

The Effect of Gingival Retraction Cord on Periodontal Health Compared to Other Gingival Retraction Procedures: A Systematic Review

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Abstract

Background: An accurate impression is obtained for the fabrication of fixed restorations only when the gingival tissue is managed properly. And this is especially true when the location of the finish line is at, or within, the gingival sulcus. Gingival retraction is an important aspect of current impression techniques in fixed prosthetic procedures. Effective gingival retraction prior to taking an impression without damaging periodontal tissues is very important in long-term success of cast restorations.

Purpose: To collect and evaluate, in a systematic manner, data available on the post-operative effect of retraction cords on gingival tissue in patients with healthy gingiva compared to cordless techniques in respect to effect on gingival recession, parameters of gingival inflammation and patient comfort.

Methods: PubMed/Medline, Science Direct, ISI Web of Science, the Cochrane library, EMBASE, and Google Scholar databases were searched. The studies were chosen according to the inclusion criteria followed by data extraction, and quality check.

Results: 85 potentially eligible articles were identified, of which only 5 fulfilled the objective of the study and were included. Five studies reported that the gingival retraction techniques affected the gingival health with a variable degree level and this effect was temporary in nature taking in consideration the health of the gingival tissues. One study compared three different techniques of retraction materials and reported that temporary gingival inflammation was observed with all techniques and Expasyl had the greatest effect with slower recovery. Bleeding was induced by the cordless techniques neither during nor after retraction. One study investigated non-aluminum chloride-containing injection-type retraction material (Korlex-GR) compare it with 2 other commercial retraction materials (Ultrapak 1, a medicated retraction cord, and Expasyl), there results indicated that the non-aluminum chloride-containing injection-type retraction material is as effective as the other 2 materials for gingival retraction but produces less pain and limits injury to the gingival tissue during the procedure.

Conclusions: It may be suggested that all tested gingival retraction technique will affect the gingiva negatively temporarily, however, well-fitted fixed dental prosthesis and its procedures performed to periodontally healthy subjects will have a reversible effect on the periodontal tissue health.

Keywords: Periodontal health; Gingival retraction; Gingival tissue; Dental prosthesis

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Introduction

An accurate impression is obtained for the fabrication of fixed restorations only when the gingival tissue is managed properly. And this is especially true when the location of the finish line is at, or within, the gingival sulcus [1-4] or with restoration of cervical lesion because of its proximity to the gingival tissues [5].

The deflection of the marginal gingiva away from the tooth is the definition of gingival displacement. This procedure is performed to create sufficient space between the finish line of the preparation and the gingival tissue to allow for the placement of adequate amount of impression material into the expanded gingival crevice [6-9]. Gingival retraction is an important aspect of current impression techniques in fixed prosthetic procedures [10]. Effective gingival retraction prior to taking an impression without damaging periodontal tissues is very important in long-term success of cast restorations [11].

This is especially important when using materials that do not displace the gingival tissues such as hydrophobic impression materials [12]. Gingival tissues usually return to their original position because of the gingival cuff elasticity and the rebound forces of the compressed adjacent attached gingiva [13]. Sulcular width is very crucial to the accuracy of the impression, it has been reported that approximately 0.15-0.2 mm is the significant Sulcular width for an Impressions without voids, tearing and high marginal accuracy [4,14-16].

Different types of retraction techniques are available such as; mechanical, chemical or surgical, and they are frequently used in combination. The most widely used method by 98% of the prosthodontists is the retraction cords they are mechanical form of retraction [17]. They are predictable, effective, and safe compared to rotary gingival curettage and electrosurgery [8,17]. Retraction cord offers a fast and inexpensive retraction method, using either a single-cord or a double-cord technique. To ensure a meticulous impression with adequate biological width, the double-cord technique is used where two cords of different sizes are used. The technique is safe and effective, given that the periodontal health is good. With the single-cord technique, a single retraction cord is placed in the sulcus [18].

The use of gingival retraction cord is technique-sensitive and requires expertise. Difficulty in placing the retraction cord has been reported in the literature, in addition to gingival bleeding, patient discomfort and root sensitivity [10]. And when inappropriately manipulated varying degrees of tissue trauma may result, it can lead to epithelial attachment damage and/or exacerbating gingival recession, bleeding and bone resorption [10,18-21]. Retraction cords can be used with haemostatic agents or without. Various haemostatic agents with varying degrees of safety and effectiveness are available such as aluminium potassium sulphate (Alum), aluminium chloride, epinephrine, zinc chloride, ferric sulphate and sympathomimetic amines.

Another type for mechanical retraction is the cordless retraction techniques. It has many claimed advantages, such as less time consuming; enhanced patient comfort in addition, is considered

minimally invasive. An example is Expasyls (Kerr Corp., Orange, CA, USA). It is a paste-like retraction material. The main ingredients has haemostatic properties (aluminium chloride) and hygroscopic expansion (kaolin) when it comes into contact with the crevicular fluid, accordingly it provides mild displacement of the gingiva in about 2 min [22]. Another example is the Magic Foam Cords (Colte`ne Whaledent AG, Altstatten, Switzerland), which is an expanding poly vinyl siloxane material with the advantage of ease of application and the fast retraction of the sulcus without trauma to the gingiva and with shorter time of application compared to the retraction cord [23-25].

The effect of cordless techniques on the gingival and periodontal health is not well documented, as most of the studies are only demonstrations of their clinical use [26-28]. A study by Yang et al. reported no significant difference in achieving gingival deflection when they compared two cordless techniques: Expasyl and Korlex- GRs (Biotech-one, San-Chung, Taiwan) with Ultrapaks cords (Ultradent Products Inc., South Jordan, Utah), however they reported that Ultrapak was more painful and created more gingival recession than the cordless technique [29].

To the best of our knowledge, the effect of retraction cords techniques in comparisons to cordless retraction techniques on gingival health has not been evaluated in a systematic manner. Accordingly, the aim of this review is to collect and evaluate, in a systematic manner, available data on the post-operative effect of retraction cords on gingival tissue in patients with healthy gingiva compared to cordless techniques in respect to effect on gingival recession, parameters of gingival inflammation and patient comfort.

Materials and Methods

Focused question

For patients with healthy gingiva, does retraction cord have a significant harmful effect on gingiva compared to cordless techniques in respect to the clinical parameters of gingival inflammation?

Search strategy

The following electronic databases sources were searched for appropriate articles that satisfied the study purpose from their earliest records to January 2013: the PubMed/MEDLINE, Science Direct, ISI Web of Science, the Cochrane library. This comprehensive search was designed to include any published articles that evaluated the effects on healthy gingiva by the retraction cords and/or cordless technique. To minimize the potential for reviewer bias, the screening was performed independently by two reviewers (NYA and MQR). Disagreement regarding the inclusion or exclusion of the retrieved articles was resolved by a discussion between reviewers until reaching a consensus.

The databases were searched using the following search format; Intervention. <([MeSH terms] retraction cords or Ultrapack or gingival retraction cord or Hemodent gingival retraction cord or Cordless gingival retraction techniques or Expasyl retraction

material or Magic Foam Cord or Cordless retraction paste material and ([MeSH terms] gingival health or Gingival Crevicular fluid or Bleeding Index or Gingival Index or [text words] periodontal health> and Outcome. <([MeSH terms] recession or [MeSH terms] bleeding or [MeSH terms] Pocket depth or [MeSH terms] periodontal attachment loss or [MeSH terms] dental plaque index or [MeSH terms] periodontal pocket or [text words] gingival recession or [text words] patient discomfort or [text words] sulcus bleeding or clinical attachment level or bleeding on probing.

Study inclusion and exclusion criteria

Only Studies written in English language were selected by the two authors (NYA and MQR). The selection procedure was as the following; the articles were screened independently by title and abstract, then if the title contains the search key words, the article was selected. However, if the title has none of the key words, the abstract was then read to search for key words.

Articles selected for full text reading were articles that has no clear abstract, but the title seemed to be relevant, or if abstract was not available, but the title contained the key words. The two authors (MQR and NYA) read the selected full-text articles in detail and the articles that fulfilled all selection criteria were processed for data extraction. All reference lists of the selected studies were hand searched by the same authors for additional published work that could possibly meet the eligibility criteria of the review. The studies were analyzed according to the following inclusion criteria: the study 1) involved human adult patients (age \geq 18 years) 2) clinical trials, prospective studies, and observational studies and 3) patients with healthy gingiva. Only studies that fulfilled all of the inclusion criteria were admitted to the second phase.

In the second phase, the preselected studies were submitted to the following exclusion criteria: 1) patients with systemic diseases, 2) a primary outcome of interest was not analyzed, and 3) insufficient information on the mode of therapy.

Outcome measures

Primary outcome of interest; to address the focused question, the primary outcomes of interest were the pre- and post intervention changes in sulcus depth and the effect on gingival recession.

Secondary outcomes of interest were changes in the gingival index (GI), and GCF levels and content. Adverse events, sensitivity and pain related to the intervention were evaluated as reported by authors.

Data extraction

Was performed by the two authors independently using specially designed data-extraction forms created by the author (NYA) based on quality and methodology checklist for systematic reviews and meta-analyses created by the National Institute for Health and Clinical Excellence [30]. Data on the following issues were extracted and recorded: 1) Title, and year of publication; 2) study design: clinical trial and /or observational study; 3) characteristics of participants: sample size, gender, age and

systemic conditions; 4) methodological quality of trials: patient and defect selection bias, adequate inclusion criteria, statistical analysis, randomization selection, validity of conclusions, and clinical variables analyzed; 5) characteristics of interventions and follow ups (Table 1).

Quality appraisal

A quality and methodology checklist for systematic reviews and meta-analyses created by the National Institute for Health and Clinical Excellence [30] was used for every article selected (Table 2). The checklist items included the sample size calculations, randomization methods, inclusion and exclusion criteria, subject follow ups, presence of a comparable control group, presence of masking, and the appropriateness of statistical analysis.

Table 1 Self-developed data collection table used to extract data from each article.

Checklist Item	Criteria	Data
Reference	Title	
	Author	
	Language	
	Country of Origin	
	Journal	
Year of Publication		
Objectives of the study	Number of patients	
Type of study	Age of the patients	
Population	Sex of the patients	
	Medical health of patients	
	Inclusion criteria	
	Exclusion criteria	
Ethical Regulations	Consent Form	
	Study protocol design	
	Supervising Committee	
Location of the study		
Design of the study (RCT)		
Intervention	Description	
	Number of surgeons performing procedure	
Implants used		
Intervention (other)	Description	
	Examiners	
	Examiners reliability	
Laboratory Procedures	Description	
Statistical Analysis		
Outcome		
Patient retention		
Follow up	Period	
	Regulations	
Conclusions		
Comments		

Results

Search results

The search strategy identified 85 potentially eligible articles of which 47 articles were excluded after the titles and/or abstracts were reviewed. Subsequently, the full texts of the remaining articles that were considered potentially relevant were screened. From the 38 articles, 33 of them did not meet the criteria of eligibility. Therefore, 5 articles were finally included.

Reasons for exclusion of full-text articles include the following: 1) Gingival retraction cord is not a variable in the study; 2) the effects of the retraction material was not measured clinically; 3) Review articles and case reports; 4) Presence of a contradictory factor.

Analysis of included studies

Description: The five studies included in this review are presented in **Tables 3 and 4**, it included 4 randomized clinical trials (RCT) [11,29,31,32] and 1 [33] Pilot clinical studies. These 5 studies were performed in 5 different countries (Iran, Taiwan, Germany, Jordan, and Turkey) and were published from 2000 to 2012.

From these five studies the following was reported; Yang et al. [29], compared 3 material (Epinephrine-impregnated cord (Ultrapak1), Injection-type material with 15% A1C13 (Expasyl) and Injection-type material with 0% A1C13 (Korlex-GR). They reported that there is a significant increase in the sulcus width >0.2 mm after retraction by all the 3 materials also there is significant gingival recession ($p < 0.05$) however, Ultrapak 1[®] produced the greatest amount of recession and was also significantly more painful compared to the other 2 materials ($p < 0.05$). Also Wöstmann et al. [31], reported that there is increase in the crevicular fluid flow when pure cotton retraction cords were used, however with the use of both chemo-mechanical and chemical retraction cords a

significant reduction in the crevicular fluid was observed. Another study by Al Hamad et al. [32] also compared Ultrapack knitted non-impregnated retraction cord with Magic foam cord and Expasyl, and they reported that except for the GI, the periodontal parameters were not statistically significant among the groups at all time intervals, which was increased for all groups after 1 day. The highest was in Expasyl. After 7 days, the GI returned to a non-significant level compared with baseline except for Expasyl, which was still significant. Expasyl induced sensitivity in four subjects. Ultrapak only induced bleeding during and after retraction. And they concluded that all techniques caused a temporary gingival inflammation; the greatest was in Expasyl, which also showed slower recovery and that cordless technique did not induce bleeding during or after retraction. However in 2009, Kazemi et al. [11], when compared Plain cord (Ultrapack knitted RC#1 Ultradent) pre-saturated with 15% aluminum chloride solution to Expasyl paste reported that the mean width of the retracted sulcus in the pre-saturated cord group was greater than Expasyl paste group and that the mean gingival recession in the cord group was significantly greater than Expasyl paste group. Also the inflammation score was significantly higher in the cord group compared to the paste group, in 7th day and 14th day. And they concluded that the gingival retraction with Expasyl paste method caused less injury to gingival tissues than impregnated cord. In 2012, Bıçakcı et al. [33] When they compared the effect of gingival retraction cord pre-saturated with potassium-aluminum-sulfate to Expasyl paste and Korlex-GR paste retraction materials suggested that on a periodontally healthy subjects the well fitted fixed dental prosthesis and its procedures has no negative effect on the periodontal tissue health.

Population: Three of the included studies were conducted in university hospitals and one in dental practice. One study failed to mention the location of the study. Sample sizes ranged from 8 to 60 subjects, however one study used number of teeth

Table 2 Quality assurance checklist by the national institute for health and clinical excellence (January 2009).

Category	Description	Grading
A	Sample-size calculation, estimating the minimum number of participants Required to detect a significant difference among compared groups	0=did not exist/not mentioned/not clear 1=was reported but not confirmed 2=reported and confirmed
B	Randomization and allocation concealment methods	0=clearly inadequate 1=possibly adequate 2=clearly adequate
C	Clear definition of inclusion and/or exclusion criteria	0=no 1=yes
D	Completeness of follow-up (specified reasons for withdrawals and dropouts in each study group)	0=no/not mentioned/not clear 1=yes/no withdrawals or dropouts occurred
E	Experimental and control groups comparable at study baseline for important prognostic factors	0=no 1=unclear/possibly not comparable for one or more important prognostic factors 2=clearly adequate
F	Presence of masking	0=no 1=unclear/not complete 2=yes
G	Appropriate statistical analysis	0=no 1=unclear/possibly not the best method applied 2=yes

Table 3 Description of all the included studies.

Author	Follow up period	No of Participants	Population	Inclusion Criteria
Yang et al.	Before retraction, immediately after retraction, 14 days after retraction	8 pts (4 M, 4 F)/24 teeth	Aged (25 ± 2.26 yrs) Good oral hygiene	<ul style="list-style-type: none"> • Subjects had healthy gingiva (no calculus or plaque deposition, of a pale-pink color, with knife-edged papilla, and no swelling or bleeding) and the absence of deep periodontal pockets (pocket depths of <3 mm) • PI (Silness and Loe) • GI (Loe and Silness)
Wostmann	Base line after preparation	340 prepared teeth	-	<ul style="list-style-type: none"> •Teeth with maximum PD<4 •IPI (Silness/ Loe)>30 •BBI >2
Al Hamad et al.	0-1-7 days	60 pt	4 th and 5 th year Dental students (20-29 yrs), healthy gingiva, premolars with no high scalloped margin with 2 mm of keratinized tissue, no fibrotic gingival tissue, no recession, PD ≤ 3 mm, No CAL, no BOP, GI=0 or 1, PI=0 or 1	<ul style="list-style-type: none"> •Currently enrolled student •No relevant medical history •Non smoker/quit 6 m •At least 3 premolars
Kazemi et al.	7, 14, 28 days following gingival retraction	10 pts/20 specimens	Age 21-48 yrs, No medical problem, require FPD in both side/same arch	<ul style="list-style-type: none"> •No smoking, no alcohol, •no medication healthy periodontium •PI (silness and Loe);0, GSD;1-2 mm, •Normal gingival contour, •no BOP
Tolga et al.	2, 3, 7 days and 1 month after finishing, GCF, baseline day (0), before impression, after gingival retraction, after metal try in, 1 month after completion	8 pts (3 F and 2 M)	Age (28-72 yrs), Periodontally healthy Pt. ≥ 90% has PD=3 mm, CAL=1 mm, BOP=<10% of the probing sites, No radiograph of ABL (<3 CEJ-Bone crest)	<ul style="list-style-type: none"> •Nonsmoker or who smokes <10/day for <5 years), •needs FD, •at least 2 abutments for preparation. <p>Exclusion Criteria:</p> <ul style="list-style-type: none"> • Oral diseases, ongoing ortho tx, history of systemic or oral disease with influence on the immune system, diabetes, hepatitis or HIV, Immunosuppressive chemotherapy or current pregnancy or lactation.

(340 prepared teeth) regardless of the number of patients. All participants were healthy patients.

Age of participants: The age of the participants was (>20 years old). However, one study failed to report any information on the age of the participants [31]. 4 studies reported age ranges [11,29,32,33]. One studies reported age range of 21-48 years old [11], a study reported 28-72 years [33], and two studies reported 25-29 years [29,32].

Duration: The majority of the studies included were short-term clinical studies, which either finished after sampling or lasted one month. In one study impressions were made before retraction, immediately after retraction, and 14 days after retraction [29], in the another study Probing depth, clinical attachment level, gingival index (GI), plaque index, mobility, bleeding, and sensitivity were assessed at baseline, and at 1 and 7 days after application [32], however, in Kazemi [11] study the widths of gingival sulcus were measured by a jig in 4 phases, 0, 7, 14 and 28 days. The gingival index was evaluated in the 4 phases as well. The Gingival crevicular fluid (GCF) samples were collected before starting the fixed dental prosthesis treatment and repeated on days 2, 3, 7 and first month after cementation. In the study by Tolga [33], the Gingival Crevicular fluid flow was measured before and directly after the removal of the individual retraction material [31].

Quality analysis: Most included studies in the review presented a proper sample-size calculation that were reported and confirmed except in 1 study [31]. Randomization methods were considered possibly adequate in 4 studies [1,29,31-33], and clearly adequate in one study [11]. In the other hand, all studies compared their experimental results to a control group in a clearly adequate method [11,29,31-33]. In addition, appropriate statistical analyses were done in all included studies. Quality characteristics of each study are presented in **Table 5**.

Discussion

Systematic reviews have rapidly gained an important place in supporting clinical decision-making in medicine; however, dentistry has been somewhat slower to adopt this approach. The objective of a systematic review is to present a complete and modern assessment of research using transparent methods while intending to reduce bias. If such situations are met, there should be greater certainty in the conclusions of the appraisal than in other summaries of clinical evidence.

Effective gingival retraction prior to taking an impression without injuring the periodontal tissues is very significant in the long-term success of cast restorations. The gingival crevice normally is about 2 mm in depth accordingly, it should be treated with care,

Table 4 Intervention and outcome of the included studies.

Author	Data collection	Intervention	Control Group/ Alternate Group	Analysis	Outcome
Yang et al.	<ul style="list-style-type: none"> • Preliminary impression: (PSIM) • Each subject received all 3 types of retraction material on the labial of Max. Unprepared RT or LFT central or lateral incisors • Double phase impression tech with PSIM • 3 impressions were taken from each subject to duplicate 3 stone models with Improved dental stone (Diekeen, Heraeus, Kulzer, Germany). • The retraction materials were pressed into the gingival sulcus to a depth of approximately 1 mm and allowed to stay in position for 2 minutes. • The cord was manually removed. • The teeth were air-dried, and a second duplicated stone model immediately afterwards. The second duplicated stone model served to register the width of the retracted sulcus. • Fourteen days after gingival retraction, a third impression was made in the same way except that the gingiva was not retracted this time. • From the third impression, a third stone model was poured to register the position of the gingival margin 14 days after retraction to determine gingival recession. • The maximum difference was recorded and considered to be the amount of gingival retraction • To determine gingival recession, the images of the first and third stone models were superimposed. 	<ul style="list-style-type: none"> • Epinephrine-impregnated cord (Ultrapak 1) 	<p>Intervention 2:</p> <ul style="list-style-type: none"> • Injection-type material with 15% A1C13 (Expasyl). <p>Intervention 3:</p> <ul style="list-style-type: none"> • Injection-type material with 0% A1C13 (Korlex-GR) 	<ul style="list-style-type: none"> • Wilcoxon signed ranks test • Kruskal-Wallis test • Mann-Whitney U test 	<ul style="list-style-type: none"> • Significant increase in the sulcus width >0.2 mm after retraction by all 3 • Significant gingival recession (p<0.05) by all 3 • Ultrapak 1® produced the greatest amount of recession and was also significantly more painful compared to the other 2 materials (p<0.05).
Wostmann	<ul style="list-style-type: none"> • Collection of GCF using cotton caps • On base line, day 1 and 7 the following was recorded; PD, CAL, GI, PI recorded on the buccal of selected teeth 	<ul style="list-style-type: none"> • Ultrapack cord 	<ul style="list-style-type: none"> • Surgident epinephrine impregnated cord • Expasyl paste 	<ul style="list-style-type: none"> • Nonparametric (H&U tests for paired sample groups P=0.05) 	<ul style="list-style-type: none"> • Increase in GCF by mechanical technique and decrease with chemical techniques
Al Hamad et al.	<ul style="list-style-type: none"> • Tooth preparation with slope shoulder finishing line • Mesio buccal line angle to distolingual line angle at height of free gingiva • Reference line; Teeth were marked in the middle third of buccal surface with inverted cone bur #38 • First Light and heavy bodied silicone impression was made using custom acrylic tray • First Cast poured using improved lab stone • Cord was placed on buccal gingival sulcus of teeth from molar or premolar region after isolation 	<ul style="list-style-type: none"> • Ultrapack knitted non-impregnated retraction cord was applied to the buccal gingival sulcus along the distance from M to D papilla of the one selected premolars first (application time 10 min) • Maxillary premolars selected in 1/2 of subject • Mandibular premolar in other 1/2 	<ul style="list-style-type: none"> • Magic foam cord (5 min) • Expasyl (2 min) 	<ul style="list-style-type: none"> • Kruskal-Wallis test • Mann-Whitney U test 	<ul style="list-style-type: none"> • Mobility and CAL no difference between groups, sensitivity with Expasyl (n=4), PD, PI=no significant difference among GPS • Ultrapack ↓ mean PD after day 1, more ↓ after 7d • All tech. ↑ GI, highest ↑ by Expasyl later ↓ GI except Expasyl, bleeding only with Ultrapack

<p>Kazemi et al.</p>	<p>Parameters recorded at 6 sites of each tooth: PI, BOP, PPD, single calibrated and blind examiner, GCF samples analyzed for MMP-1, MMP_8 and TNF-α levels using (ELISA)</p>	<ul style="list-style-type: none"> Plain cord (ultrapack knitted RC#1 ultradent) presaturated with 15% aluminum chloride solution for 10 min Removed while moist 	<ul style="list-style-type: none"> Expasyl paste in the other side of the same arch Remained in site 2 mm Washed out by air & water spray Second impression and cast was done Cast were sectioned by saw then teeth were sectioned in a buccolingual direction@the buccal ridge using diamond disk 	<ul style="list-style-type: none"> Paired T test Wilcoxon signed ranks test 	<ul style="list-style-type: none"> Mean Sulcular width was significantly greater with the gingival cord than Expasyl paste Mean Gingival recession was significantly greater with cord 0.14 ± 0.07 at 28 days at 7, 14 days after retraction, significant increase in GI with cord group ($p=0.03$) but at 28 days returned back to base line
<p>Tolga et al.</p>	<p>-</p>	<ul style="list-style-type: none"> 6 abutment preparation (4 maxi canine, 9 maxi premolars, 2 maxi molar, 1 mandi (premolar) by Local anesthesia, subgingival margins, 2 teeth/patient evaluated, one abutment gingival retraction with potassium-aluminum-sulfate braided retraction cord (T=12 min) Impression with conventional c-silicone impression material in two stages (wash tech). for each pt one tooth was the negative control 	<ul style="list-style-type: none"> Injection-type material with 15% A1C13 (Expasyl) Intervention 3 Injection-type material with 0% A1C13 (Korlex-GR) 	<ul style="list-style-type: none"> Kolmogorov-Smirnov test Logarithmic transformation ANOVA 	<ul style="list-style-type: none"> The GCF MMP-8 concentrations showed significant differences among study groups ($p<0.05$) The differences between GCF MMP-8 concentrations of both ret (-) and ret (+) groups were not significant among the sampling days ($p>0.05$) The GCF MMP-8 concentrations of control group was significantly decreased at the 1st month ($p<0.05$) The GCF TNF-α concentrations showed significant differences in between study groups ($P<0.05$) In contrast to ret(-) and control groups, the GCF TNF-α concentrations of ret(+) group was significantly different among sampling days ($p<0.05$), it reached a peak at the first month in ret(+) group. The GCF flow rate in ret(+) group was significantly higher than those of ret(-) and control groups on day 3 (after gingival retraction) ($p<0.05$).

Table 5 Quality evaluation of all the studies.

Categories	Grading	Yang et al.	Wostmann	Al Hamad et al.	Kazemi et al.	Tolga et al.
Category A: Sample-size calculation, estimating the minimum number of participants Required to detect a significant difference among compared groups	0=did not exist/not mentioned/not clear 1=was reported but not confirmed 2=reported and confirmed	2	0	2	2	2
Category B: Randomization and allocation concealment methods	0=clearly inadequate 1=possibly adequate 2=clearly adequate	1	1	1	2	1
Category C: Clear definition of inclusion and/or exclusion criteria	0=no 1=yes	0	1	1	0	1
Category D: Completeness of follow-up (specified reasons for withdrawals and dropouts in each study group)	0=no/not mentioned/not clear 1=yes/no withdrawals or dropouts occurred	1	0	1	1	0
Category E: Experimental and control groups comparable at study baseline for important prognostic factors	0=no 1=unclear/possibly not comparable for one or more important prognostic factors 2=clearly adequate	2	2	2	2	2
Category F: Presence of masking	0=no 1=unclear/not complete 2=yes	0	0	0	0	0
Category G: Appropriate statistical analysis	0=no 1=unclear/possibly not the best method applied 2=yes	2	2	2	2	2
Total		8	6	9	9	8

thus, a conservative approach should be used to expose the tooth margins and control bleeding, and in the same time do not cause detachment or injury of the tissue. Different techniques have been used for this purpose [17]. Gingival retraction techniques have been classified as mechanical, chemical, surgical or a combination. The most widely used technique of gingival displacement is a chemo-mechanical technique, saturating the gingival retraction cords with specific hemostatic medicaments [4].

The available data on the post-operative effect of retraction cords on gingival tissue in patients with healthy gingiva compared to cordless techniques in respect to effect on gingival recession, parameters of gingival inflammation and patient comfort are very limited and after a thorough revision of the literature only 5 articles addressed this issue in a comparative matter.

Although Yang et al. [29], reported that there is a significant increase in the sulcus width >0.2 mm after retraction by the three materials (Ultrapak1), (Expasyl) and (Korlex-GR) with significant gingival recession, however, they reported that the Ultrapak 1® produced the greatest amount of recession and was also significantly more painful compared to the other 2 materials. This was also true in the report by Kazemi et al. [11], When they compared (Ultrapack knitted RC#1 Ultradent) pre-saturated with 15% aluminum chloride solution to Expasyl paste where they found that the mean width of the retracted sulcus, the mean gingival recession and the inflammation score was significantly

higher in the pre-saturated cord group compared to the paste group. However, on the contrary Wöstmann et al. [31], reported that there is increase in the crevicular fluid flow only when pure cotton retraction cords were used, but with the use of both chemo-mechanical and chemical retraction cords a significant reduction in the crevicular fluid was observed. Also, Al Hamad et al. [32] when compared Ultrapack knitted non-impregnated retraction cord with Magic foam cord and Expasyl, reported that GI only increased for all groups after 1 day and Expasyl was the highest. However the GI returned to a non-significant level after 7 days compared with baseline except for Expasyl.

Accordingly, although some previous histological studies [17,20,21] demonstrated that placement of the pre-saturated cord with various retraction medicaments caused a different degree of gingival inflammation, and other clinical studies found that gingival retraction with plain cord, produced acute injury [10,31]. However, all of these studies has reported either that the histological appearance has returned to its normal condition in 3-24 days or that the clinical picture has returned to it's normal condition in 2 weeks as indicated by the gingival index and/or GCF.

In conclusion, cordless retraction techniques in comparison to pre-saturated cord are associated with less gingival recession and inflammation although both can provide good gingival retraction. It should be also clear that although most of the retraction techniques can produce some type of gingival inflammation nevertheless, it is

temporary in nature and tissue will return it is healthy condition especially if the biological width was not violated and the patients has a healthy periodontium to start with.

Author Contributions

As this is a systematic review all authors had contributed equally in reaching to the concept of the research, analysis, interpretation,

critical revision of the article, approval of the articles included. Summarization of the articles was equally distributed as well. In writing the manuscript all authors participated equally in each part of the manuscript.

Conflict of Interest

The authors declare that they have no conflicts of interest.

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