# WITHDRAWN: Evaluation of the Effect of Headgear on the Eruption of Maxillary Third Molars: A Longitudinal Controlled Study.

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The full text of this preprint has been withdrawn by the authors while they make corrections to the work. Therefore, the authors do not wish this work to be cited as a reference. Questions should be directed to the corresponding author.

# Abstract

**Objectives:** To evaluate the short and long term effects of headgear on the third molar eruption space and the eruption status of the maxillary third molar at the long term follow up.

**Materials and Methods:** Records were collected for 33 Class II cases treated with headgear. Three records were collected: before treatment (T1), after treatment (T2), and at the long term follow up (T3). Three corresponding time points were selected for the control sample. Lateral cephalograms were used to measure the distance from the distal surface of the maxillary first molar to pterygoid vertical (PTV). The third molar status at T3 was categorized into five groups as follows: impacted, extracted, erupted, missing, and formation stage.

**Results:** No significant statistical difference was found between test and control groups for U6-PTV at T1 (p= 0.128) and T3 (p= 0.289). However, a significant statistical difference was found at the end of treatment T2 (p=0.000). Regarding molar status, no significant statistical difference was observed (p= 0.108).

**Conclusion:** Headgear caused a temporary decrease in the U6-PTV distance that was recovered later on. This decrease was not observed in the control group and did not affect the eruption of the third molar.

**Clinical Relevance:** The use of headgear to correct Class II malocclusion does not seem to increase the risk of upper third molar impaction.


# Introduction

Third molar impaction has been a concern for a very long time. Among all teeth, the most commonly impacted teeth are the third molars[1, 2] with the maxillary third molars having the highest rate of impaction.[3] The etiology of impaction is variable but could be explained by space deficiency, inadequate skeletal bone growth, unfavorable direction of eruption, root configuration or the large mesiodistal width of the impacted tooth.[4] The space available for their eruption usually depends on the remaining space available after the eruption of all teeth. This retromolar space is affected by the growth potential, the amount of crowding, and the mesial migration of the dentition[5].

In the maxillary arch, posterior arch lengthening occurs by bone apposition at the maxillary tuberosities.[6] Peak maxillary growth is about eight to nine years in girls and ten to eleven years in boys.[7] Growth slows to adult levels, on average, at about 15 years in girls and at about 17 years in boys.[8] That growth could be attributed to further remodeling of the maxillary tuberosities. Vardimon et al in 2010 stated that the growth of the maxillary tuberosity continues to the age of 20 years and that it is directly related to dental development of the 2nd and 3rd molars.[7]

Third molar impaction was not as frequent in ancient skeletons. This could be caused by interproximal wear attributed to the type of food they used to chew resulting in mesial drift of the dentition.[9, 10]

Similarly, extraction of second molars have shown to have a favorable effect on the third molar eruption and the retromolar space.[11, 12] This is due to creating a greater space in the arch posteriorly for the third molar eruption.[13]

Various treatment modalities in orthodontics might have variable effects on the available space for the maxillary third molar eruption. Premolar extraction, for example, might result in mesial migration of the 1st and 2nd molars, increasing the available space for the eruption of 3rd molars and decreasing the likelihood of impaction or eruption in an unfavorable angulation related to the occlusal plane. Moreover, researchers have found that premolar extraction increased the U6 to pterygoid vertical (PTV) distance by 3 mm and reduced the impaction rate of maxillary third molars.[14, 15]

With the theory of the retromolar space in mind, some orthodontic treatment options may negatively affect the available space for the third molar eruption, such as those causing distalization or inhibition of the mesial migration of the dentition whether this is achieved by the use of extraoral devices such as headgears or any intraoral distalizer.[16–18] Furthermore, this might be influenced significantly if there is minimal growth potential or lack of development of the tuberosities[19].

Regarding the effect of headgear, a study conducted by Ricketts in 1960 evaluated the effect of different orthodontic treatment modalities on the growing orthodontic patient, one of which were Class II cases treated with cervical headgear and compared them to a Class II control group. He found that in a 27 to 30 month period, the maxillary first molars were mesialized in the control group and distalized in the headgear group.[20] A similar pattern was seen in another study, however, their sample at the follow up time point was around 17 years of age which is very early to judge the eruption of third molars. A recent study looked at the before and after records of orthodontic patients treated with headgear for the correction of Class II relationship. They stated that the third molar eruption space was less in patients treated with headgear than the control group. [21].

Although some studies evaluated the efficiency of different orthodontic appliances used for distalization and their effect on the U6 to PTV distance[18, 22–24], only a few looked at the effect of headgear on that space[20, 21, 25], and none have evaluated the long term effect after the average age of third molar eruption. Thus, the objective of this study was to examine the short and long term effects of headgear on the eruption space of the maxillary third molars and to examine the actual eruption status of maxillary third molars at the long term follow up.

# Material And Methods

This study was a retrospective study design. The test group was cases with Class II malocclusion treated by cervical headgear. Lateral cephalograms collected before treatment (T1), after treatment (T2) and at the post retention follow up (T3). T1 was taken within 6 months before treatment, T2 was taken on the day of appliance removal, and T3 was taken at least 4 years after T2.

The inclusion criteria included: (1) age at T1 between 8–14 years old, (2) Patients treated with a cervical headgear, (3) good quality lateral cephalometric radiographs with a minimum of 4 years for T3, (4) Class II molars at T1, and (5) Class I molars at T2 and T3. The exclusion criteria included: (1) patients with systemic diseases, hormonal disturbances or craniofacial anomalies, (2) patients with missing permanent teeth, (3) cases where right and left third molars had different eruption status at T3. A sample of at least 15 cases in each group was needed for a power of 80 per cent with a 0.05 type I error to detect a mean difference of 1 standard deviation between the groups. A total of 46 test cases were examined, 13 were excluded for the following reasons: missing data, lateral cephalometric radiograph not clear, missing permanent teeth. To select the control sample, the Bolton-Brush study records were examined for the following criteria: (1) Age at T1, T2, and T3 matched the test group, (2) availability of good quality lateral cephalometric radiographs, (3) Class II molars at T1 and (4) no orthodontic treatment done. The test group had 33 cases, while the control had 18 cases.

Dental charts were examined for age, treatment start date, end date and the post retention record date. Dolphin Imaging® software version 11.95 designed by Dolphin Imaging and Management Solution (California, United States), was used to trace lateral cephalograms by two consultant orthodontists. The distance available from the distal surface of the maxillary first molar to pterygoid vertical (U6 to PTV) on lateral cephalometric radiographs was measured at the three time points for case and control groups. The lateral cephalograms at T3 were examined to identify the status of the maxillary third molar. The status of third molars was categorized as the following: (1) Erupted, if it was at the level of the occlusal plane; (2) Extracted, if it was present at T2 but not present at T3; (3) Impacted, if full root formation was achieved while it was above the occlusal plane; (4) Missing, if there were no signs of the tooth bud at T1, T2 and T3; (5) At the formation stage, if there was incomplete root formation at the T3 record. The cases selected had to have a similar third molar category on both the right and left sides of each case.

# Statistical Analysis

Intra-examiner and inter-examiner reliability testing were done using Cronbach's alpha test. Each examiner traced 10 radiographs twice 2 weeks apart. The test and control groups were examined for differences at T1 for the study variable (U6-PTV) using independent t test and at the three time points for age using repeated-measures analysis of variance to ensure that they were comparable at baseline. Mean and standard deviation for the treatment times of the test group were calculated. Means and standard deviations for U6-PTV at T1, T2 and T3 were calculated for both groups and statistical significance was tested using independent t test. Thereafter, repeated-measures analysis of variance tests was done to test for differences in each group for U6-PTV at the three time points, while Pearson Chi-Square was performed to study the difference in third molar status between the two groups. The level of statistical significance was set at $P < 0.05$. The statistical analysis was done using Statistical Package for the Social Sciences (IBM SPSS Statistics for Windows, Version 22.0).

# Results

Intra-examiner and inter-examiner reliability scores were 0.975. Table 1 shows the baseline comparison between means and standard deviations of the test and control groups for the age at the three time points and at T1 for U6 to PTV. No significant statistical difference between the two groups was found, indicating the proximity of age of the two groups at three time points as well as the similarity of the U6-PTV distance at the start point; so, the two groups could be further compared for the study variable. Average headgear treatment time was 3 years ± 1.37. Furthermore, the average post retention time for the cases was 8.3 years ± 4.2.

Table 1
Baseline comparisons between both groups.

| | **U6PTV (T1)** | **Age at T1** | **Age at T2** | **Age at T3** |
|---|---|---|---|---|
| Cases (n = 33) | 16.50 (4.03) | 11.2 (1.6) | 14.4 (1.9) | 22.7 (4.3) |
| Control (n = 18) | 14.58 (4.90) | 11.1 (0.3) | 14.12 (0.3) | 28.3 (13.1) |
| P value | 0.128 | 0.613 | 0.526 | 0.091 |

Table 2 shows the comparisons between the test and control groups for U6-PTV. U6-PTV decreased as a result of headgear treatment from T1 to T2, but increased again from T2 to T3. The control group showed a continuous increase from T1 to T3. In addition, comparing the mean difference between the test group and the control group from the treatment initiation to the follow-up record (T3-T1), U6-PTV distance increased 2.68 mm in the test and 6.31 mm in the control group. This mean difference was not statistically significant.

Table 2
Means and standard deviations of U6 to PTV at the three time points, as well as the mean difference in U6-PTV in mm between each two time points for the test group and the control group.

| | **U6-PTV distance** | | | **U6-PTV (Mean difference, SD)** | | |
|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | T2-T1 | T3-T2 | T3-T1 |
| Cases (n = 33) Mean (SD) | 16.50 (4.03) | 13.24 (4.27) | 19.18 (4.42) | -3.26 (4.45) | 5.94 (5.25) | 2.68 (4.42) |
| Control (n = 18) Mean (SD) | 14.58 (4.90) | 19.30 (3.12) | 20.83 (6.52) | 4.77 (4.72) | 1.54 (5.1) | 6.31 (3.99) |
| P value | 0.128 | 0.000* | 0.289 | 0.000* | 0.004* | 0.058 |
| *Statistical significant at p < 0.05 | | | | | | |

When looking at the third molar status in Table 3, there was no significant statistical differences between the test group and control group for this variable. Furthermore, an attempt was made to combine the impacted and extracted cases together since the reason for extraction is unknown to us. Thus, combining

them would cover any possible chances that they were extracted because of impaction, but still there was no significant statistical difference between the test group and the control group after this combination.

Table 3
Molar status at T3 presented as frequency and percentage.

| | 3rd Molar Status at T3: Frequency (percentage) | | | | | |
|---|---|---|---|---|---|---|
| | Impacted | Extracted | Erupted | Missing | Formation | Impacted +Extracted |
| Cases (n = 33) Mean (SD) | 18(54.5%) | 5(15.2%) | 5(15.2%) | 4(12.1%) | 1(3%) | 23(69%) |
| Control (n = 18) Mean (SD) | 6(33.3%) | 7(38.9%) | 5(27.8%) | 0 | 0 | 13(72.2%) |
| P Value | 0.108 | | | | | 0.298 |

# Discussion

This study aimed to examine the short and long term effects of headgear treatment on the space available for the eruption of maxillary third molars and the status of eruption of maxillary third molars at the post retention follow-up. The U6 to PTV distance has been used to measure the available retromolar space in our study as well as previous studies.[14, 18, 20, 25, 26] A study by Miclotte et al in 2017 evaluated the immediate headgear effect on the eruption of maxillary third molars. They found that the U6 to PTV distance decreased after headgear treatment by around 1 mm compared to the control group. The control experienced an increase of 1.9 mm in this distance while the cases experienced an increase but only of 0.9 mm and they did not evaluate the U6 to PTV distance at a follow-up time point.

Our findings show that the available space for the eruption of the maxillary third molars decreased as a result of headgear treatment, but this decrease was temporary as it increased again after cessation of headgear treatment at the long-term follow-up time point. In the test group, it decreased 3.96 mm and then increased 5.94 mm at the third follow up record, whereas in the control group the distance increased 4.77 mm and then increased again but only 1.54 mm at the third follow-up time point. The net increase for test and control groups was not statistically significant. Thus, it appears that this distance follows the normal growth pattern which is apposition of bone at the tuberosity[6], and even though headgear treatment has restrained this forward growth, the maxilla recovers after the stop of headgear use and starts gaining the horizontal bone length that was ceased at the time of headgear use. This is coincident with the study by Ricketts in 1960 who found that the headgear treated cases showed distalization of 1.3 mm while the control group showed mesialization by 2 mm.[20] In addition, a similar pattern was seen in a study by Mitani and Brodie in 1970 where they found that the controls showed a continuous increase of about 6 mm from the age of 8 to 16 years, whereas the cases showed stability in the U6 to PTV distance

during headgear treatment, then it caught up with an increase in this distance at the follow-up record of about 2.7 mm. However, It is important to note that their sample was much younger than ours at the follow-up time point so that might explain the difference in the amount of increase between our results and theirs.[25]

A study by Ganss et al in 1993 stated that 60 per cent of the maxillary third molars will erupt if the U6-PTV was 25 mm and only 10 per cent will erupt if the space was less than 25 mm.[27] In addition, another study stated that the U6-PTV should be at a minimum of 18 mm for the maxillary third molars to erupt. This was not true for our study. Only 33 per cent of the cases that had U6- PTV greater than 25mm and only 23.5 per cent that had U6-PTV greater than 18 mm had erupted. Furthermore, there were cases where the maxillary third molar had erupted in a space as small as 12 mm. We also observed third molars that had been impacted in a space as big as 26 mm. This is coincident with the study by Kim et al in 2003 which experienced similar results with third molars erupting in a space less than 13 mm and being impacted in a space as big as 24 mm.[14] Furthermore, 88 per cent of the maxillary third molars erupted in a space less than 25 mm which coincides with Kim et al who observed 70 per cent of maxillary third molars erupting in a space less than 25 mm.[14] This indicates that there are definitely variables other than the retromolar space that play a significant role in the eruption of maxillary third molars.

The average age of maxillary third molar eruption has been recorded to be between 17 to 21 years of.[28] In our sample, the average age of both groups at T3 was 25.5 years. Most of the study sample was older than 17 years except for 2 of the test cases: one was 16.7 and the third molar was diagnosed as erupted, and the second was 15.2 and the third molar was in the formation stage.

Evaluating the third molar status from a panoramic radiograph would have been a better diagnostic tool but multiple records were missing. We used visual evaluation on the cephalometric radiograph which has its limitations due to the overlapping of the right and left sides.

There was no significant statistical difference between the test group and control group in the maxillary third molar status at T3. Among the control group, 39.9 per cent had impacted third molars, whereas only 15.2 per cent of the treated cases were impacted. Moreover, 33.3per cent of the controls had third molars extracted while 54.5 per cent of the cases were extracted. Although this was not statistically significant, this difference in percentage could probably be attributed to the care those treated patients were receiving from their orthodontist. This close monitoring could have led to the referral for extractions when impactions were suspected. Unfortunately, we do not have the justification for extractions in the test and control groups, thus, an effort was made to normalize this problem by combining the impacted and extracted groups together. This resulted in the controls having 69 per cent while the cases having 72 per cent of impacted plus extracted third molars. However, this was still not significant statistically.

# Conclusion

Considering the study limitations, the following conclusions could be drawn:

1. There is a transient decrease in the retromolar space as a result of headgear treatment that would recover later with normal growth.
2. The normal growth pattern of the U6 to PTV distance as observed from the control group is a continuous increase.
3. The use of headgears did not increase the rate of impaction of the maxillary third molars in this study sample.
4. There is a need for further prospective longitudinal studies with a larger sample size to provide insights and more information about this subject.

# Declarations

**Author Contribution:**

S.G: suggested the research idea, performed cephalometric analysis, wrote the conclusion, and revised the manuscript.

A.A: did data collection, and wrote the literature review and discussion.

S.A: did data collection, and wrote the literature review and discussion.

A.N: performed statistical analysis, prepared the tables, and wrote the results.

R.A: performed cephalometric analysis and revised the manuscript.

A.L: wrote materials and methods and edited and revised the manuscript.

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**Ethics Approval and Consent to Participate:** No need for consent since it is a retrospective study looking at previously acquired patients' records.

**Conflict of Interests:** The authors declare that they have no conflict of interest.

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