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Axial Contour Alteration following Restorative Treatment: A Systematic Review

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Abstract

Purpose: This qualitative systematic review had two aims: (1) evaluation of the impact of restorative treatment on tooth contour, and (2) investigation of the effect of altered tooth contour on biological health.

Methods: An electronic search was conducted using PubMed (MEDLINE), Cochrane Library and Google Scholar. A combination of relevant key words was applied. The search was completed in October 2015 and was confined to peer-reviewed studies published in English.

Results: The initial search had disclosed a total of 1057 studies; however, after applying the inclusion criteria, only 12 studies were suitable for inclusion. The studies had revealed that the axial tooth contour is vulnerable to increasing following restorative treatment. The axial contour tends to increase gradually as the distance from the gingival margin increases. Still, the contour increase was within the anatomical range. There were signs that increased tooth contour was associated with negative biological consequences. However, a clear relationship between contour increase and the biological consequences was not apparent. There were indications that the observed negative consequences may be related to restorative variables such as plaque retentiveness and subgingival margin placement.

Conclusions: As the contour increase appears to be very likely to occur after restorative treatment, and the negative biological consequences cannot be solely attributed to the contour increase, it can be concluded that reasonable contour alteration is acceptable. The key factors that will reduce the negative consequences are cleansability and the maintenance of a healthy restoration-soft tissue relationship.

Keywords: Contour; Emergence; Profile; Prosthodontics; Dental restoration

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Introduction

Naturally, teeth exhibit straight axial profile from the base of the gingival sulcus to the supragingival aspect of the clinical crown [1]. This relationship is believed to reduce plaque accumulation and enhance the cleansability [2]. Frequently, restorative treatment is planned to improve dental esthetics which can be achieved by altering tooth colour and morphology. The treatment mandates tooth surface reduction to provide adequate space for restorative material. The sufficient space will facilitate achieving properly contoured, durable and esthetic restoration. However, it is not uncommon for the tooth contour to be altered following the restorative treatment which can evoke negative biological sequelae such as dental caries and periodontal complications. Therefore, it has been recommended that whenever a tooth is restored, the restoration should blend harmoniously with the natural tooth contour [1,2].

The literature presents three different methods for restoring the axial tooth contour: preserving the original tooth contour, under-contouring and over-contouring. Maintaining the original contour has been advocated to preserve a natural and physiological relationship between the tooth and the gingival tissues, which

will not interfere with routine cleaning [1,2]. However, this method may restrict the final tooth shape modifications. Under-contouring has been suggested to facilitate the self-cleansing abilities of the gingival tissues [3-5]. Although this method has some merits, it is impractical as it may negatively influence the appearance, restoration material thickness and preparation invasiveness [4]. In some situations, the clinician can prescribe an over-contoured restoration if the planned restoration volume is greater than the initial tooth volume [6,7]. This method is advantageous in allowing significant esthetic improvement if dentition irregularities exist. However, there are concerns that the contour increase will evoke plaque retention and biological complications [2]. Therefore, it is desirable to investigate the implications of altered tooth contour on biological health. This systematic review aims to evaluate the impact of restorative treatment on axial tooth contour and assess the relationship between the altered axial tooth contour and biological health.

Materials and Methods

The electronic search was conducted through PubMed (MEDLINE), Cochrane Central Register of Combined Trials and Google Scholar. The search was completed in October 2015. Through the PubMed database, the Boolean operator was employed to combine the following key words: ("contour" OR "emergence profile" OR "axial surface") AND ("restoration" OR "crown" OR "prosthesis") NOT ("implant" OR "removable"). All the articles related to tooth contour were retrieved from the Cochrane Database. The Google Scholar search engine was used to retrieve relevant studies by combining the following terms: tooth contour, restoration contour and emergence profile. No publication year limit was applied. The search aimed to retrieve all the clinical, laboratory and animal studies that investigated the restoration effect on the contour and the biological consequences of the altered contour.

Three stages for selecting the relevant studies were followed: (1) studies selection according to the relevance of the title; (2) studies selection according to the abstract relevance; (3) full text analysis and application of predefined inclusion criteria **(Table 1)**. After studies selection, additional relevant articles were searched manually through the bibliographies of the included studies.

Two categories of studies were considered for this review:

- Group I: Contour measurement studies. Where the study evaluates the contour alteration after the restorative treatment.
- Group II: Contour implications studies. Where the study investigates the effect of the altered contour on biological variables.

Table 1 Inclusion criteria.

English language study
Laboratory, clinical or animal study
Study on restored dentition
Direct restoration or fixed prosthesis
No implant or removable prosthesis
There is a well-defined control group or comparison group

Results

Literature search

A total of 1057 studies were retrieved after the initial search. After the analysis of titles, 990 studies were excluded. Additional 41 studies were excluded after reading the abstracts. Therefore, a total of 26 studies were suitable for full-text analysis. Following the application of the inclusion criteria, 10 studies were considered for inclusion. Manual searching through bibliography lists of the selected studies had identified an additional two studies. Thus, a total of 12 studies were analysed in this review.

Description of studies

From the selected papers, five studies fit in to Group I **(Table 2)**, and nine studies fit in to Group II **(Table 3)**. Four studies of Group I were clinical and based on actual treated patients [8-11], and one of them was a laboratory study [12]. From Group II, six studies were human studies [8,11,13-16] and three studies were animal studies [5,17,18].

In relation to Group I, the studies had evaluated the axial tooth contour alteration after full gold crowns, porcelain-fused to metal (PFM) crowns, direct composite resin veneer, indirect composite resin veneer, and ceramic veneer. All the measurements were executed on dental casts. The contour was evaluated by either comparing the treated tooth to an intact contralateral tooth or to its pre-treatment contour. Three forms of tooth contour parameters were evaluated: the width of the tooth, the emergence angle and post-treatment volume. The increased tooth width, increased emergence angle or greater volume indicated an increase in tooth contour. The implemented contour measurement methods were the dimensional measurement of tooth width [8], surface morphology [10,12], and cross sectional analysis [9,11]. In addition, the relationship between the axial tooth contour alterations and the location on the tooth from the gingival margin was evaluated by some studies [10-12].

For Group II human studies, the contour alteration was either part of the actual treatment or purely experimental. When the contour alteration was part of the definitive treatment (gold, PFM, ceramic and acrylic full crowns, or partial crowns), the contour increase was evaluated and was related to the biological variables [8,11]. The experimental studies involved altering the tooth contour to a defined dimension by a temporary approach throughout the experiment duration [13-16]. These studies were distinguished with the short-term contour alterations. The contour alteration methods were PFM crowns, acrylic crowns, acrylic veneers and metal veneers.

Similar to Group I studies, the axial tooth contour was evaluated by measuring the tooth width and the emergence angle. In relation to the width, the increase of the applied contour increase was in the range of 0.18 mm to 0.5 mm. One study had reduced the tooth width by 1 mm (0.5 mm per surface). The emergence angle ranged from normal contour (0°) up to an emergence angle of 40°. The level of contour alteration was subgingival, equigingival or supragingival. The evaluated biological variables were plaque quantity and quality, gingival index, probing depth, crevicular fluid, bleeding index, and clinical attachment level loss.

Table 2 Summary of studies that evaluated the impact of restorative treatment on axial tooth contour.

Study (year)	Study description	Sample number and description	Treatment	Method of measurements	Results
Parkinson [8]	Clinical study	50 teeth Compared to intact contralateral teeth	Crowns -25 gold crowns -25 PFM crowns	Tooth width measurements	80% of the crowns had a wider buccolingual dimension than the contralateral teeth The width increase was 0.71 mm for PFM crowns and 0.36 mm for gold crowns
Meijering et al. [10]	Clinical study	15 maxillary central incisors Compared to the pre-treatment contour	Veneers -5 direct composite veneers -5 indirect composite veneers -5 ceramic veneers	Volumetric measurements at 3 vertical locations -Cervical -Middle -Incisal edge	Greater dimension increase occurred incisally than cervically At the cervical region, the tooth width was minimally affected At the middle region, 60% of the veneers were wider than the pre-treatment contour At the incisal edge, 73% of the veneers were wider than the pre-treatment contour The different restorative treatments had similar effect on the contour
Alhouri et al. [9]	Clinical study	55 teeth Compared to intact contralateral teeth	Crowns -32 anterior crowns -23 posterior crowns	Analysis of cross sections and curvature measurements Straight profile was interpreted as under-contoured while curved profile was interpreted as over-contoured	Most of the full crowns had similar curvature or slight tendency to have less curvature The buccal contour of most of the posterior crowns was minimally affected The buccal contour of half of the anterior crowns was similar to the contralateral teeth The lingual contour of half of the posterior crowns was similar to the contralateral teeth Lingual contour of half of the anterior crowns was under-contoured
Yotnuengnit et al. [11]	Clinical study	50 anterior teeth Compared to intact contralateral teeth	Crowns -88% PFM crowns -4% porcelain crowns -2% partial veneer crowns	Analysis of cross sections and measurement of subgingival and supragingival emergence angle	Overall, the crowns had greater emergence angle than the contralateral teeth The recorded mean emergence angles were -Supragingival emergence was 11.1° for natural teeth, and 14.2° for restored teeth. The difference is not significant -Subginigval emergence was 9.9° for natural teeth, and 17.1° for restored teeth. The difference is significant
Vasconcelos et al. [12]	Laboratory study	24 maxillary canines Compared to the pre-treatment contour	Indirect composite veneers by 3 different technicians -12 veneers with no reference tooth -12 veneers with reference tooth	Tooth width measurements in 5 vertical locations from the gingival margin -0 mm -0.5 mm -1 mm -1.5 mm -2 mm	All the veneers were over-contoured None of the dental technicians could establish the original contour, even with the presence of a reference intact tooth The contour increased gradually as the distance from the gingival margin increases The average contour increase for each vertical location was -Level 0.0 mm: 0.31 mm -Level 0.5 mm: 0.37 mm -Level 1 mm: 0.43 mm -Level 1.5 mm: 0.45 mm -Level 2 mm: 0.47 mm

Table 3 Summary of studies that evaluated the impact of tooth contour alteration on biological variables.

Study (year)	Study description and duration	Sample number and description	Contour alteration method and magnitude	Evaluation method	Results
Human studies					
Parkinson [8]	Clinical study of restored teeth Non-specified duration of restoration service	50 teeth Compared to intact contralateral teeth	Crowns -25 gold crowns (0.36 mm width increase) -25 PFM crowns (0.71 mm width increase)	Plaque index	Significantly greater plaque accumulation around the restored teeth than intact teeth There was no significant difference in plaque index between gold and PFM crowns
Sackett and Gildenhuys [13]	Clinical study of experimental modifications of tooth contour Duration: 42-49 days	42 first premolar teeth Compared to intact adjacent teeth	Processed acrylic veneers located supragingivally (1 mm buccal contour increase)	Gingival status Pocket depth Gingival crevicular fluid	The evaluated variables were significantly affected after increasing the contour 59% of mandibular sites and 70% of maxillary sites showed signs of degradation, inflammation and gingival tissues morphological alterations than control sites 59% of mandibular sites and 50% of maxillary sites showed greater production of gingival crevicular fluid than control sites
Ehrlich and Hochman [14]	Clinical study of experimental modifications of tooth contour Duration: 4 months	Several teeth in 4 patients Compared the effects of over-contouring and under-contouring	Fixed acrylic partial dentures with supragingival margin -Over-contouring (1 mm width increase) -Under-contouring (1 mm width reduction)	Tissue changes and the gingival margin reaction in relation to colour, size, contour and inflammation	Significant clinical difference was not observed between the two sides. The response of the gingiva to the different crown contours was clinically normal 3 of the 4 patients reported esthetic difference No difficulties in cleaning was noticed by any of the patients
Creugers et al. [15]	Clinical study of experimental modifications of tooth contour Duration: 10 days for each oral hygiene protocol (one period with home care, one period with no cleaning)	20 teeth Compared to intact contralateral teeth	Resin bonded metal wings located supragingivally (0.5 mm palatal contour increase)	Plaque index Papillary bleeding index	In the cleaning period, there was minimal difference in the plaque and bleeding indices In the no cleaning period, the plaque and bleeding indices had increased for the two groups. There was tendency for the experimental group to show more increase plaque and bleeding indices than the control group
Sundh and Kohler [16]	Clinical study of experimental modifications of tooth contour Duration: 9 days for each crown	7 premolar teeth Compared the effects of different crown contours	4 PFM crown designs with equigingival or supragingival margins -Natural emergence -10° contour increase -25° contour increase -40° contour increase	Plaque quantity and quality	The experimental crowned teeth had less plaque than the control teeth There was no plaque quality difference between the different groups

Yotnuengnit et al. [11]	Clinical study of restored teeth Duration: about 30 months of restoration service	50 anterior teeth Compared to intact contralateral teeth	Crowns with subgingival margins -88% PFM crowns -4% porcelain crowns -6% acrylic crowns -2% partial veneer crowns Mean emergence angle -Natural teeth (11.1° supragingival emergence, 9.9° subginigval emergence) -Restored teeth (14.2° supragingival emergence, 17.1° subgingival emergence)	Plaque index Gingival index Pocket depth Clinical attachment loss	There was significantly greater plaque and gingival indices for the restored teeth in all sites Plaque was detected in 52% of restored teeth and 32.5% of natural teeth Normal gingival morphology was observed in 22.7% of restored teeth and 57.5% of control teeth Severe gingival inflammation was detected in 2% of the restored tooth surfaces. Control tooth surfaces did not have severe gingival inflammation Probing depth was generally greater for the restored teeth than control teeth. But this difference was only significant in the proximal region Clinical attachment loss was greater for the restored teeth than for the control teeth. However, no significant difference was observed The proximal sites demonstrated greater deterioration of all the variables for the restored teeth than control teeth
Animal studies					
Perel [5]	Animal study of experimental modifications of tooth contour Duration: 1-9 weeks	Mandibular teeth of 6 dogs Compared the effects of over-contouring and under-contouring	-Contour increase by supragingival cervical acrylic resin restoration (2 mm contour increase) -Contour reduction by axial convexity elimination	Clinical gingival evaluation in relation colour, shape and bleeding on probing Histological evaluation	Gingival deterioration was observed after increasing the contour (gingival swelling, redness, hypertrophied gingiva, tendency to bleed after probing and plaque accumulation) Reducing the contour did not have negative consequences on the gingiva Histological evaluation revealed increase of inflammatory cells and engorgement of blood vessels in the gingival margin in the over-contoured sites
Kohal et al. [17]	Animal study of experimental modifications of tooth contour Duration: 5 months	Second and third premolars in three quadrants of 4 dogs Compared to the intact teeth of the last quadrant	Gold crowns with subgingival margins -Natural emergence -30° contour increase -50° contour increase	Plaque index Gingival index Gingival crevicular fluid Pocket depth Clinical attachment loss	Over-contouring had negatively influenced the evaluated parameters Plaque index, gingival index, gingival crevicular fluid and probing depth had increased for 30° and 50° emergence groups. Minimal alterations were observed for control and normal contour groups There was minimal difference between 30° and 50° emergence groups, and between control and normal contour groups Clinical attachment level tends to decrease over the experiment period for all the restored teeth. The control group showed a stable clinical attachment level

Kohal et al. [18]	Animal study of experimental modifications of tooth contour Duration: 5 months	2nd and 3rd premolars in three quadrants of 4 dogs Compared to the intact teeth of the last quadrant	Gold crowns with subgingival margins -Natural emergence -30° contour increase -50° contour increase	Microbiological analysis	The contour had minimal effect on the bacterial composition No major differences existed between the contour, normal contour and 50° emergence groups. The 30° emergence group had 3 times the amount of total bacterial count Overall, no trend was observed regarding the pathological bacterial species. The means of microorganisms number and the means of total bacterial load for a given organism were higher in the 30° and 50° emergence groups than in the control and normal contour groups

The three animal studies were experimental in nature. The teeth contour was altered by resin restoration or crowning with gold crowns. The contour was increased by widening the tooth surface by 2 mm or increasing the emergence profile angle (0-50°). One study altered the contour supragingivally [5] while the other two studies subgingivally [17,18]. In addition, one study had reduced the contour by eliminating the tooth axial convexity [5]. The evaluated biological variables were plaque quality and quantity, gingival index, probing depth, crevicular fluid and clinical attachment level loss. One study had conducted microscopic examination of the gingival tissues [5].

Studies' outcome

Group I: All the included studies confirmed that the axial tooth contour is vulnerable to modifications following restorative treatment. Most of the alterations tended to be an increase of the contour [8,10-12]. Only one study reported a reduction of the contour following restorative treatment [9]. However, this study had primarily evaluated the convexity of the surface rather than the contour dimensions. Parkinson had found that 80% of the treated teeth with crowns were over-contoured [8]. Depending on the location on the tooth, up to 73% of the veneers were reported by Meijering et al. to have a contour increase [10]. Yotnuengnit et al. had found the emergence angle of the restored teeth was likely to be greater than the control teeth [11]. Vasconcelos et al. had found that 100% of the teeth had an increase in the contour following restorations [12]. This was the case even when the technicians had access to the reference tooth contour.

Magnitude of contour increase: Parkinson had recorded that the magnitude of contour increase was in the range of 0.36 to 0.71 mm (0.18 to 0.36 mm per surface) [8]. Yotnuengnit et al. had shown the emergence angle to increase by a range of 3.1° to 7.2° [11]. Depending on the vertical location on the restored tooth, Vasconcelos et al. had reported that the increase was in the range of 0.31 to 0.47 mm [12].

Effect of restoration type: From the limited amount of evidences, the effect of the different restoration type on the contour is not very clear. Parkinson found the PFM crowns had double the contour increase than the full gold crowns [8]. Meijering et al. had found that there was no difference in the magnitude of contour alteration after restoring the tooth with ceramic veneer, direct composite veneer or indirect composite veneer [10].

Location effect on the contour: there is a trend for the tooth surface that is furthest away from the gingival tissues to experience greater contour increase. According to Meijering et al. the incisal width was more affected from over-contouring while the cervical width is very identical to the original tooth contour [10]. Similarly, Vasconcelos et al. had observed a consistent increase of the contour as the distance from the gingival margin increases [12]. On the other hand, Yotnuengnit et al. had found the emergence angle was greater for the subginigival profile than the supragingival profile [11].

Group II: Some of the studies reported a direct relationship between the contour increase and biological complications [8,11,13,15] while others did not [14,16]. The studies on permanent restorations consistently reported a negative biological relationship with dental restoration. Parkinson had found a greater plaque index associated with crowns that had increased contour [8]. Likewise, Yotnuengnit et al. had confirmed this relationship [11]. Although the actual increase in contour is minimal (about 7°), there was more detectable plaque around the restored teeth [11]. On the contrary, the short-term studies provided conflicting findings. In a cross-mouth study by Ehlrich and Hochman, under-contouring or over-contouring by 1 mm alteration of tooth width was not associated with significant clinical changes in the healthy gingiva [14]. Thus they concluded that healthy gingival tissues can tolerate contour changes. This was supported by Sundh and Kohler, who found that the increase in crown contour was not associated with greater plaque accumulation over a short period [16]. Further, the plaque quality was similar between the restored and intact teeth. On the other hand, Sacket and Gildenhuys had observed deleterious effects on gingival parameters after increasing the contour of premolars by augmenting the buccal contour with 1 mm thick acrylic veneer [13]. Similarly, after bonding 0.5 mm thick metal veneers on the palatal surfaces of central and lateral incisors, Creuger et al. had observed over-contouring was associated with greater plaque retention [15].

The animal studies confirmed that biological consequences

may develop after altering the tooth contour for dogs. Perel had increased and decreased the contour of dogs' teeth and found that reducing the tooth contour was not associated with negative consequences [5]. However, increasing the contour was significantly related to negative consequences [5]. The other two studies were published by the same research group [17,18]. After increasing the contour, the periodontal parameters were negatively affected [17]. However, according to the microbiological analysis, there was a minimal effect of the contour on bacterial composition [18]. In addition to restoration contour, there are additional factors that are likely to contribute to the outcome of the included studies, such as plaque retentiveness and the restoration margin location.

Effect of plaque retentiveness: It appears that plaque retentive methods of altering the contour exacerbate the negative biological outcome. For example, the studies that had provided an abrupt contour increase found negative consequences [5,13,15]. The abrupt contour alteration is responsible for hindering the physiological cleaning methods. Some authors anticipated that material selection has a biological impact, where acrylic resin is more plaque retentive [5,13]. The effect of plaque accumulation is further supported by the observation that the lack of routine cleaning significantly increases the biological complications [5,15].

Effect of restoration margin location: The margin location was found to be a main contributing variable to the observed outcome. For example, the studies that had increased the contour supragingivally or equigingivally, with a restoration that is not plaque retentive, did not confirm the negative biological consequences [14,16]. On the other hand, the studies that had altered the contour by subgingival restorations had found negative outcomes [11,17]. In fact, Yotnuengnit et al. had found that even with a minimal contour increase, the subgingival over-contouring was associated with more negative biological consequences [11]. Therefore, given that the magnitude of contour increase is minimal, the negative consequences may be related to tissue reaction to prosthesis or subgingival placement [8,11].

Discussion

This systematic review confirms that restoring teeth with direct or indirect restorations can easily change the contour [8,12], mostly in the form of increasing the contour. This could be attributed to several factors such as tooth preparation effect, contour increase for durability and esthetics. In addition, the likelihood of altering the tooth contour indicates the difficulties for the clinician and technician in achieving the exact pre-treatment contour [10,12]. The magnitude of contour increase appears to be influenced by several factors such as the type of restoration and location on the tooth. Further, there are indications that increasing the contour of the restored teeth might negatively influence the periodontal health.

The magnitude of tooth contour alteration could be attributed to the amount of tooth preparation and the requirements of esthetic improvements. In order to restore natural contour with dental restoration, a sufficient amount of tooth structure should be removed. For example, crown restoration margin width for an esthetic crown (PFM or all ceramic) ranges from 1-1.2 mm [3]; therefore, a significant portion of tooth structure will irreversibly be prepared, which can lead to a loss of up to 30% to 70% of natural tooth structure [19]. However, extensive tooth preparation will render the tooth more susceptible to endodontic complications and weakening of tooth structure [3]. From the conservative perspective, the clinician might opt to reduce the amount of preparation. As a result, the technician may restore the tooth to natural contour but with compromising material thickness and esthetic quality. Alternatively, the restorative materials can be used in their recommended thickness thereby overbuilding the crown, thus increasing its emergence profile [3,20]. In accordance with this explanation, Parkinson had found gold crowns were associated with half the contour increase of the PFM crowns [8]. This also coincides with the amount of axial reduction required for gold crowns which is about half the amount required for PFM crowns [3]. In addition, in some situations, the deliberate increase of tooth contour, mainly anterior teeth, is advantageous in the improvement of dental esthetics. From the morphological perspective, altering the anterior tooth contour can restore the width, height, width-to-height ratio, and tooth natural alignment [21,22].

Since the studies that evaluated the contour increase along the axial surface consistently reported a regular increase of the contour as the distance increases from the gingival margins [10,12], it could be speculated that the contour increase had occurred gradually. One study found subgingival contour is slightly greater emergence angle than supragingival contour [11]. However, this is not necessarily contradicting the observation of the other studies, as it reflects the orientation of the axial surface rather than the width of the contour. Nevertheless, this gradual contour increase is different from an abrupt increase or an overhanging contour, and might not necessarily support plaque retention, as shown by some of the Group II studies [5,13,15]. In general, it appears from the included studies, that a contour increase that provided a smooth increase of the contour, at least in the short-term, did not indicate a pronounced increase in biological complications [14,16]. On the other hand, the studies that provided more plaque retentive design by abrupt contour increase had found a negative impact [5,13,15]. This is anticipated to be due to hindering the physiologic cleaning by lip, tongue or food chewing [13,15]. This is further supported by Perel who found no biological impact after under-contouring the teeth by removing the tooth convexity [5]. Therefore, it is evident that the studies that had increased the contour by a non-cleansable design, found negative consequences on periodontal health.

Interestingly, Vasconcelos et al. had found that even if the anatomical reference tooth was presented to the dental technicians, it was difficult to mimic the original contour, and over-contouring was still observable [12]. It is likely this is due to inevitable contour variation introduced from human intervention and material manipulation [12]. This indicates that although the operator may aim to achieve a specific contour or morphology, by pre-treatment or wax-up models, a precise contour is not always possible. Nevertheless, it is also possible that the slight

difference in the contour is not necessarily clinically significant. In the future, greater precision of tooth contouring might become achievable with the implementation of digital technologies that reduce the reliance of human intervention and control materials manipulation [23].

In relation to the magnitude increase, although the studies had detected a contour increase, this increase was still within the recommendation of many authors. For example, the maximal increase hardly exceeded 0.5 mm [8,12], which is still within the range of natural teeth anatomy [24]. Similarly, in relation to the emergence angle, the natural teeth have an emergence angle of about 15° from the cement-enamel junction [25,26], which is similar to the observation by Yotnuengnit et al. for natural (9.9°-11.1°) and even for restored teeth (14.2°-17.1°) [11]. Further, it is important to indicate that although many studies in Group II found increased negative consequences after increasing the contour to these dimensions [8,11,17], a few studies did not indicate a clear relationship with biological problems, even if the contour width was significantly increased [14,16]. Moreover, if negative consequences occur, they may not be fully attributed to contour alterations. Part of the variation within Group II studies can be related to the inevitable differences in the studies' design and duration, and to the restorative procedure effect on periodontal health. Several researches discussed restorative variables that can influence periodontal health, such as restoration margin location. Subgingivally crown margin placement has been confirmed to be associated with gingival inflammation, loss of periodontal support, pocket development and gingival recession [27-29]. This could be due to preparation trauma, constant irritation, microbial biofilm formation close to the gingiva, a likelihood of violating the biologic width, and difficulties in maintaining a good level of cleanliness at the margin. The inevitable roughness of restoration-tooth junction may facilitate microbial adhesion and plaque accumulation. On the other hand, supragingival margins have been found to be related to the lower gingival scores in comparison with subgingival margins [27,30,31]. This may explain the observation of the studies included in this systematic review, as the ones that had increased the contour by subgingivally placed restoration found negative biological consequences [11,17], while the ones that kept the restorations supragingivally did not find a negative biological impact [14,16].

This systematic review outlines the limitations of evidences in relation to the impact of restorative treatment on tooth contour and the impact of altered contour of the restored teeth. This is very clear in the limited participant number of several studies and the method of altering the contours. Although it appears from the included studies that there is an impact of increasing the contour of the restored teeth, much of the impact can be attributed to restorative factors such as the cleansability of the restoration and the gingiva-restoration relationship. Thus, it is difficult to attribute the observed negative biological consequences purely to the altered axial contour. Therefore, more studies that can isolate the effect of each restorative variable are desirable. In addition, the clinical significance of the observed negative consequences is yet to be determined [17,18]. According to the currently available evidences, it can be envisaged that reasonable over-contouring can be provided, as long as the restoration is cleansable and does not violate the biologic width.

Conclusion

Within the limitations of this review, it can be concluded that axial contour alteration is inevitable after restorative treatment. The alterations were mainly in the form of increasing the contour. Contour alteration appears to be associated with negative biological consequences. However, much of the negative consequences appear to be exacerbated by the restorative procedure instead of purely from the increased contour. Reasonable contour alteration can be considered as part of the treatment. However, it might be beneficial to keep it minimal, without plaque retentive features and without violation of the biologic width.

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