related to their design complexity and to the existence of confounding factors.

Moreover, the masticatory performance was not influenced by increased OVD<sup>16</sup>. On the other hand, bite force and swallowing duration increased with the vertical dimension<sup>10,17</sup>. However, these studies had different amounts of OVD increase as well as different treatment modalities.

Furthermore, we found that increasing OVD altered the smile's dimensions<sup>19</sup> but failed to generate a change in lower face height and in the facial esthetics<sup>20</sup>. Thus, clinicians should not increase a patient's OVD in fixed prosthetic rehabilitations based solely on the objective of favorably improving lower face height and facial esthetics. However, the participants included in this study<sup>20</sup> didn't have a loss of OVD preoperatively, and thus didn't have a facial collapse. The results of these studies<sup>19,20</sup> may be questioned, given that the variables measured were cutaneous landmarks and the samples were not homogeneous.

Based on the study conducted by Ormianer and Palty<sup>21</sup> (2009), we inferred that increasing OVD is a safe procedure in patients with implant-supported fixed restorations. While there are few published researches on the ability of patients with implant-supported restorations to adapt to new OVD relationships, it is known that an increase in bite force and periodontal ligament (PDL) absence are two consequences of implant-supported restorations: together, these factors may reduce a patient's ability to accommodate to OVD changes and adversely affect the survival of implants and their restorations<sup>21</sup>.

## CONCLUSION

This review demonstrates that the stomatognathic system (comprising temporomandibular joint and masticatory muscles) may adapt well to OVD increment. Within the limitations of this review, we can claim that the following guidelines are worth to be considered:

First, it is safe to increase OVD in adult patients up to 5 mm in one stage. As to masticatory muscles, they would adapt 4 to 6 weeks subsequent to OVD increase.

Second, clinicians shouldn't increase OVD for the sole purpose of improving esthetics.

Third, patients should be informed of the possible increase in the duration of swallowing.

In conclusion, due to the limited number of available studies and the heterogeneity of the experimental design, randomized, controlled, and adequately designed clinical studies are warranted to validate the outcome of this review.

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