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RESEARCH ARTICLE

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Mandibular second molar extraction: A retrospective cohort study of spontaneous occlusal changes in adolescent patients

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Abstract

Objectives: Evaluate long-term spontaneous occlusal changes following L7 extraction in adolescent patients.

Materials and Methods: Study models of 144 participants (63 males, 81 females) retrospectively assessed prior to L7 extraction (9–16 years old; T1) and following L8 eruption (14–25 years old; T2). All received upper fixed appliances. A sub-group (n = 86) received no lower fixed appliances and acted as controls. Occlusal changes were compared between treatment (lower fixed appliance) and control (no lower fixed appliance) groups using PAR index. At T2, L8 occlusal outcome was assessed using ABO grading system.

Results: Mean follow-up period 6 (SD 2) years. At T1, lower scores observed in control group for Lower Anterior ($P < .001$), Midline ($P = .033$) and Lateral Segments ($P = .040$) components. At T2, lower scores continued being observed in control group for Midline ($P < .001$) and Lateral segment ($P = .019$) components. Higher decrease in Lower Anterior PAR scores observed in treatment group (<.001) with comparable scores between groups at T2 ($P = .057$). Similar PAR score changes between groups for Lateral Segments, Overjet and Overbite components. At T2, no significant difference observed in Total PAR score reduction between control (83%) and treatment (82%) groups. Good-to-acceptable occlusal outcome of the L8 observed in 81.55% of cases at T2 with no difference between groups.

Conclusion: In growing patients with mild mandibular crowding, extraction of L7 followed by upper fixed appliance therapy, leads to favourable occlusal changes over a 6-year follow-up period, with or without lower fixed appliance therapy, being an alternative extraction protocol where lower fixed appliance therapy is not recommended.

KEYWORDS
crowding, extraction, occlusal changes, orthodontics, second molars

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1 | INTRODUCTION

The extraction of second molars in the developing dentition and the reported beneficial effects and limitations on the occlusion have long been a controversial subject in the orthodontic literature, with a variable evidence-base for their rationale.

Extraction of upper second molars is a relatively well-recognized accompaniment to buccal segment retraction in selected patients.[1,2] In contrast, the indications for extracting the lower second molars are less clear, partly explained by the less predictable pattern of eruption of the accompanying third molar, compared with upper third molar.[3,4] A further reason is the lack of well-documented long-term evidence as to the benefits this extraction pattern offers to the mandibular dental arch with or without accompanying fixed appliance therapy.[4]

Second molar extraction approach is based on the assumption that the third molar will spontaneously erupt in a more mesial position and will function as a substitute for the extracted second molar. Two important concerns are the size of the third molars and the need for orthodontic alignment after eruption. The upper third molars are predicted to always be smaller in size than the first and the second molars.[5] In the mandible, there is no stereotypic pattern of molar proportions, and the third molars are predicted to be smaller (44.9%), larger (34.2%) or equal to the first molars in size (21%).[5] Maxillary third molars are more likely to erupt into acceptable position[2,4] Conversely, mandibular third molars post-eruptive inclination is rarely identical to the one of the second molars before extraction, assessed on panoramic radiographs.[4,6]

Extraction of lower second molars may allow for spontaneous relief of small amount of anterior crowding[7] and has been advocated in well aligned arches to prevent third molar impaction[8–12] as well as to minimize late crowding.[9,11] Whilst mild buccal segment crowding shows spontaneous resolution, the same could not be reliably expected in lower labial segment alignment.[13]

Mild malocclusions are increasingly being treated on a non-extraction basis[11,14] but are these treatments always non-extraction as third molars are often later removed?[15]

Extraction of lower second molars, with accompanying fixed appliance treatment, has been reported to be beneficial in solving cases with lower arch irregularity,[16] open bite, buccal crossbite in the molar area[4] and non-surgical Class III cases.[17] However, it is unclear whether the extraction of these teeth without fixed appliance therapy would give a similar result.

The present study aims to assess the long-term spontaneous occlusal changes, following extraction of mandibular second molars. The null hypothesis is that the spontaneous occlusal changes occurring in the mandibular arch after the extraction of lower second molars not followed by lower fixed appliances are similar to the occlusal changes taking place after extraction of the lower second mandibular molars followed by lower fixed appliance therapy.

2 | MATERIALS AND METHODS

In this retrospective, cohort study, records of 178 participants, aged 9–16 years, presenting either a Class I or a Class II malocclusion were screened. They were consecutively treated with extraction of mandibular second molars between 1993 and 2012 in a private practice by a single operator that donated the material for research purposes when retiring. The rationale for extracting mandibular second molars were: (1) resolve lower crowding; (2) increase the incisor overbite; (3) facilitate the eruption of the developing third molars; (4) an attempt to prevent development of late crowding in the absence of bonded retainers.

The study inclusion criteria were: (1) extraction of both lower second molars (L7) after radiographic confirmation of the presence of lower third molars (L8) with crown formation and prior to root development; (2) prior to extractions all mandibular permanent teeth including L7 were erupted; (3) available plaster models prior to treatment (T1) and following L8 eruption (T2).

The exclusion criterium applied to this sample was absence of plaster models at any of the investigation periods. Finally, the material consisted of 144 participants.

All participants received upper fixed appliance treatment (pre-adjusted edgewise brackets, '022 slot). A Headgear was used where upper molar distalization or anchorage control was required. Prior to the extraction of L7, subjects with a class II malocclusion and an increased overjet (>7 mm) had a preliminary phase with an Andresen Activator. An Activator was used as a retainer for 1.5 years. No fixed retainers were bonded in either jaw. The participants were followed-up until eruption of the L8. Panoramic radiographs and study models were taken both prior to extraction of the L7 (T1) and when the L8 had erupted (T2). All participants had their L8 erupted. However, not all L8 were in functional occlusion, with interproximal and occlusal contacts with the adjacent and opposing molars, as participants comprised an age group too young to be studied regarding third molar occlusal assessments in all subjects.

Participants were divided into two groups based on whether they received orthodontic treatment in both jaws (Treatment group, T), or fixed appliances in the maxilla but not in the mandible (Control group, C). The rationale for not treating the mandible was mild lower anterior crowding (less than 6 mm) accompanied by a dental overbite less than 4 mm.

Occlusal changes, as a primary outcome, were assessed using the Peer Assessment Rating (PAR) index and compared between groups. A blinded examiner (LF), previously calibrated in the PAR index, performed all the measurements. The PAR index provides a reliable and valid weighted index of treatment need and importantly outcome, allowing the degree of occlusal improvement following orthodontic treatment to be calculated.[18] The following Weighted Components were assessed: Upper Anterior Alignment (UA); Lower Anterior Alignment (LA); Overjet (OJ); Overbite (OB); Midline Deviation (MID) and occlusion in the Lateral Segments (LS). For the assessment of the lateral occlusion, the fit of the

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TABLE 1 Bland–Altman plots with limits of agreement (LO) for the continuous outcomes and the kappa statistic for the categorical outcomes.

Outcome	Mean difference or Bias (LO)	Outside the LO
PAR upper front	−0.09 (−0.86, 0.68)	23/144 (15.97%) at values 1 or −1
PAR lower front	−0.10 (−0.75, 0.54)	17/144 (11.81%) at values 1 or −1
	Kappa	**Agreement**
PAR Right lateral segment	0.81	86.11%
PAR Left lateral segment	0.85	88.89%
PAR Overjet	0.87	90.28%
PAR Overbite	0.83	88.89%
PAR Midline	0.89	93.06%
L8 occlusal outcome	0.67	80.28%

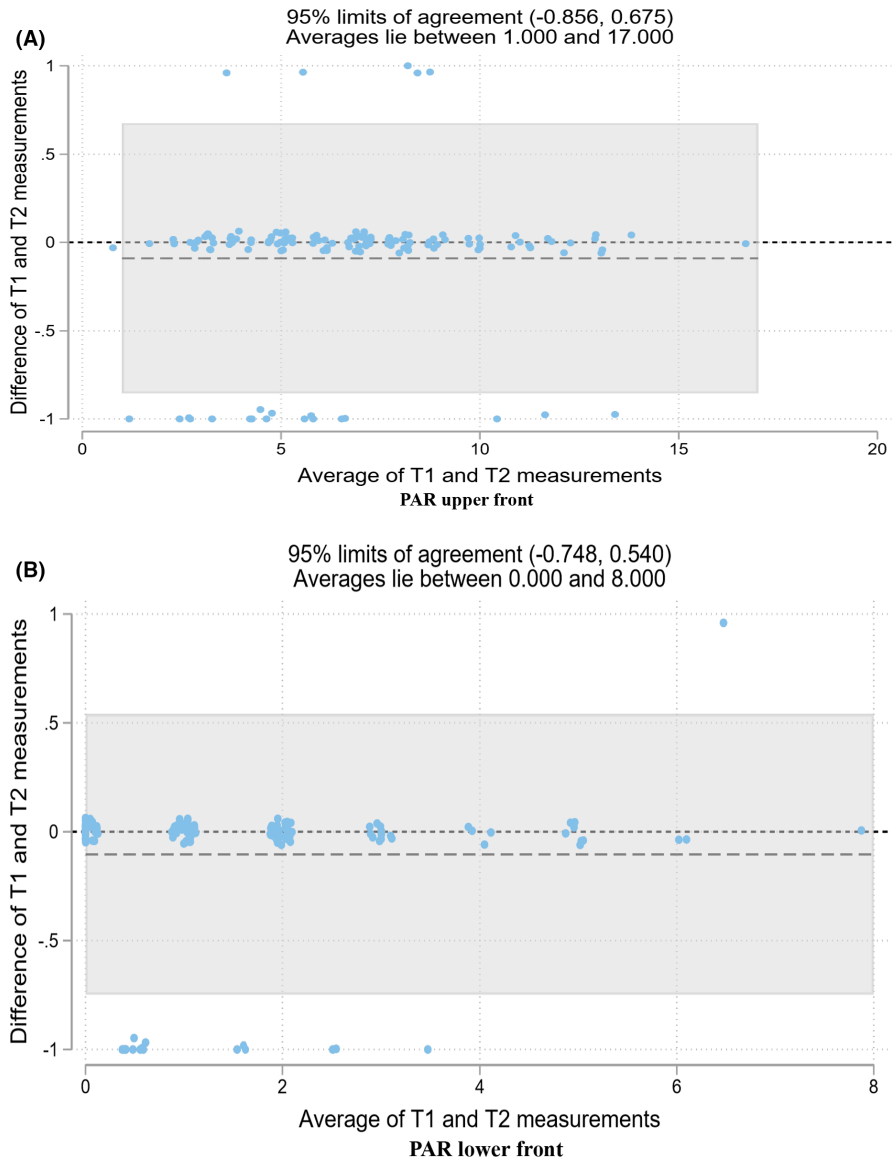

FIGURE 1 Bland–Altman plots with limits of agreement for PAR upper front (A) and PAR lower front (B).

teeth in all three planes of space was recorded from the canine to the first permanent molar on the right and left sides. The following weightings to the PAR components were applied[19]: UA (1); LA (1); OJ (6); OB (2); MID (4); LS (1). Weighted PAR scores at T1 and at T2, the changes (T2-T1) and the percentage change (T2-T1/T1) were calculated.

The occlusal outcome of the L8 at T2, as secondary outcome, was assessed with an adaptation of the American Board of

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TABLE 2 Subject characteristics of the control (n = 86) and treatment (n = 58) groups, with statistical testing of group comparisons at start of treatment (T1).

	Control group[a]		Treatment group[a]		
Subject characteristic	Boys	Girls	Boys	Girls	*P*-value[b]
Gender	40 (47%)	46 (53%)	23 (40%)	35 (60%)	.42
Age T1 (years)	12.4 (1.8)	12.1 (1.6)	12.5 (1.3)	12.2 (1.8)	.47
Treatment duration (years)	5.6 (1.7)	6.4 (2.2)	6.2 (2.1)	6.3 (1.8)	.39
Overjet T1 (mm)	5.76 (2.42)		6.07 (2.52)		.40
Angle Class					
Class I	25 (29%)		24 (41%)		.13
Class II	61 (71%)		34 (59%)		
Activator	29 (34%)		19 (33%)		.90
Headgear	49 (57%)		29 (50%)		.41

[a]n (%); Mean (SD).

[b]Pearson's Chi-squared test; Wilcoxon rank sum test; Fisher's exact test.

Orthodontics (ABO) Objective Grading System for scoring dental casts.[20] Displacements were measured with an ABO measuring gauge. Four criteria were used: (1) alignment – the mesiobuccal and distobuccal cusps of the L8, L6 and premolars in the same mesiodistal alignment or within 1 mm; (2) marginal ridge – the marginal ridges of the L8 and L6 at the same vertical level or withing 1 mm; (3) interproximal contact–the mesial surface of the L8 in contact with the distal surface of L6 or within 1 mm; (4) buccal overjet – the buccal cusps of the L8 positioned in the centre of the occlusal surfaces of the antagonist teeth buccolingually or within 1 mm. Three categories were created based on the occlusal outcome of the L8: (G) good, when all the 4 conditions were met; (A) acceptable, if at least two of the conditions were met; (P) poor, where neither the criteria for G nor A were met.[2]

A priori sample size estimation was not undertaken in view of the lack of available evidence and meaningful standardized difference.

2.1 | Statistical analysis

Descriptive statistics were calculated for the participant characteristics by treatment arm. The Wilcoxon Sum Rank Test or Pearson's Chi^2 test were used to compare participant characteristics between treatment groups. Ordinal logistic regression was used to examine the effect of treatment of the lateral segment PAR score at the end of treatment adjusted for age at baseline, gender and lateral segment PAR score at baseline. Median regression was used to examine the effect of treatment of the lower anterior PAR score at the end of treatment adjusted for age at baseline, gender and lower anterior PAR score at baseline. Ordinal logistic regression was used to examine possible association between group and L8 occlusal outcomes (3-level ordinal), after adjusting for tooth (38 or 48), age at baseline and treatment duration. Robust standard errors were used to account for clustering due to multiple observations within patients. The level of statistical significance for all tests was pre-specified at 0.05. Analyses were performed in Stata 18.0 (Stata Corp, College Station, TX, USA).

2.2 | Error of the method

Peer Assessment Rating (PAR) variables were measured twice, by the same operator (LF) with an intervening interval of 4 weeks. Bland–Altman plots with limits of agreement (LO) were calculated for the continuous outcomes and the kappa statistic for the categorical outcomes. Good agreement was observed for both continuous and categorical outcomes. The values outside the limits of agreement were either 1 or −1; those deviations were not clinically important (Table 1, Figure 1).

The intraexaminer agreement for the L8 occlusal outcome was accessed with the kappa statistic. Twenty randomly selected participants were measured twice for the L8 occlusal outcome by the same operator (LF), with 2 weeks interval. Intraexaminer agreement was high at 80% and kappa was 0.67 (Table 1).

3 | RESULTS

3.1 | Baseline characteristics

Complete data sets were available for 144 participants, of which 58 (23 [40%] male) received lower fixed appliance treatment and 86 (40 [47%] male) participants acted as controls.

No difference in gender distribution between the treatment and control groups was observed. The mean age of participants at T1 was 12 (SD 1.6) years old and the mean follow-up period (T1-T2) 6 (SD 2.0) years with no difference between groups (Table 2). There was no significant difference in malocclusion distribution between groups, with Class II malocclusion predominating within each group (59% treatment group; 71% in the control group; Table 2). The

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percentage of participants given an Activator prior to extraction of the lower second molars or a Headgear appliance during treatment was similar in both groups (Table 2).

3.2 | Occlusal analysis

At baseline (T1), lower scores were observed in relation to the following PAR Components: Lower Anterior ($P<.001$), Midline ($P=.033$) and Lateral Segments ($P=.040$) in the control group (Table 3). These differences accounted for the significantly lower initial Total PAR score observed in the control group compared to the treatment group ($P=.001$; Table 3).

Overjet was the Component that most contributed to the Total PAR score in both groups, with no significant difference observed (Table 3).

At follow-up (T2), the mean PAR scores decreased notably in both groups (Table 3; Figure S1). A high percentage reduction in the Total PAR score was observed in both control (83%) and treatment (82%) groups, with no significant different scores between groups at T2 ($P=.83$; Table 3; Figure S1H).

At follow-up, significantly lower scores continued to be observed in the control group for the Midline ($P<.001$) and Lateral segments ($P=.019$) components (Table 3). Changes in PAR scores for the lateral segments were similar for both groups (Table 3; Figures S1F and S2A). Treatment did not seem to be a significant predictor for the lateral segment PAR score at T2 ($P=.33$, Table 4A). Similar changes in PAR scores were also observed for the Overjet and Overbite components (Table 3; Figure S1C,D). A higher decrease in the Lower Anterior PAR scores was, however, observed, in the treatment group, compared to the controls ($P<.001$, Table 3; Figures S1B and S2B) but comparable scores were observed between groups at T2 ($P=.057$; Table 3). The adjusted median lower anterior PAR score was 1 unit lower for the treated vs. the untreated group ($P=.01$, Table 4B) indicating an effect of treatment on the Lower Anterior PAR score at follow-up.

3.3 | Lower third molar occlusal analysis

A total of 288 lower third molars were evaluated in all 144 participants. The L8 occlusal outcome categories per group is shown on Table 5A with 81,55% of the total sample presenting good-to-acceptable occlusal outcome. The results of the ordinal logistic regression model are shown in Table 5B. In the adjusted model, the odds of belonging to a poorer occlusal outcome is 25% lower for the control group vs treatment group [OR: 0.75, 95% CI: 0.43, 1.29], a not statistically significant finding ($P=.29$).

4 | DISCUSSION

The present study aimed to address some of the current shortcomings in the literature. Occlusal changes, in a sample of growing

TABLE 3 Weighted Peer Assessment Rating (PAR) index scores in the treatment (T; n = 58) and control (C; n = 86) groups, with statistical testing of group comparisons.

	C[a]	T[a]	*P*-value[b]
T1			
UA	6.50 (3.00)	6.00 (4.00)	.65
LA	3.00 (2.75)	6.00 (2.89)	<.001
OJ			
0	22 (26%)	11 (19%)	.57
6	22 (26%)	13 (22%)	
12	20 (23%)	19 (33%)	
18	19 (22%)	11 (19%)	
24	3 (3.5%)	4 (6.9%)	
OB			
0	19 (22%)	5 (8.6%)	.12
2	33 (38%)	28 (48%)	
4	33 (38%)	23 (40%)	
6	1 (1.2%)	2 (3.4%)	
MID			
0	44 (51%)	19 (33%)	.033
4	30 (35%)	22 (38%)	
8	12 (14%)	17 (29%)	
LS			
0	28 (33%)	16 (28%)	.040
1	20 (23%)	8 (14%)	
2	28 (33%)	16 (28%)	
3	7 (8.1%)	9 (16%)	
4	1 (1.2%)	7 (12%)	
5	2 (2.3%)	2 (3.4%)	
Total PAR	26 (14)	31 (18)	.001
T2			
UA	1.00 (2.00)	1,00 (2.00)	0.057
LA	1.00 (2.00)	1.00 (2.00)	0.057
OJ			
0	80 (93%)	42 (72%)	.001
6	5 (5.8%)	15 (26%)	
12	1 (1.2%)	1 (1.7%)	
OB			
0	43 (50%)	28 (48%)	.86
2	40 (47%)	29 (50%)	
4	3 (3.5%)	1 (1.7%)	
MID			
0	83 (97%)	45 (78%)	<.001
4	3 (3.5%)	12 (21%)	
8	0 (0%)	1 (1.7%)	

(Continues)

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TABLE 3 (Continued)

	C[a]	T[a]	*P*-value[b]
LS			
0	26 (30%)	16 (28%)	.019
1	24 (28%)	9 (16%)	
2	29 (34%)	17 (29%)	
3	2 (2.3%)	10 (17%)	
4	2 (2.3%)	4 (6.9%)	
5	2 (2.3%)	1 (1.7%)	
7	1 (1.2%)	1 (1.7%)	
Total PAR	5.0 (4.0)	5.5 (7.0)	.35
Changes T2-T1			
UA	−5.0 (4.0)	−5.0 (4.0)	.63
LA	−2.0 (3.0)	−4.5 (5.0)	<.001
OJ			
−24	3 (3.5%)	3 (5.2%)	.53
−18	18 (21%)	8 (14%)	
−12	18 (21%)	13 (22%)	
−6	22 (26%)	21 (36%)	
0	25 (29%)	13 (22%)	
OB			
−6	1 (1.2%)	2 (3.4%)	.76
−4	10 (12%)	8 (14%)	
−2	38 (44%)	28 (48%)	
0	34 (40%)	19 (33%)	
2	1 (1.2%)	1 (1.7%)	
4	2 (2.3%)	0 (0%)	
MID			
−8	10 (12%)	12 (21%)	.004
−4	31 (36%)	23 (40%)	
0	45 (52%)	18 (31%)	
4	0 (0%)	5 (8.6%)	
LS	0.00 (1.00)	0.00 (1.75)	.51
Total PAR	−21 (12)	−23 (16)	.014
Percentage change			
Total PAR	83 (20)	82 (19)	.83

Weightings to the PAR components: UA (1), LA (1), OJ (6), OB (2), MID (4), LS (1).

[a]n (%); Median (iqr).

[b]Pearson's Chi-squared test; Wilcoxon rank sum test; Fisher's exact test.

subjects undergoing the extraction of the mandibular second molars were evaluated and compared, between those with accompanying lower fixed appliance treatment and those without, the latter providing a meaningful control group.

Although retrospective in design, the sample demographics in both groups were comparable at baseline and represented the prevalence of malocclusion in the general population, with class II malocclusion being predominate within each group as such the results remain generalizable. The treatment approaches were also comparable with a similar percentage wearing an Activator before the extraction of L7 and a Headgear after the extraction of L7. The activator use might have contributed to proclination and alignment of the lower anterior segment, confusing one of the issues investigated in the study which is the improvement in dental alignment brought about by second molar extraction. However, activator was used in the mixed dentition, prior to extraction of the lower second molars, and the plaster models at T1 were obtained after lower second molar eruption, therefore, after the use of activator. Also, the distribution of activator was similar in both groups and the influence would have been similar for both groups. The Headgear is an appliance commonly used in orthodontic treatment with fixed appliances and the proportion of Headgear use was also similar in both groups.

Morphological significant differences were detectable between groups at baseline. The initial lower PAR score for the control group compared to the treatment group largely reflected the lower level of mandibular anterior crowding and midline deviation observed and the justification for not undertaking lower arch fixed appliance therapy in conjunction to the upper arch (Figure S3A,B). The Midline Component score is a reflection of the Lower anterior Component score at baseline.

The PAR index provides a reliable and valid weighted index of treatment need and treatment outcome.[19] Furthermore, it quantifies the extent of the deviation from an ideal dental arch and occlusion and provides a means of quantifying occlusal changes resulting from treatment. The current sample demonstrated baseline weighted Total PAR scores of 31 and 26 for the treatment and control groups, respectively, representing high values of treatment need.[19]

Previous studies have shown that a 70 per cent reduction in PAR score is considered as greatly improvement in terms of occlusal factors.[18,19,21] In the present study, a 83 and 82 per cent reduction was observed in the control and treated groups, respectively. These figures are equally representative of the reported 78% PAR reduction in a sample treated by Norwegian Orthodontists.[22]

At follow-up, no difference in the lower anterior Component PAR score were observed between groups due to a higher decrease in the PAR scores in the treatment group compared to the controls (Table 3). Whilst this was an expected finding, it was especially interesting to observe a spontaneous improvement in lower anterior crowding in 75% of the controls over time (Figures S1B and S2B). Spontaneous improvement of anterior crowding in the mandible (Figure S3B,C) is consistent with observations in cohort studies following extraction of second or third molars, performed for relief of lower crowding.[9,23-26]

A longitudinal study showed that occlusal interferences and premature contacts might contribute to increased lower incisor crowding over a seven-year period when treating only the upper arch with fixed appliances with no lower second molar extraction.[25] In the present study, 75% of the control group showed decreased lower anterior crowding after a 6 year follow-up and we may assume that a spontaneous distal drifting of the lower lateral segments may have occurred after extraction of the second molar which contributed to this finding.

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TABLE 4 Regression analysis. (4A) Ordinal logistic regression analysis output including coefficients, 95% confidence intervals and *P*-values for the adjusted effect of treatment on the final PAR score for the lateral segment, (4B) Median regression analysis output including coefficients, 95% confidence intervals and *P*-values for the adjusted effect of treatment on the final PAR score for the lower front region.

(A)

	PAR Lateral at T2		
Predictors	**Odds ratios**	**CI**	***P***
Age			
Per unit	0.99	0.97–1.00	.12
Gender			
0	Reference		.22
1	1.47	0.80–2.72	
PAR lateral T1			
Per unit	1.73	1.33–2.28	<.001
TRX			
No	Reference		.33
Yes	1.38	0.73–2.62	

(B)

PAR lower front	**Coefficient**	**95% CI**	***P*-value**
Treatment			
No	Reference		.01
Yes	−1	−1.78, −0.21	
t1_par_low_front	Per unit	−.14, 1.40	1.00
Gender			
0	Reference		<.01
1	−1	−1.67, −0.31	

Previous research confirms higher PAR scores for patients without retention in the long-term, compared with those using fixed retainers.[27,28] In the present study an activator was used during the retention period and no lower fixed retention was provided.

Of particular clinical relevance was the degree of improvement in the lateral occlusion from canine to first molar in participants not receiving lower fixed appliance treatment (Table 3; Figures S1F, S2A and S3B). This finding may indicate some degree of passive settling occurring in the lower dentition as the upper teeth is being moved with fixed appliances.

The rational for extracting lower second molars is based on the assumption that the third molars will end up replacing the extracted second molars in a satisfactory occlusal relationship. An evaluation of the occlusal outcome of the lower third molars was made based on the ABO Objective Grading System. The occlusal outcome categories of the L8 were not significantly different between control and treatment groups with a total of 81.55% presenting good-to-acceptable occlusion outcome. De-la Rosa-Gay et al[29] reported that 66.2% of fully erupted mandibular third molars with complete root development were in a good occlusion, meaning proximal contacts within 0.5 millimetre and a final angle between −35 and 35 degrees with the adjacent first molar. Orton-Gibbs et al[30] in a study with panoramic radiographs reported 99% of the mandibular third molars presenting a good-to-acceptable occlusion. A lower success rate was presented by Asai et al[4] in 35 cases in the retention phase. Older studies have reported excellent or satisfactory occlusal position of the mandibular third molars in 75% to 96% of cases replacing extracted second molars.[30] In a subjective evaluation on panoramic radiographs, Gooris et al[6] reported 46% of L8 having a satisfactory contact relationship with the L6.

No occlusal contacts between L8 and the antagonist were assessed as two situations were observed: (1) the L8 were not fully erupted showing root development potential on the radiographs, (2) the antagonist upper third molars were not fully erupted in cases where the upper second molars were extracted. After gingival emergence the lower third molars may take 1–2 years to reach full functional occlusion.[5] No longer follow-ups of the participants in this study were possible to perform as the orthodontist who treated the patients went into retirement and donated the material for research purposes. The eruption of the mandibular third molar precedes the eruption of its maxillary counterpart in both genders by an average of half a year.[5]

Root parallelism of the L8 in relation to the L6 is difficult to access on plaster models and will be addresses in a later radiologic study.

The present observational study provides a better understanding of the occlusal changes that take place in the mandibular

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TABLE 5 L8 occlusal outcome (5A) L8 percentage occlusal outcomes per group. (5B) Ordinal logistic regression estimates, 95% confidence intervals and p-values for the adjusted association between group and L8 occlusal outcomes.

(A)

	Occlusal_status		
Group	**Good**	**Acceptable**	**Poor**
T	14.18	16.67	9.57
C	23.40	27.30	8.87

(B)

Variable	**Odd ratio (95% Confidence Interval)**	***P*-value**
Group		
T	Reference	.29
C	0.75 (0.43, 1.29)	
Tooth		
38	Reference	.65
48	0.93 (0.67, 1.29)	
Age at baseline		
Per unit	1.22 (1.02, 1.46)	.03
Treatment duration		
Per unit	1.002 (0.99, 1.01)	.68

arch after extraction of the second molars not followed by orthodontic therapy. Despite the mainly positive results, questions arise concerning the eventual need to correct the position of the L8 for a good functional occlusion with a later round of mechanotherapy.

The extraction of lower second molars to solve mandibular crowding in selected cases may offer additional advantages. The uprighting of mesially tipped first molars following premature loss of deciduous molars to regain space may be easier and the risk of relapse by reopening of the extraction spaces reduced. Also, in cases of severely compromised lower second molars due to decay or ectopic position, the extraction of these teeth with possible need for orthodontic alignment of the third molars may be an alternative to its retention with certainly lower costs but higher needs for re-treatments. Difficult clinical problems managing fixed appliance therapy as in cases of amelogenesis imperfecta may also benefit with the extraction of lower second molars not followed by fixed appliance therapy.

The evident limitation of this retrospective study is the convenient sampling and the risk of bias due to subjects being omitted from the analysis on the basis of incomplete data sets. However, the samples in each group were of a sufficient size to permit meaningful statistical analysis. Every effort was made to limit, as far as permissible, the risks of bias by: reporting the initial screened sample size; providing the number of subjects subsequently excluded with reasons; including all available participants with complete records; ensuring all participants were treated by the same operator; ensuring as much as possible similar characteristics of the sample in each group accounting for the rationale behind each group at baseline and a defined treatment protocol being followed to all subjects. There is insufficient evidence in the literature to justify a randomized controlled trial (RCT) on the basis of equipoise existing in the comparison of occlusal changes between placement of a lower fixed appliance or not. The present retrospective study provides a good basis for an optimally designed RCT to best evaluate the effect of no treatment versus treatment with fixed appliances in the lower arch when lower second molars are extracted.

The main limitation of the present study is that only patients with successful eruption of the L8 were included, and thus, no information about the proportion of successful eruption of the L8 after extraction of the L7 can be given by the present data.

5 | CONCLUSIONS

The results of this retrospective cohort study showed that extraction of mandibular second molars followed by fixed appliance therapy in the upper jaw leads to significantly favourable changes in the occlusion of adolescent patients over a 6-year follow-up period, with or without lower fixed appliances, which included:

- Spontaneous relief of mild lower anterior crowding without lower fixed appliance therapy.
- Mechanical relief of moderate lower anterior crowding with lower fixed appliance therapy.
- Improvement of the lateral occlusion with or without lower fixed appliance therapy.

On this basis, the hypothesis that similar occlusal changes occur following extraction of lower second molars, with or without accompanying lower fixed appliance therapy, can be accepted in cases with mild lower anterior crowding.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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ETHICS STATEMENT

Ethical approval was provided by the Regional Committees for Medical and Health Research Ethics (REC) registration number 2019/826 in Norway.

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