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**DIRECT COMPOSITE RESIN FOR THE
MANAGEMENT OF TOOTH WEAR: A SYSTEMATIC
REVIEW AND META-ANALYSIS**

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ABSTRACT

Direct Composite Resin for the Management of Tooth Wear: A Systematic Review and Meta-Analysis

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Background: The survival of direct composite resin restorations for the treatment of worn teeth has been reported in several studies. This systematic review aims to integrate studies with outcomes that are comparable and to critically evaluate the literature.

Methods: A comprehensive electronic search of 4 databases (Medline-PubMed, Cochrane Central, Scopus, Google scholar) was performed on literature published between January 1990 and December 2017. Inclusion criteria were based on the PICO format. Exclusions included studies on children, adults with non-carious cervical lesions, cast and all-ceramic restorations, case reports with ≤ 4 participants, narrative and systematic reviews, other meta-analyses.

The risk of bias was assessed by a funnel plot. Selected data extraction included participant sample size, number of composite restorations, number of operators, type of composite, whether the Occlusal Vertical Dimension (OVD) was increased or not, location (anterior or posterior), mean or total follow-up time and success rate expressed as either percent of successful restorations or Median Survival Time (MST) in years.

Results: A total of 1461 studies were identified and 1316 were screened. 61 full text papers were assessed for eligibility resulting in 11 studies that met inclusion criteria for quantitative analysis. These 11 publications assessed 2,733 direct composite restorations placed in 375 subjects with

survival ranging from 50% to 96.4%. The funnel plot showed a low risk of publication bias. A meta-analysis of proportions using survival percentage of direct composite restorations gave a pooled effect size estimate of 81.3 % survival, but considerable heterogeneity was evident ($I^2=96.7$). Between study variance was high. Studies were mainly of a case series type performed in hospital settings.

Conclusions: Clinical heterogeneity was a significant factor with different operators, different interventions (composite manufacturer, micro-filled or hybrid) and outcomes expressed in different ways (percentage survival, Median Survival Time, Annual Failure Rate). Furthermore, sample sizes varied from 6 to 164 patients with concomitant wide age range and the number of restorations followed-up varied widely also from 16 to 1,010 composites. Follow-up times were generally short which could have a significant influence on survival outcome. It is reasonable to assume more advanced wear would be seen and treated in a hospital setting but few studies described the severity of the wear which would also affect survival outcome. Inconsistent results between studies implies statistical heterogeneity may also be present. Overall, the estimated survival of direct composite restorations in tooth wear cases was 81.3% although the substantial heterogeneity seriously limits the precision of this estimate.

DEDICATION

This thesis is dedicated to parents, in-laws and most of all my husband Jay Vajani for being a wonderful source of support and encouragement during this journey of mine to be a Prosthodontist.

DECLARATION

I declare that all the content of the thesis is my own work. There is no conflict of interest with any other entity or organization.

Name: Disha Jay Vajani

Signature:

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LIST OF ABBREVIATIONS

VDO: Vertical Dimension of Occlusion

BEWE: Basic Erosive Wear Examination

BPE: Basic Periodontal Examination

ACE Classification: Anterior Clinical Erosive Classification

GORD: Gastro-Oesophageal Reflux

IBS: Irritable Bowel Syndrome

TWI: Tooth Wear Index

OVD: Occlusal vertical dimension

RCP: Retruded contact position

ICP: Inter-cuspal position

RBCs: Resin bonded crowns

FWS: Freeway space

GCF: Gingival crevicular fluid

ICR: Intermediate Composite Restoration

PVS: Poly Vinyl Siloxane

CAD-CAM: Computer Aided Design and Computer Aided Manufacture

RFH: Resting face height

RCT: Randomized Controlled Trial

MIP: Maximum intercuspation

USPHS: United States Public Health Service

DW: Diagnostic waxing

OP: Occlusal Positioning

VDI: Vertical Dimension Increase

AFR: Annual Failure Rate

PRISMA: Preferred Reporting Items of Systematic Reviews and Meta-Analyses

NHS: National Health Service

1.0 LITERATURE REVIEW

Tooth wear is a term which encompasses the surface loss of tooth structure not occurring due to factors such as caries, trauma or developmental disorders. (1) Tooth wear is also commonly known as Tooth Surface Loss (Eccles, 1982) and is the non-carious loss of enamel and dentin which can threaten the survival of the tooth, oral health, and quality of life of the individuals affected by it. (1) Tooth wear is commonly found in patients of all ages. (2) Lambrechts et al estimated normal vertical loss of enamel from physiological wear to be approximately 20-38 micrometer per annum. (3)

1.1 Definition

Tooth wear is defined as the loss of tooth tissue to the process of attrition, erosion and abrasion.

(1) Grippo put forward a new classification of hard tissue lesions of teeth. He defined them as,

Attrition – The loss of tooth substance as a result of tooth to tooth contact during normal or parafunctional activity.

Erosion – The loss of tooth substance by acid dissolution of either an intrinsic or extrinsic origin. E.g. Gastric acid or dietary acids.

Abrasion- The pathological wear of tooth substance through biomechanical frictional processes. eg. tooth brushing. (2)

Tooth wear has a multifactorial aetiology and may be generalized throughout the dentition but is often localized to the incisor and canine teeth. (3) In a referred hospital sample attrition is seen most frequently, followed by erosion and multifactorial wear. Abrasion is rarely seen as a sole aetiological factor. (1) The appearance clinically depends on the causative factors, habits, restorations and occlusion.

When tooth wear is severe there is damage to the teeth which then gives an appearance of short teeth and there may also be a reduced Vertical Dimension of Occlusion (VDO). Patients who have lost posterior support (no premolar and no molar contacts) have more severe wear and had a significantly higher number of worn anterior teeth than those with posterior support. (4)

1.2 The measurement of tooth wear

A general concept to measure tooth wear was introduced by Smith and Knight in 1984 which was termed as Tooth Wear Index (TWI) which scores all four surfaces of a tooth (buccal, lingual, occlusal/ incisal and cervical). This index was the first one used to measure multifactorial tooth wear. The disadvantages of this index were that it was time consuming to chart the whole dentition and the calculations were needed.(2)

Table 1: Tooth Wear Index by Smith and Knight(3)

GRADE	CRITERIA
0	No loss of enamel surface characteristics
1	Loss of enamel surface characteristics
2	Buccal, Lingual and Occlusal Loss of enamel, exposing dentine for less than one third of the surface. Incisal Loss of enamel Minimal dentine exposure
3	Buccal, lingual and occlusal loss of enamel, exposing dentine for more than one third of the surface Incisal loss of enamel Substantial loss of dentine
4	Buccal, Buccal, lingual and occlusal loss of enamel, pulp exposure or exposure of secondary dentine Incisal pulp exposure or exposure of secondary dentine

Another index that was proposed to measure erosion is the Basic Erosive Wear Examination (BEWE) which is like the Basic Periodontal Examination (BPE) so far it is sextant based. The most severe tooth in each sextant is recorded and an overall score of the patient is calculated by

adding the score of each sextant. No Surface Loss (Score 0), initial loss of Enamel Surface (Score 1), distinct defect, hard tissue loss(dentin) less than 50 % of the surface area (Score 2), or hard tissue loss greater than 50 % of the surface area (Score3). (1)

Vailati and Belser devised the anterior clinical erosive classification (ACE) which has six classes of tooth loss. It also has a guide for the clinician to decide how to restore the worn anterior dentition. “Sandwich approach” indicates the method by which palatal composites and labial ceramic veneers are used to restore palatal and labial wear. (1) (5)

Table 2 : The ACE Classification(5)(3)

CLASS	PALATAL ENAMEL	PALATAL DENTINE	INCISAL EDGE LENGTH	FACIAL ENAMEL	PULP VITALITY	SUGGESTED THERAPY
Class I	Reduced	Not exposed	Preserved	Preserved	Preserved	No Restorative treatment-prevention only
Class II	Lost in contact areas	Minimally exposed	Preserved	Preserved	Preserved	Palatal composites
Class III	Lost	Distinctly exposed	Lost < 2mm	Preserved	Preserved	Palatal Onlays
Class IV	Lost	Extensively exposed	Lost greater than 2mm	Preserved	Preserved	Sandwich approach
Class V	Lost	Extensively exposed	Lost greater than 2mm	Distinctly reduced/lost	Preserved	Sandwich approach (experimental)
Class VI	Lost	Extensively exposed	Lost greater than 2mm	Lost	Lost	Sandwich approach (highly experimental)

1.3 Tooth wear prevalence

Tooth wear is recognised as a major problem in both children and adults associated with changing dietary and lifestyle habits. Furthermore, elderly patients are retaining their teeth which will wear with age. The prevalence of tooth wear according to the most recent UK Adult dental health survey (2009) is 77 % of the adults who have teeth in the anterior region, whilst 15 % had moderate wear and 2 % had severe wear.(6)Moderate tooth wear was 11 % in 1998 and now increased to 15 % in 2009.(7) The percentage of adults presenting with severe tooth wear increased from 3% at the

age of 20 years to 17% at the age of 70 years. Thus, tooth wear increases significantly with age.

(8)The prevalence of tooth wear in Abu Dhabi primary school children was found to be 97.6% .(9)

The presence of at least a single tooth with advanced tooth wear in Europe is 30 % between the ages of 18-35 years.(10)

The prevalence of tooth wear is more commonly seen in males than females in the ratio, 2.3:1(M:

F). (4)The reasons often given are that men tend to exert stronger forces while chewing than

females. Their diet, lifestyle accompanied with stress is also a causative factor. It is also understood

that tooth wear increases with age according to a systematic review. (8)

1.4 Aetiology

1.4.1 Attrition

The term attrition is derived from the Latin verb “atritum” which describes the action of rubbing

against something. (11) It is defined as the loss by wear of tooth substance or a restoration caused

by mastication or contact between occluding or approximal surfaces .(12) Attrition is also defined

as the physiologic wear of tooth structure as a result of tooth-to-tooth contact (Eccles). Awake and

Sleep Bruxism are often the leading causes of attrition.(13)

The areas commonly affected are incisal and occlusal surfaces which contact opposing teeth. Initial

appearance is of small polished facets on the cusp or ridge, or the slight flattening of an incisal

edge. It thus appears as equal and matching wear facets. (14) As it progresses the cusp height

reduces, and the occlusal plane flattens. In severe cases there is reduction in the clinical height of

the crown of the tooth or teeth that are affected. (3) Attrition is accelerated by habits such as

bruxism (grinding), traumatic occlusion and malocclusion. (14) Severe attrition leads to dentin

exposure which thus leads to increased rate of wear.

1.4.2 Erosion

The term erosion is derived from the Latin verb *erosum* (to corrode) which describes the process of gradual destruction of a surface, usually by chemical or electrolytic process. (11) It is defined as the progressive loss of hard dental tissues by chemical process not involving bacterial action. (13) Erosion rarely occurs alone and is commonly seen along with attrition or abrasion. Not everything that is acidic causes erosion, but for erosion to occur the acid exposure needs to be frequent, severe and over a long period. (15)

Erosion can be of Intrinsic or Extrinsic origin. Intrinsic is of gastric acid origin. The acid is due to Gastro-oesophageal reflux (GORD), vomiting or rumination. (16) Regurgitation essentially means when acid refluxes and enters the mouth. It is often involuntary which occurs due to gastrointestinal issues such as hiatus hernia, gastric ulcers or pregnancy. Vomiting can be spontaneous or self-induced and can be linked to a variety of medical conditions such as cyclic vomiting syndrome in children which itself is associated with irritable bowel syndrome (IBS), epilepsy, motion sickness and migraine. (16) Voluntary regurgitation is seen in those who suffer from eating disorders such as anorexia nervosa or bulimia nervosa. (4) It is said that a higher number of females suffer from eating disorders than males (10:1.5) (3) The use of Ecstasy, a recreational drug has also been associated with erosion and tooth wear. (16)

Extrinsic sources of dietary erosion occur due to food or drinks which are acidic for example orange juice, colas and sports drinks. Citric acid and phosphoric acid are the main ingredients of juices and sodas with the former able to chelate and thus dissolve calcium ions from the tooth structure. (12) Fruits such as citrus fruit, vinegar (acetic acid) in pickled food, salt and vinegar crisps and ketchup also have erosive potential. (16) The greater the frequency of erosive food and drinks intake per day, the higher is the risk of erosive tooth wear. (15) Over the counter medicines

like Gaviscon, which are used to treat regurgitation, may also a cause tooth wear as they contain abrasive particles. Also, Asthma inhalers which contain steroids, aspirin (salicylic acid) and chewable Vitamin C (Ascorbic acid) have been linked with erosion. (3) Chronic alcoholism often leads to gastritis and regurgitation of acids. (12)(16) The functions of saliva are dilution, lubrication and buffering action of these acids. Various other medications like diuretics, antidepressants, antihypertensives, appetite suppressants and radiation therapy may reduce salivary buffering and lead to more wear. Sjogren's syndrome or xerostomia will also reduce saliva. (3)

Extrinsic or environmental erosion occurs when acids are exposed to the labial surfaces of incisors at the work place or during leisure.(12)It is said to look like scooped out depressions.(1)Erosive wear often has been reported in swimmers due to poorly maintained swimming pools and copper mine workers as they come in contact with sulphuric acid .(3)Wine tasters and workers in battery factories are also exposed to acidic liquids and vapours and thus are at a risk of being exposed to erosion.(15)

A typical presentation of erosive lesions are bilateral smooth concave defects without chalkiness or roughness. Early lesions affect enamel with shallow, smooth and glazed surface. As the lesion effects dentin, it gives a dull appearance. (1) In cases where erosion is severe "cupping" is seen on the incisal parts on anterior teeth and occlusal surfaces of posterior teeth. (1) When erosion is in the advanced stages the occlusal form doesn't appear the same and there are hollowed out surfaces.(15)

1.4.3 Abrasion

Abrasion is defined as the loss by wear of tooth substance or a restoration caused by factors other than tooth contact.(12)A common cause of abrasion is vigorous tooth brushing as it leads to the

gingival recession and wear on the buccal or labial surfaces near the region of the cemento-enamel junction (CEJ).The teeth most affected are the canines and premolars.(1)The incisal edge of the maxillary central incisor often gets notched because of habits such as biting on pins, pipe, pencils/ pen biting , nails or an instrument.(1)

1.5 Tooth wear management

The management of tooth wear has many challenges for dentists.(17)Since tooth wear has a multifactorial aetiology, an in depth clinical examination must include medical and dental history, occupation, diet and assessment for any parafunctional habits.(14)Some patients often take time to disclose a cause at the initial appointment as it might be sensitive or embarrassing information .(1) The early recognition and diagnosis of tooth wear will prevent the rest of the dentition from being worn down.(18)

Most patients complain of the poor appearance of their teeth as worn teeth are shorter than normal teeth and sensitivity may be present.(4) On some occasions due to the formation of tertiary dentine ,patients do not feel any symptoms of pain even after wear has advanced.(4)Problems with function such as chewing food is another complaint often encountered by such patients but in some cases contacts are still maintained between teeth due to various methods of compensation .(4)A reduced vertical dimension of occlusion(VDO) can be observed in some patients who suffer from tooth wear or alternatively the alveolar bone and the Freeway Space (FWS) is normal .(19) Previously the options to restore teeth affected by wear were crowns for full mouth rehabilitation but crowning can be difficult if there is significant lack of height for retention, not to mention further tissue loss during crown preparation.(20)

Treatment and management are often considered to be synonymous but are different. Treatment indicates the active intervention that is done whereas management is a much broader term which includes monitoring, passive intervention and active intervention. (20)

Management will be discussed in the following sections.

1.6 Monitoring and advice (prevention)

The approach for treatment must be for a lifelong approach and not a short-term one as long-term monitoring assesses the effectiveness of preventive measures and can check for further wear before starting any restorative procedure. (14)

Early diagnosis with a preventive plan is appropriate for mild wear but in more severe cases, restorations are essential along with assessment and elimination of the causative factors. (1)

- Dietary Analysis: According to Watson and Burke a food diary should be maintained by the patient for 3 consecutive days to give the dentists an insight into their eating and drinking habits.(3)

We must advise the patient to reduce the frequency of acidic drinks, to drink more water and milk, not to swish or froth drinks in the mouth, to avoid sipping, to use a straw, to avoid drinking at bedtime and avoid brushing until 20 minutes after exposure.(20)

- Fluoride: Application of sealants and topical fluoride can benefit the affected teeth. (18) Neutral Sodium Fluoride mouth rinse, toothpastes or gels such as Flucan or Colgate Gel-Kam can be used daily to attempt reversing the damage caused by acids. (3)(20)

- Referral to a medical practitioner: If tooth wear is caused by any medical condition such as severe erosion secondary to eating disorders, gastric problems or alcoholism the general medicine practitioner (GP) must be consulted.(7) Drugs such as antacids, omeprazole and ranitidine can be prescribed and where xerostomia may be present a specialist in oral medicine can advise.(1)

•Sensitivity : indicates erosion or abrasion is still active and is managed by applying a resin sealant, varnish , desensitizing tooth paste or bonding material to seal the dentinal tubules and reduce sensitivity for a short period of time.(15)(20)A study by Sundaram et al spoke about the life of the bonding agents being limited on teeth affected by severe tooth wear. (3)The application of 0.7% fluoride solution in the dental office and followed up with 0.4% at home has been seen to benefit patients. (3)Tooth Mousse ACP (GC) contains Recaldent that contains casein which promotes remineralization .This is a beneficial product when used in a bleaching tray.(3)

•Habits: The patient should be encouraged to avoid using toothpastes which are abrasive, brushing overzealously and habits such as pen/pencil biting should avoided. (1)Swishing and not drinking acidic beverages with a straw should also be avoided.(3)

•Splint therapy: The habit of tooth grinding during the day can result in attrition. As dentists we must encourage the patient to discontinue this habit. (14) When we confirm night time grinding (nocturnal bruxism), a full coverage hard acrylic splint such as a Michigan splint or Tanner appliance is recommended. (1) A hard splint is preferred as it lasts longer and can be adjusted than as opposed to soft vinyl splints. The splint must have occlusal contact along with anterior and lateral guidance. (14)The splint also allows the muscles to relax into normal function by not allowing the patient to close in centric occlusion and ensures the teeth are separated. (1)

According to Holbrook and Arnadottir (1), non-carious tooth loss may be prevented if dentists

- Recognize that the problem is preventable
- Grade its severity
- Diagnose the likely cause or causes
- Monitor tooth wear

Monitoring can be done by indices, clinical photographs, study casts at intervals of 6-12 months, sectional silicone index (1)(20) and now intra-oral scanning may provide more accurate assessment of changes of the surface topography. Indices are used mainly for epidemiological research.

1.7 Restorative

The main objective of restorative management is to reduce or stop the progression of wear by controlling risk factors and restore to improve aesthetics and function. (15)The restorative treatment decisions should be decided on the needs of the patient and the severity of wear. The position in the arch of the worn tooth along with the remaining tooth structure determine the most suitable type of restoration according to Poyser et al.(21)Clinical symptoms such as sensitivity or pain that cannot be treated conservatively , or progressive , uncontrolled wear with altered vertical dimension indicate the need for restorative care.(22)Articulated study models along with a diagnostic wax-up should be carried out prior to formulating comprehensive treatment options for each individual so as to know the final end-point of the treatment.(14)

Treatment planning steps:

- The case must be analysed and the models to be mounted in ICP.
- Diagnostic Wax-Up
- Setting up the new vertical dimension of occlusion (VDO)
- Planning direct or indirect restorations (13)

The important aspects to note while considering the restoration of tooth wear are: (17)

- Pattern of tooth wear
- Existing inter-occlusal space
- The space required for the restorations

- Aesthetic needs of the patient
- The amount of enamel and remaining tooth structure available.

Anterior Wear: Sometimes there is no space for build ups between the mandibular and maxillary incisors because of dento-alveolar compensation. Then we may need to increase the occlusal vertical dimension (OVD), by the Dahl Approach which was originally proposed in 1975 to create space in the treatment of anterior tooth wear. (11)The patient wore a Dahl Appliance, a removable chrome cobalt appliance with an anterior bite platform. With new technological advances resin composite build-ups or “Dahl” restorations achieve the same purpose. At first the posterior teeth are discluded and the anterior teeth are in occlusion. Later posterior contact is re-established owing to the intrusion of anterior teeth and eruption of posterior teeth which takes approximately 4 to 6 months. Thus, it increased or re-established the VDO and facilitated space to restore teeth affected by wear. Patients complained of problems with chewing and speaking. (23)On most occasions there is passive eruption that occurs along with tooth wear and thus the space for restorations is not sufficient.(13) Direct and Indirect composite veneers are recommended to be bonded to enamel and dentine once the space has been created.(20)

Jaeggi et al put forth 3 categories of treatment options depending on the amount of vertical dimension lost:

Category 1(vertical loss <0.5mm): sealing of the eroded areas or direct composites

Category 2 (vertical loss < 2mm): Direct composites

Category 3(vertical loss >2mm): Indirect ceramic veneers and overlays. (24)

Local and General Occlusal Wear: In patients who have anterior palatal wear or localized occlusal wear on a few posterior teeth the teeth can be restored in Intercuspal position (ICP) if space is present and thus there is no need to increase the occlusal vertical dimension. Also, in cases of

generalized tooth wear with no space in ICP but there is more than 3mm of freeway space (FWS) options such as resin bonded composites, ceramic crowns, partial dentures or over dentures can be used to restore the dentition. If the freeway space is 3mm or less elective crown lengthening is indicated providing there is good bone support and low lip line.(20)

The treatment of choice must be the least invasive. Restorative treatments can be direct (composite) or indirect (composite, metals, ceramics). According to a study by Dietschi et al the recommendations are:

- a) Limited tissue loss and small fillings- Direct composite
- b) Moderate tissue loss and medium size existing restorations- Mix of Direct and Indirect Composites
- c) Extensive tissue loss with large restorations – Indirect restorations

Also, they recommended to restore the anterior guidance, smile line and tooth proportions with adhesive restorations. (13)

On most occasions direct restorations are less invasive than indirect. Therefore, composite is recommended as an option. (15)

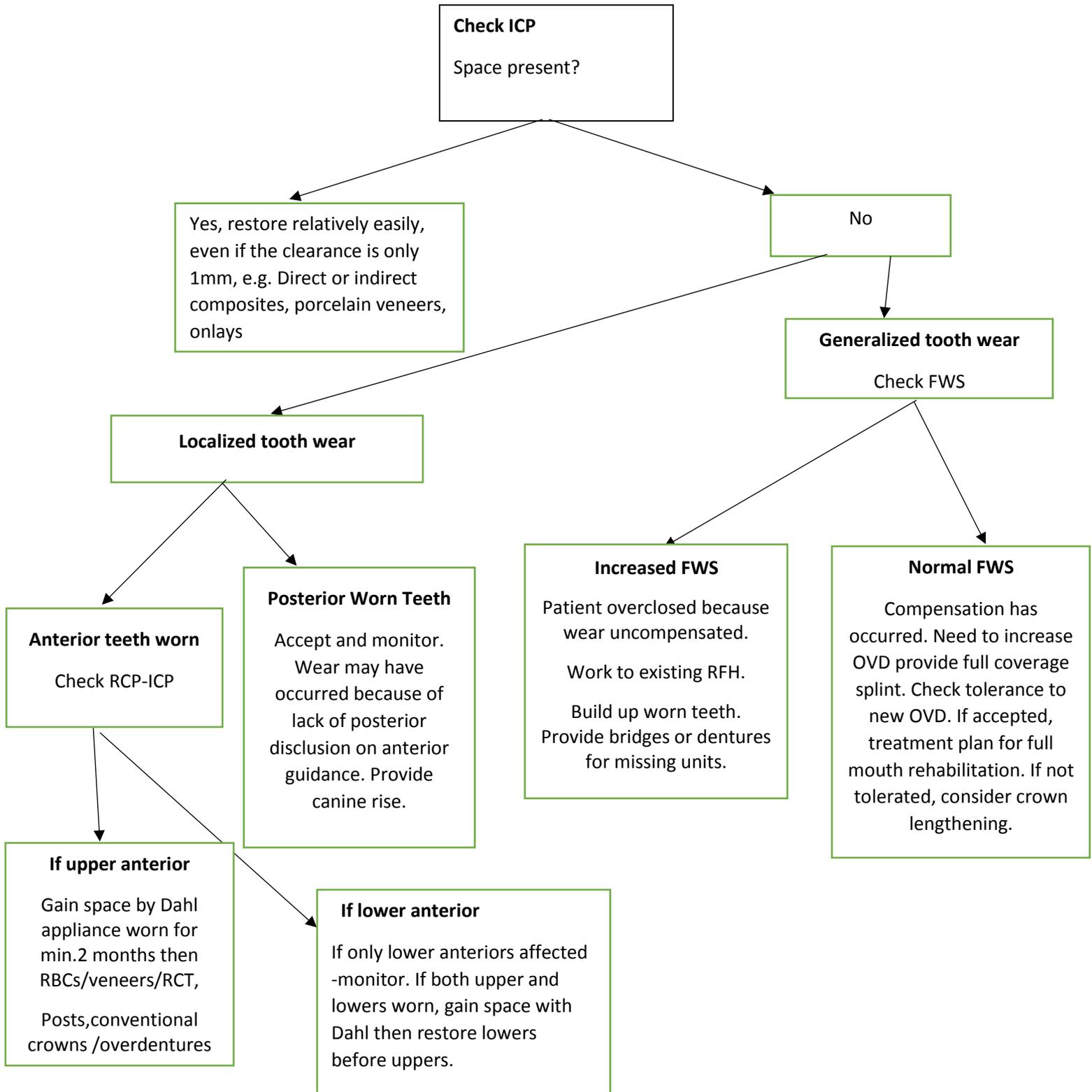


Figure 1: Flowchart for management of Tooth Wear (20)

1.7.1 Direct restorations

The use of composite resin restorations was first described by Bevenius et al and has been used to restore anterior teeth for over 35 years. (25) The rim of enamel also known as the “gingival ring” which surrounds the gingival margins found at the margins of teeth which have severe erosion. (26) The formation of the ring is thought to occur because of the protection from plaque and gingival crevicular fluid (GCF). This ring helps in the bonding between enamel and composite resin. A study by Briggs et al puts forth the use of direct composite resin restorations as Intermediate Composite Restorations (ICR) so that vulnerable teeth are protected from further wear. (26)

Direct composite resin restorations usually are easy to place and have good aesthetics but at the same time it is essential to maintain moisture control. (27) The complications that are likely to occur are wear, chipping and detachment. The latter rarely occurs. (13) Resin bonded composite usually needs 1.5 to 2mm of thickness in areas of high stress. (18) Usually they are indicated for moderate to intermediate loss of tooth structure. (13) There are usually 3 methods of applying direct composite a) Freehand technique b) Using a customised polyvinylsiloxane (PVS) matrix c) Using a customised vacuum formed matrix. (28)

Direct composite restorations are also used in a method called as additive approach to let the patient adjust to the increased vertical dimension. (24) The advantages of direct composite are that it is an additive approach and thus conservative. Composite can be repaired and replaced easily, and the cost is not very high. (13) The method is highly technique sensitive and the clinician must be skilled. (13) Hybrid composites show high fracture and wear resistance, thus they are preferred over micro-filled composite resins. (19)

A study on the survival of 1010 direct composite restorations in the management of severe tooth wear in 164 patients where most restorations were placed in the maxillary arch using the Dahl approach.(7) The mean follow-up time was 33.8 months and 71 restorations failed where most failures were on the mandibular arch. The cause for failures was higher in older patients and in patients who lacked posterior support. This study concluded that the restoration of teeth affected by wear is a challenge but regarded direct nano-hybrid composite as a suitable material for restorations.

Failure of 23 restorations (6.9%) occurred out of 332 restorations over a mean period of 3.98 years. In cases where the occlusal vertical dimension was increased using direct hybrid composite resin for patients with severe tooth wear out of which 8 restorations (2.4%) had major fractures, 11 (3.3%) had minor fractures and 4 (1.2%) failed owing to caries due to leakage. These patients were interviewed regarding their satisfaction with the restoration using the Visual Analogue Scale (VAS) and found that the mean score was 9, which determines a high level of satisfaction. (19)

A ten-year study carried out on the survival of Dahl restorations to manage anterior tooth wear in 26 patients and 283 restorations had a median survival time of 5.8 years. Failures occurred due to fracture, wear and marginal discolouration. Direct, indirect and combination of direct and indirect restorations were used.(29)

1.7.2 Indirect restorations

Indirect restorative options are preferred when larger restorations are required in cases where more severe types of tooth wear have occurred. (13) Various options are available such as composite, ceramic or newly developed polymer ceramic CAD-CAM restorations.(17)

1.7.2.1 Indirect composite resin restorations

They initially were spoken about in the mid –1970s. Indirect composites are mostly composed of hybrid resins which have a high fracture resistance and have less polymerization shrinkage than direct composites.(28)According to Kilpatrick and Mahoney(28), there are advantages and disadvantages of using indirect composite resin restorations to manage tooth wear cases,

Advantages:

- Less chairside time
- In large cases with multiple restorations there is control over the contour and increase in vertical dimensions.
- Aesthetically more pleasing than cast metal restorations.
- They are not as abrasive as ceramic restorations.
- The wear resistance and strength are more than direct restorations.
- Polymerization shrinkage is reduced to a great extent except for the resin cement.

Disadvantages:

- Inferior marginal fit when comparing to ceramic and metallic restorations.
- Increased laboratory costs.
- The restorations might tend to be bulky.
- Additive repair can't be easily done.
- Wear and leakage of the resin-based cement
- Undercuts might have to be removed from the tooth structure.
- The margin where the restoration has been cemented may require some masking. (28)

Bartlett and Sundaram (30)compared the success rate of posterior teeth restored with direct and indirect composite resin . There were two groups, one was a tooth wear group and the other was a

control group. The tooth wear group had 32 paired indirect and direct restorations in 16 patients with a mean observation period of 12 months. The control group on the other hand had 26 pairs of restorations consisting of direct and indirect in 13 patients (6 premolars and 7 molars) with a mean observation period of 16 months. Only 16 (50%) of the tooth wear group restorations were retained out of which 7 were indirect and 9 were direct. Also 7 fractured (22%) out of which 4 were indirect and 3 were direct and 9(28%) were lost from which 5 were indirect and 4 were direct. These needed replacing. On the other hand, in the control group 21 (80%) restorations survived out of which 10 were indirect and 12 were direct. Thus, the study showed that direct and indirect composite resins were contraindicated to treat posterior tooth wear as there was a high fracture rate. Moreover an increased vertical dimension and bruxism are thought to increase the rate of failure. (30)

Another study of 75 indirect palatal veneers (Artglass-Heraeus. Kulzer GmbH, Hanau, Germany) at an increased vertical dimension in 12 patients with severe anterior wear were reviewed until the posterior teeth had erupted into the new occlusion. Minor failures after 2 years accounted for 13.3% of cases which were repaired with direct composites or by polishing. On an average, the posterior occlusion was re-established after 9 months in 10 cases. Therefore, Artglass can be recommended as a short-term treatment option for anterior tooth wear. (27)

1.7.2.2 Cast alloys (metal palatal veneers and metal onlays)

These restorations are used where tooth wear restorations do not have to be aesthetically appealing. A study by Smales and Berekally has shown good long-term prognosis for full veneer gold crown restorations to treat worn posterior teeth. (31) Resin cements such as Panavia (Kuraray, Tokyo 100-8115, Japan) have shown us that we can predictively bond cast metal restorations to the tooth structure. Thus, the tooth preparation can be minimal which preserves the remaining worn tooth structure.

Advantages of adhesive cast restorations to worn occluding surfaces is:

- The thickness needs to be only 0.5mm with minimal tooth preparation.
- They have good fit
- The wear of the opposing surface is minimal.
- Margins are placed supra-gingivally
- Indicated for patients who have parafunctional habits and for posterior restorations.

Disadvantages are:

- Limited indication for anterior teeth as they have a metallic grey colour which can show through
- They cannot be repaired intra-orally.
- Enough enamel must be present for bonding.
- Temporary restorations are difficult to place.(28)

1.7.2.3 All ceramic restorations

Ceramic restorations when used to restore tooth surface loss,

Advantages:

- Superior Aesthetics is superior (Depending on the placement of the margin).
- Abrasion resistance of ceramic is good.
- The gingival tissue shows good response to ceramic.
- Compared to composites they have low surface free energy therefore do not stain easily.

Disadvantages:

- They are easily prone to fracture as they are brittle

- They abrade the teeth that are in contact with restoration. Especially feldspathic porcelain.

When comparing Type III gold restorations and porcelain it has been found that they are 40 times more abrasive.

- Difficult to repair intra-orally and adjust.
- Expensive
- Can be degraded in acidic surroundings.(28)

Zirconia based crowns such as LAVA™ (Lava, 3M Espe, St. Paul, MN) have been used for the restoration of the severely worn dentition especially for anterior teeth worn into dentin.161 LAVA crowns were placed for 30 patients of which 27 were males and 3 were females. Only 25 of the 161 crowns failed with a mean survival time of 6 years. (32)

A minimally invasive approach to treat worn down palatal surfaces with used the Dahl principle with an occlusal splint to create space and then permanently restore with palatal ceramic veneers Maximum Intercuspal Position (MIP). (33)

The success of ceramic restorations for tooth surface loss over 5 years was reported to be 90%. (34)Oh et al recommended that a splint be provided for night time use after completion of the restorative treatment with ceramic restorations in order to protect the restorations in case parafunctional habits continued.(35)

1.8 Assessment of intervention

The most commonly used assessment tool for clinical performance is the modified United States Public Health Services (USPHS) criteria as it is often difficult to assess restorations. (24) The USPHS is known to be a blunt tool but is still used in various studies. (24)

Where,

Alpha(A) – The restoration is acceptable in all aspects

Bravo(B) – There is a perceived short coming of the restoration that requires either monitoring, refinishing or repair.

Charlie(C) – There is a small fault and the restoration must be repaired

Delta (D) – There is a fault and the restoration must be replaced.

Table 3: Modified United States Public Health Services (USPHS) criteria for the clinical evaluation of restorations (43)

	ALPHA (A)	BRAVO (B)	CHARLIE(C) (Reparable)	DELTA (Complete restoration replacement needed)
Surface texture	Sound	Rough	-	-
Anatomical Form	Sound	Loss of material within the resin composite	Loss of material extending to the tooth surface	Complete or partial (>50 %) loss of bulk material
Marginal Integrity	Sound	+ve / -ve step, removable by finishing	-ve step, Not removable by finishing	Strong -ve step not removable in many areas
Marginal Discolouration	None	Slight discolouration removable by finishing	Discolouration localized,not removable	Strong discolouration in many areas,not removable
Secondary caries	None	Caries present without new restoration	Caries present with new restoration	-
Marginal Inflammation	None, No pockets, 3 mm, No bleeding	Slight, No pockets <3mm, bleeding	Moderate, Pockets 4 to 5 mm, Bleeding	Severe, Pockets >6mm, Bleeding
Colour Stability of the restoration	No change	Change of colour compared to baseline	-	-
Colour match	Sound	Slight loss of translucency and difference in colour in comparison to baseline	Moderate loss of translucency and difference in colour in comparison to baseline	Total Mismatch
Postoperative sensitivity(air)	None	Moderate	Severe	

1.9 Survival rates of direct composite

Gulamali et al defined “survival” of a restoration as the interval between the date of placement and date of failure. If a restoration failed it was replaced by a new one and entered as a new restoration. More than 90 % exhibited failures, minor and major over the 10 years and failures were wear, marginal discolouration and fracture. The mean survival time was thus 5.9 years.(29) Similarly Redman et al mentioned the median survival rate for all microfilled, hybrid and Artglass at an increased OVD to be 4.9 years. Though they mentioned that after the fifth year there was increased chance of failure. They also mentioned that Artglass has a promising 3- year survival rate.(23) Gow and Hemmings(27) in a study of 75 indirect Artglass restorations over a mean follow-up period of 2 years had a success rate of 87%.

Al-Khayatt et al defined “survival” as any restoration that had not been lost, replaced or repaired in the preceding 7 years. 72 of the 85 restorations survived over 7 years therefore the survival was 85%. (36) The study by Hemmings et al showed that the success rate was 89.4% for 93 restorations which survived out of 104 restorations.(37)

Milosevic and Burnside said from a total of 1010 direct composite restorations in 164 patients and only 71 restorations failed. Thus, the failure was 7%. They defined failure as total debond or chip.(7)

Aljawad and Rees found the success rate in their retrospective study was 88.8% and the survival rate was 95.6%. Where they defined “success” as number of restorations with no complications and “survival” as number of restorations with no complications plus the restorations with minor failures, such as chipping, that was easily repairable.(38)

1.10 Other systematic reviews

To date three systematic reviews have been published regarding treatment options for tooth wear.(39)(40)(41)

The first systematic review aimed to look for similar treatment options for generalized tooth wear and to recommend the best method to rehabilitate worn teeth using the best evidence available at that time. A search conducted from 2003 to 2013 with various search terms analysed clinical steps that included Diagnostic Waxing (DW), occlusal positioning (OP), vertical dimension increase (VDI), restoration and follow-up. According to the study there was not enough evidence to form conclusions and they recommended more clinical research. (37)

Ahmed and Murbay systematically reviewed the survival of resin composites in the anterior region for the management of tooth wear. Six hundred and sixty-six articles were selected for the systematic review of which eight articles were full text reviewed. Only five articles were selected of which three were prospective and two were retrospective studies. The total number of restorations placed was 772 direct and indirect composites in 100 patients. The follow-up period ranged between 5 months to 10 years. At 2 years the survival rate was less than 90% and at 5 years it was 50%. The posterior occlusion was re-established by 18 months in 91% in patients after increasing the vertical dimension. Thus, they concluded that anterior composites can be used to increase the vertical dimension for short- and medium-term management of wear. (38)

A systematic review that described the rehabilitation of severely worn teeth with various materials calculated the annual failure rates (AFR) of each study. A total of 511 articles were found of which 23 were accepted for full text analysis as well as 7 papers found from hand searching. Out of these

30 studies, 12 were selected for the systematic review. The AFR was 0.4% for micro hybrid and 26.3% for micro filled direct resin composite. For indirect composites the AFR range from of 0% to 14.9% and 2.7% for porcelain veneers. The authors concluded that both direct and indirect methods can be used to treat severely worn teeth and did not reach a conclusion to state which method was superior. (39)

1.11 Conclusion

With advances in medicine, life expectancy increases, and teeth will be retained for longer. Therefore, the problem of a worn dentition will increase. We as dentists need to understand the factors causing tooth wear to appropriately diagnose and treat patients who suffer from it.(14)

1.12 Aim and objective

A Systematic Review is defined by the Cochrane Collaboration (2014) as a review of a clearly formulated question that uses systematic and explicit methods to identify, select and critically appraise relevant research and to collect and analyze data from studies included in the review.

The survival of direct composite resin restorations for the treatment of worn teeth wear has been reported in several studies. This systematic review aims to integrate studies with outcomes that are comparable and to critically evaluate the literature.

The specific objective of this systematic review was to identify and assess the use of direct composite in the restoration of tooth wear.

The Research Question is therefore “What is the survival rate of direct composite resin in the management of Tooth Wear?”

A PICO method was used to set an answerable clinical question.

P for – Patient /Population/Problem

I for– Intervention

C for – Control/ Comparison

O for – Outcome

Thus, P were patients with tooth wear, I was restorative treatment modality, C was the comparison between treatment modalities and O was survival of the restoration.

Table 4: Eligibility criteria for the systematic review based on PICOS

DOMAIN	INCLUSION CRITERIA	EXCLUSION CRITERIA
POPULATION/ PARTICIPANTS	Adults of any age, ethnicity and gender Tooth wear including erosion, abrasion and attrition	Children Adults with Non-Carious Cervical Lesions (NCCL; Class V abrasion)
INTERVENTIONS	Restoration of worn teeth with direct composite resin	Indirect composite, Cast (PFM) & all-ceramic restorations, removable prostheses
CONTROL/COMPARISON	None	
OUTCOMES	Survival of restorations expressed as Annual Failure Rate or Median Survival Time (MST) or clinical performance (eg USPHS)	
STUDY DESIGNS	Case series or cohort studies with ≥ 7 subjects, randomized or non-randomised to treatment groups	Case reports <4, narrative reviews, other systematic reviews and meta-analyses

The PRISMA (Preferred Reporting Items of Systematic reviews and Meta-Analyses) statement consists of a 27-item checklist and a four-phase flow diagram.(42) The aim of the PRISMA statement is to help authors improve the reporting of systematic reviews and meta-analyses. The 27 checklist items pertain to the content of a systematic review and meta-analysis, which include the title, abstract, methods, results, discussion and funding. (www.prisma-statement.org/)

Previously in 1999, to address the suboptimal reporting of meta-analyses, an international group developed a guidance called the QUOROM Statement (Quality Of Reporting Of Meta-analyses), which focused on the reporting of meta-analyses of randomized controlled trials. (42)

In 2009, the guideline was updated to address several conceptual and practical advances in the science of systematic reviews and was renamed PRISMA.(42) Subsequently in 2015, there was an update (PRISMA -P 2015) which consists of seventeen item checklists aimed at enhancing the preparation and reporting to get a robust protocol for the systematic review. (43)

PRISMA-P 2015 Checklist

This checklist has been adapted for use with protocol submissions to *Systematic Reviews* from Table 3 in Moher D et al: Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Systematic Reviews* 2015 4:1

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
ADMINISTRATIVE INFORMATION					
Title					
Identification	1a	Identify the report as a protocol of a systematic review	<input type="checkbox"/>	<input type="checkbox"/>	
Update	1b	If the protocol is for an update of a previous systematic review, identify as such	<input type="checkbox"/>	<input type="checkbox"/>	
Registration	2	If registered, provide the name of the registry (e.g., PROSPERO) and registration number in the Abstract	<input type="checkbox"/>	<input type="checkbox"/>	
Authors					
Contact	3a	Provide name, institutional affiliation, and e-mail address of all protocol authors; provide physical mailing address of corresponding author	<input type="checkbox"/>	<input type="checkbox"/>	
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review	<input type="checkbox"/>	<input type="checkbox"/>	
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	<input type="checkbox"/>	<input type="checkbox"/>	
Support					
Sources	5a	Indicate sources of financial or other support for the review	<input type="checkbox"/>	<input type="checkbox"/>	
Sponsor	5b	Provide name for the review funder and/or sponsor	<input type="checkbox"/>	<input type="checkbox"/>	
Role of sponsor/funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol	<input type="checkbox"/>	<input type="checkbox"/>	
INTRODUCTION					
Rationale	6	Describe the rationale for the review in the context of what is already known	<input type="checkbox"/>	<input type="checkbox"/>	
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)	<input type="checkbox"/>	<input type="checkbox"/>	

METHODS					
Eligibility criteria	8	Specify the study characteristics (e.g., PICO, study design, setting, time frame) and report characteristics (e.g., years considered, language, publication status) to be used as criteria for eligibility for the review	<input type="checkbox"/>	<input type="checkbox"/>	
Information sources	9	Describe all intended information sources (e.g., electronic databases, contact with study authors, trial registers, or other grey literature sources) with planned dates of coverage	<input type="checkbox"/>	<input type="checkbox"/>	
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	<input type="checkbox"/>	<input type="checkbox"/>	
STUDY RECORDS					
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	<input type="checkbox"/>	<input type="checkbox"/>	
Selection process	11b	State the process that will be used for selecting studies (e.g., two independent reviewers) through each phase of the review (i.e., screening, eligibility, and inclusion in meta-analysis)	<input type="checkbox"/>	<input type="checkbox"/>	
Data collection process	11c	Describe planned method of extracting data from reports (e.g., piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators	<input type="checkbox"/>	<input type="checkbox"/>	
Data items	12	List and define all variables for which data will be sought (e.g., PICO items, funding sources), any pre-planned data assumptions and simplifications	<input type="checkbox"/>	<input type="checkbox"/>	
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale	<input type="checkbox"/>	<input type="checkbox"/>	
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis	<input type="checkbox"/>	<input type="checkbox"/>	
DATA					
Synthesis	15a	Describe criteria under which study data will be quantitatively synthesized	<input type="checkbox"/>	<input type="checkbox"/>	
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data, and methods of combining data from studies, including any planned exploration of consistency (e.g., I^2 , Kendall's tau)	<input type="checkbox"/>	<input type="checkbox"/>	
	15c	Describe any proposed additional analyses (e.g., sensitivity or subgroup analyses, meta-regression)	<input type="checkbox"/>	<input type="checkbox"/>	
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned	<input type="checkbox"/>	<input type="checkbox"/>	
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (e.g., publication bias across studies, selective reporting within studies)	<input type="checkbox"/>	<input type="checkbox"/>	
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (e.g., GRADE)	<input type="checkbox"/>	<input type="checkbox"/>	

(43)

2 MATERIALS AND METHODS

2.1 Search strategy

A comprehensive electronic search for literature published between the period 1990 up to and including December 2017 was conducted for articles published in Medline (PubMed), Scopus, Cochrane Central and Google Scholar. An investigator and supervisor were involved in independently reviewing the titles and abstracts.

Manual searches of the bibliographies of all full-text articles and related reviews was performed. Hand searching of major journals was conducted along with reviewing of the reference lists of relevant articles. The PRISMA guideline/ flowchart provided the template flowchart for literature searching and sifting. (43)

Search terms

1. “Restoration of Tooth Wear”

(Restoration [All Fields] AND ("tooth wear"[MeSH Terms] OR ("tooth"[All Fields] AND "wear"[All Fields]) OR "tooth wear"[All Fields])) AND ("1990/01/01"[PDAT]: "2017/12/31"

2. “Direct restorations and Tooth wear”

Direct [All Fields] AND restoration [All Fields] AND ("tooth wear"[MeSH Terms] OR ("tooth"[All Fields] AND "wear"[All Fields]) OR "tooth wear"[All Fields])) AND ("1990/01/01"[PDAT]: "2017/12/31"[PDAT]

3. “Restoration of toothwear”

(Restoration[All Fields] AND toothwear[All Fields]) AND ("1990/01/01"[PDAT] : "2017/12/31"[PDAT])

4. “Restoration of tooth wear and erosion”

(Restoration[All Fields] AND toothwear[All Fields] AND erosion[All Fields]) AND ("1990/01/01"[PDAT] : "2017/12/31"[PDAT])

5. “Restoration of tooth wear and attrition”

(Restoration[All Fields] AND toothwear[All Fields] AND ("tooth attrition"[MeSH Terms] OR ("tooth"[All Fields] AND "attrition"[All Fields]) OR "tooth attrition"[All Fields] OR "attrition"[All Fields])) AND ("1990/01/01"[PDAT] : "2017/12/31"[PDAT])

2.2 Inclusion criteria

-Studies published over the last 27 years (from 01 January,1990 to 31 December ,2017) and conducted on humans.

-Include full articles and not only abstracts.

-All studies on restoration of the worn dentition by composite resin including attrition, erosion and abrasion.

2.3 Exclusion criteria

-Studies not in the English language.

- Case reports and studies that did not determine survival. Other narrative and systematic reviews.

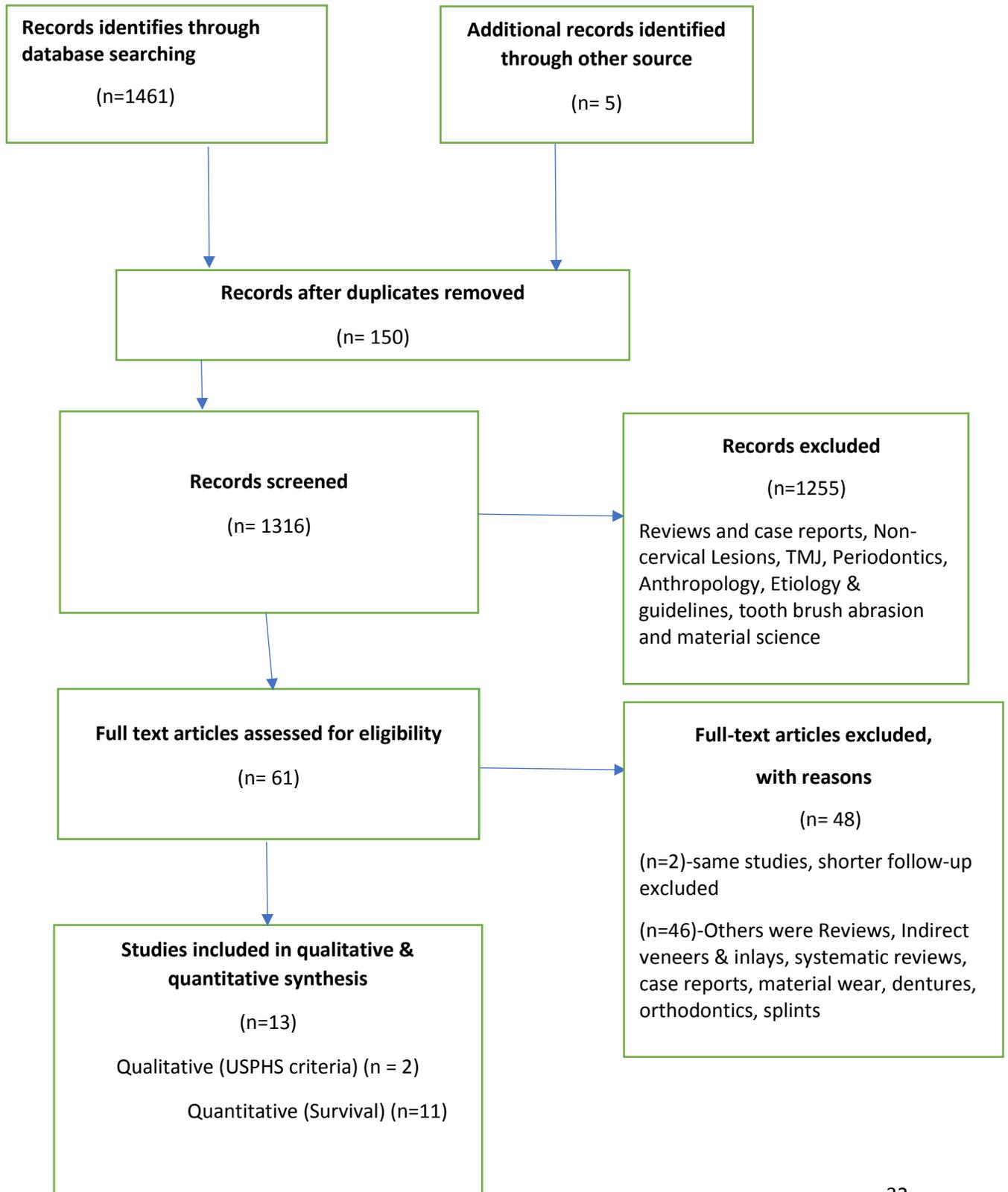
-NCL or cervical tooth wear and restoration of cervical tooth wear.

- Tooth wear treated with indirect composite resin, ceramic crowns, ceramic veneers, metal veneers, PFM crowns or dentures.

2.4 Selection of studies

Titles and abstracts were all screened and gathered by the investigator and supervisor. Full text articles were then obtained and reviewed. The articles that were included were agreed upon by both investigator and supervisor. It was agreed to include randomized control trials (RCT), retrospective and prospective studies.

Figure 2: Flow chart of the selection of studies for the systematic review according to the PRISMA statement



2.5 Data extraction

Extracted data were analysed according to the following:

- Author & Year
- Study design & Setting
- Number (N) of Patients
- Number (N) of Restorations
- Number (N) of operators
- Type of composite
- OVD increase Location
- Mean / total F- U (follow -up) in years
- Survival/ failure / AFR
- USPHS criteria given

Restoration Survival has been presented as the Annual Failure Rate (AFR) and proportion of survived restorations over a given period.

Data extraction and grouping according to the categories would also assist in assessing any potential bias present in the included studies. A meta-analysis is also planned.

2.6 Quality assessment

The quality of individual studies and the overall strength of recommendation of the systematic review will be graded according to the Strength of Recommendation Taxonomy (SORT) grading system. Strength of Recommendation Taxonomy addresses three key elements in research: quality of evidence, quantity of evidence and consistency of evidence. The clinical strength of recommendation derived from the systematic review will be accordingly graded as either: A= strong, B= moderate or C= weak.

3 RESULTS

3.1 Outcome of search

The electronic screening of PubMed (MEDLINE), Scopus, Cochrane Central and Google Scholar identified 1461 titles and hand searching identified 5 titles (Fig.2.). The duplicates which were 150 titles were removed.1316 abstracts were assessed for eligibility out of which 1255 abstracts were excluded as they were case reports and reviews, non-carious lesions (cervical), TMJ, etiology and articles were full text reviewed out of which 48 articles were excluded of which one study by Poyser et al (22) was excluded as it was reported as a follow-up study by Khayatt et al as a 7-year prospective study. A 3-year case series by Schimidlin et al(44) also was excluded as it was continued as a 5.5 year study.(24)A further 46 publications were reviews, indirect veneers & inlays, systematic reviews, case reports, material wear, dentures, orthodontics and splints and thus excluded from the systematic review. Gow and Hemmings placed Artglass an indirect composite resin and was also excluded from the meta-analysis. (28)Consequently, only articles involving 13 studies were selected for inclusion in the systematic review. (37)(45)(22)(31)(29)(19)(24)(36)(46)(47)(7)(38)(48).Two studies of these 13 studies, Attin et al (24) and Vailati et al(46) have only qualitative results, expressed as USPHS criteria.(Table 6). The remaining 11 studies had quantitative results expressed as survival (Table 5).

3.2 Sample size and study characteristics

6 studies were retrospective, 4 prospective and 1 RCT with follow-up periods ranging from 1 to 10 years. The sample size ranged from 6 to 164 patients with the number of composite restorations ranging from 70 to 1010. These 11 publications assessed 2,733 direct composite restorations placed in 375 subjects with survival ranging from 50% to 96.4%.

3.3 Description of intervention

The setting of the studies varied from university, dental hospitals to private practice. Direct composites were used which varied from microfilled composite such as Durafill© (Kulzer GmbH., Hanau, Germany), hybrid composite such as Herculite© (Kerr Corporation, Orange, Ca, USA) and nano-ceramic types such as Spectrum© (Dentsply Sirona, York, PA 1740, USA), and Ceram X Duo© (Dentsply Sirona, York, PA 17401, USA). All the studies had an increase in OVD (Occlusal Vertical Dimension) except the study by Smales and Berkally (2007). (32) The locations were anterior, posterior or both. The number of operators varied from 1, 2 to 3 and in one study 11 post-graduate residents. In some studies, the number of operators was not mentioned.

6 studies included in this systematic review used the modified USPHS criteria except the studies by Bartlett & Varma (49), Smales & Berekally(32) , Hemmings et al(38), Milosevic & Burnside(9) and Hamburger et al (2).

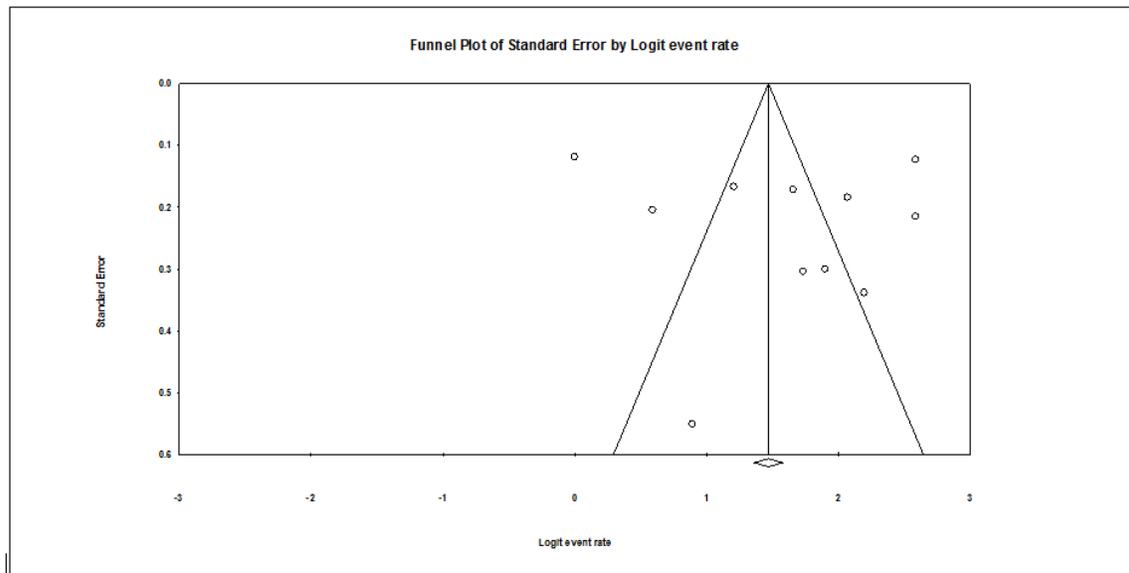
Table 5: Selected studies of quantitative results expressed as survival, included in the systematic review

Sl No	Author and Year	Study Design and Setting	N of Patients	N of Restorations	N of operators	Type of composite	OVD Increase	Location	Mean/ Total F-U in years	Survival	Also Give USPHS Criteria Yes(Y) or No(N)
1	Hemmings et al 2000	Retrospective Dental Hospital	16	104	2	microfilled & hybrid	Yes	Anterior	2.5 years	64.4%	No
2	Redman et al 2003	Retrospective Dental hospital	31	134	3	microfilled & hybrid	Yes	Anterior	7 years	90.0%	Yes
3	Bartlett & Sundaram 2006	RCT Dental hospital	16	31	1	Microfilled	Yes	Posterior	1 year	71.0%	No
4	Smales & Berekally 2007	Retrospective case series Dental Hospital	17	202	2	Hybrid	No	Anterior & posterior	10 years	77.2%	No
5	Gulamali et al 2011	Prospective Dental Hospital	15	190	Several	not stated	Yes	Anterior	10 years	50.0%	Yes
6	Hamburger et al 2011	Retrospective Dental Practice	18	332	Not stated?	Hybrid	Yes	Anterior & posterior	3.98 years	93.1%	No
7	Al-Khayyat et al 2013	Prospective randomized split mouth trial Dental Hospital	15	85	1	Hybrid	Yes	Lower Anterior	7 years	84.7%	Yes
8	Ramseyer et al 2015	Prospective Dental Hospital	7	98	3	Hybrid	Yes	Posterior	3.3 years	87.8%	Yes
9	Milosevic & Burnside 2016	Prospective Dental Hospital	164	1010	1	Hybrid	Yes	Anterior & posterior	2.8 years	93.0%	No
10	Aljawad et al 2016	Retrospective Dental hospital	41	296	1	Hybrid	Yes	Anterior	2.1 years	88.8 %	Yes
11	Bartlett & Varma 2017	Retrospective Dental hospital	35	251	11 post grad residents	Hybrid	Yes	Anterior & posterior	1.2 years	84.0%	No

Table 6: Selected studies of qualitative results expressed as USPHS criteria, included in the systematic review

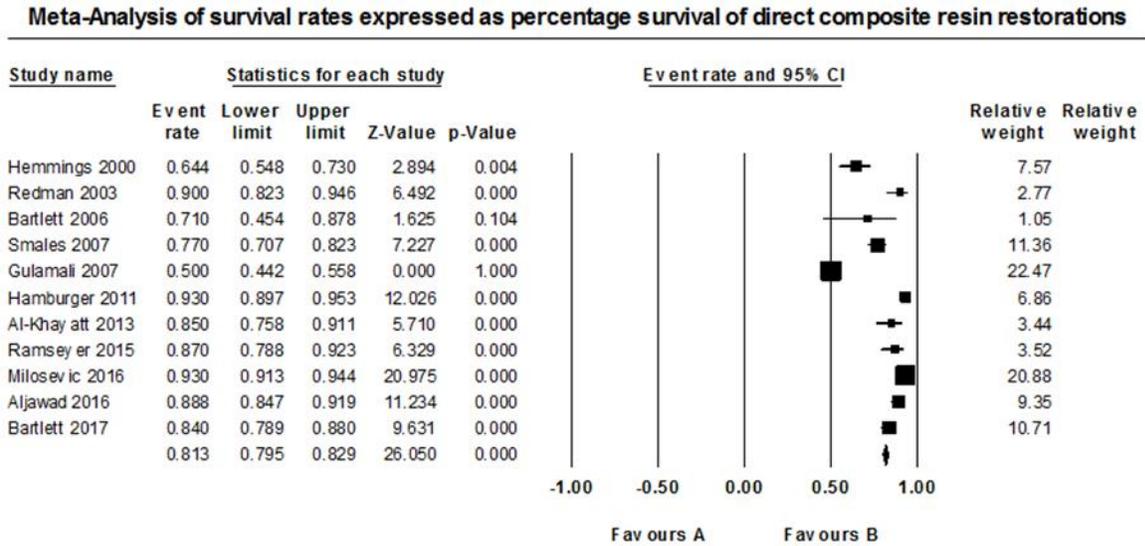
SI No	Author and Year	Study Design and Setting	N of Patients	N of Restorations	N of operators	Type of composite	OVD Increase	Location	Mean/ Total F-U in years
1	Attin et al 2012	Prospective Not stated	6	75	Not stated	Hybrid	Yes	Posterior Occlusal	5.5 years
2	Vailati 2013	Prospective University	12	70	Not stated	Hybrid	Yes	Anterior	4.19 years

Figure 3: The funnel plot was symmetrical indicating no significant publication bias.



The funnel plot (**Figure 3**) showed a low risk of publication bias. A meta- analysis of proportions using survival percentage of direct composite restorations gave a pooled effect size estimate of 81.3% survival, but considerable heterogeneity was evident ($I^2=96.7$) as shown in **Figure 4** and **Table 7**. Between study variance was high. Thus, there was a significant degree of heterogeneity between the studies. Studies were mainly of a case series type performed in hospital settings.

Figure 4: Forest plot- Shows the results for pooled data on restoration survival in the meta-analysis



Meta Analysis

Table 7: The summary estimate of survival is 81.3% but heterogeneity is very substantial

(I² = 96.7)

Model		Effect size & 95% Interval			Test of null (2-tail)				Heterogeneity			Tau ²		
Model	Number of studies	Summary estimate	Lower limit	Upper limit	Z	p	Q	df(Q)	p	I ²	Tau ²	SE	Variance	Tau
Fixed	11	0.813	0.795	0.829	26.050	0.00	302.955	10	0.00	96.699	1.083	0.608	0.370	1.041
Random	11	0.831	0.722	0.902	4.912	0.00								

4 DISCUSSION

The aim of this systematic review and meta- analysis is to investigate the survival rate of composite resin in the management of tooth wear.

A tooth wear case needs adequate diagnosis to identify and control the risk factors. Often requiring questioning which might make the patient uncomfortable as the questions can be sensitive. Ideally the restorative treatment should be postponed till the dentist is sure wear is not progressing.(49)

The worn dentition is a restorative challenge for dentists, but composite can still be used as a restorative material. (9) Composite is an additive approach and preserves most of the tooth structure. Composites are reversible and conservative. Whereas indirect crowns and veneers are a subtractive approach where tooth structure is removed from a comprised tooth structure leading to less amount of area for bonding.(49) Though is it essential for patients to know at the time of giving consent that regular maintenance is required as fractures can occur.(49)

The 11 studies present survival in different ways which necessitated conversion of failure rates to survival rates in order to compare outcomes for meta-analysis. The number of patients ranges from 7(48) to 164 (9). The number of direct composite restorations ranged from 75 to 1010. Some studies did not state how many operators carried out the treatment for tooth wear cases. (28) (25) (2) (46). On the other hand, some had 1 operator which lowered the risk of bias as reproducibility is improved with 1 operator. (31)(45)(9) In some studies the operators were consultants, in some they were post grad students (49) and some a mixture of the two (30). The experience of an operator can influence the success of treatment using a standard method of restoration as seen in the study by Milosevic and Burnside where a single operator had a low failure of 7 %.(9) contrasting

Gulamali et al in a 10 year follow-up with 50 % failure rate but 75% of the operators were consultants and 25% were senior clinical staff and postgraduate students.(30) 11 postgraduate residents placed restorations in a dental hospital over a short mean follow-up time of 1.2 years resulting in a 16% failure rate.(49) The operator in one study was a specialist at a dental hospital with a standard clinical protocol (9) and presented possibly more skill than 11 postgraduate residents. (49)

The study designs were all different and 4 were prospective(29)(36)(47)(7), 6 were retrospective(37)(23)(31)(19)(38)(48) and 1 was a Randomized Controlled Trial(RCT)(30).

The setting was in university, dental hospitals and private clinic. Different types of composite were used such as micro-filled, hybrid and nano-composite. The follow-up period ranged from 1 year to 10 years and the definitions of failure, survival and success varied. Thus, these studies overall are heterogenous and not standardised.

There is no randomization in the case-series studies thus the generalizability of results is open to question. The study by Al-Khayatt et al (37) included patients from a previous study by Poyser et al only if they had significant tooth wear affecting at least four teeth in the anterior mandible. They also mentioned that dentin had to be involved, clinical crown height must be lost, and the dentition must be periodontally stable. (37) Patients were referred to a tertiary care clinic for the restoration of their severely worn teeth therefore there was no randomization. They were also selected for this study if they were able to attend multiple appointments and follow-ups. (49) In the study by Gulamali et al the patients were already being treated with composite resins at an increased OVD for anterior tooth wear since the last 10 years. (30)

A retrospective study by Smales and Berakally (32) mentioned that since the restorations were placed by prosthodontists in a dental hospital setting, they cannot compare them with restorations carried out by General dental practitioners (GDPs).

Direct composite placed at an increased occlusal vertical dimension (OVD) showed good clinical performance in patients with severe tooth wear.(2) They have shown to have good short to medium term survival(48) in cases where the OVD is increased for anterior wear and are thought to be conservative and easy to maintain.(45) Also patients were satisfied with the appearance of the teeth after the restoration and had improved self-confidence along with reduced sensitivity.(38) The use of direct and indirect composites to treat worn posterior teeth was deemed to be contraindicated by Bartlett and Sundaram because of a high fracture rate. (31)

The major failures seen for direct resin bonded composites are bulk fracture and discolouration. (42) The relationship between occlusion and composite failure is unclear as contradictory results have been published. Composite had a higher failure rate in Class II Div 2 compared to Class II Div 1, whereas in another prospective observational study it was concluded that Class III or edge to edge incisal relationships had greater failure than Class I and Class II. (9) (24) Also resin bonded composites failed earlier if the patient had parafunctional wear. (24) On the flip side Milosevic and Burnside reached the conclusion that bruxism and an increase in the OVD were not associated with failure. They also deduced that loss of posterior support and older patients led to a higher chance of restorations failing. (9) The conclusion reached was that resin-based composites could be used at an increased vertical dimension for short-to -medium term restorations and survived well until 5 years. (24)

Clinical heterogeneity was a significant factor with different operators, different interventions (composite manufacturer, micro-filled or hybrid) and outcomes expressed in different ways (percentage survival, Median Survival Time, Annual Failure Rate). Furthermore, sample sizes varied from 6 to 164 patients with concomitant wide age range and the number of restorations followed-up varied widely also from 16 to 1,010 composites. Follow-up times were generally short which could have a significant influence on survival outcome. It is reasonable to assume more advanced wear would be seen and treated in a hospital setting but few studies described the severity of the wear which would also affect survival outcome. Inconsistent results between studies implies statistical heterogeneity may also be present. Overall, the estimated survival of direct composite restorations in tooth wear cases was 81.3% although the substantial heterogeneity seriously limits the precision of this estimate.

The Consensus Report of the European Federation of Conservative Dentistry(15) highlighted the management of erosive tooth wear recommending the use of least invasive therapies and concluded that direct restorations are less invasive than indirect and thus recommend composites. They also recommend regular monitoring and evaluation at recall appointments.

The NHS (National Health Service) in the United Kingdom provides free treatment at NHS hospitals and composites are promoted as a form of management. This is since they are economical versus choosing crowns which are expensive since they are produced by laboratories. Thus, composites are always chosen as the first line of treatment and they preserve more tooth structure. Though later if they fail and cannot be repaired more invasive treatment options need to be considered(48) In Switzerland , the United States and the United Arab Emirates healthcare

provision is privately funded thru insurance schemes mainly. In these countries aesthetic dentistry is making a mark with patients walking into clinics asking for smile makeovers and clinics providing “Hollywood Smiles” with porcelain veneers. Vailati et al have introduced The Geneva Erosion Study which is a prospective clinical trial used to treat tooth wear for anterior teeth with two veneers, one palatal indirect composite veneer and one indirect labial porcelain veneer on the same tooth. Thus, calling it The Sandwich Approach. This technique is more time consuming and does not produce better long-term results than composite restorations.(46)

In conclusion, this systematic review and meta-analysis has found that direct composite resin is an adequate treatment modality for restoration of worn teeth with estimated survival of over 80 % for composite restorations over an average of 5- years.

Most studies state that the first option should always be the least invasive therapy thus direct composite restorations are a short-term to medium-term option in the restorative treatment of tooth wear. Regular recall and maintenance along with adequate treatment for the etiological factors is necessary for success. Patients have been satisfied with the appearance, function and reduced sensitivity provided by composite restorations. This meta-analysis has formed that the estimated overall survival of composite resin restorations in 81.3% but heterogeneity is significant. Guidelines to help the General Dental Practitioner and Specialist manage tooth wear are recommended.

5 STUDY LIMITATIONS

The literature search was limited from 1990 to 2017 to include the last 27 years of studies published on the use of direct composite resin for tooth wear and only 4 data bases were reviewed. A wider search may have found further studies.

Conversion of MST and failure rate to survival rate expressed as a percentage in order to allow comparison to be made between individual studies may not be methodologically correct.

Meta-analysis, however, cannot be performed unless outcome measures are the same.

REFERENCES

1. Bartlett D. A proposed system for screening tooth wear. *Br Dent J.* 2010;(208):207–9.
2. López-Frías F, Castellanos-Cosano, L Martín-González J, Llamas-Carreras J, Segura-Egea J. Clinical measurement of tooth wear: Tooth wear indices. *J Clin Exp Dent.* 2012;4:48–53.
3. Mehta S, Banerji S, Millar B, Suarez-Ferito J. Current concepts on the management of tooth wear:part 1 .Assessment , treatment planning and strategies for the prevention and the passive management of tooth wear. *Br Dent J.* 2012;212:17–27.
4. El Wazani B, Dodd MN, Milosevic A. The signs and symptoms of tooth wear in a referred group of patients. *Br Dent J.* 2012;
5. Vailati F, Belser U. Classification and Treatment of the Anterior Maxillary Dentition Affected by Dental Erosion: The ACE Classification. *Int J Periodontics Restor Dent.* 2010;30:559–71.
6. White D, Tsakos G, Pitts N, Fuller E, Douglas G, Murray J, et al. Adult Dental Heath Survey 2009: common oral health conditions and their impact on the population. *Br Dent J.* 2012;213:567–72.
7. Milosevic A, Burnside G. The survival of direct composite restorations in the management of severe tooth wear including attrition and erosion:A prospective 8-year study. *J Dent.* 2016;44:13–9.
8. Van't spiker A, Rodrigues J, Kreulen C, Bartlett D, Bronkhorst EM, Creugers N. Prevalence of tooth wear in adults. *Int J Prosthodont.* 2009;22(1):35–42.
9. Halabi M, Al Kayoumi A, Khamis A, Chogle S. Prevalence of tooth wear in Pimary

- Dentition in school children of Abu Dhabi,UAE. *Appl Clin Res Clin Trials Regul Aff.* 2016;3:27–33.
10. Bartlett D, Lussi A, West N, Bouchard P, Sanz M, Bourgeois D. Prevalence of tooth wear on buccal and lingual surfaces and possible risk factors in young European adults. *J Dent.* 2013;41:1007–13.
 11. Litonjua L, Sebastiano A, Bush P, Cohen R. Tooth wear: Attrition,erosion,and abrasion. *Quintessence Int.* 2003;34(6):435–46.
 12. Kelleher M, Bishop K. Tooth surface loss:an overview. *Br Dent J.* 1999;186:61–6.
 13. Dietschi D, Argente A. A Comprehensive and Conservative approach for the Restoration of Abrasion and Erosion.Part 1:Concepts and Clinical Rationale for Early Intervention Using Adhesive Techniques. *Eur J Esthet Dent.* 2011;6(1):20–33.
 14. Lee A, He LH, Lyons K, Swain M V. Tooth wear and wear investigations in dentistry. *Journal of Oral Rehabilitation.* 2012.
 15. Carvalho T, Colon P, Huysmans M, Lussi A, Schlueter N, Shellis P, et al. Consensus Report of the European Federation of Conservative Dentistry : Erosive tooth wear - diagnosis and management. *Swiss Dent J.* 2016;126:342–6.
 16. O’sullivan E, Barry S, Milosevic A, Brock G. Diagnosis, Prevention and Management of Dental Erosion. *Prim Dent J.* 2008;15(1):11–2.
 17. Loomans B, Opdam N, Attin T, Bartlett D, Edelhoff D, Frankenberger R, et al. Severe Tooth Wear : European Consensus Statement on Management Guidelines. *J Adhes Dent.* 2017;19:111–9.

18. Banerji S, Mehta S. Clinical management of pathological tooth wear in general dental practice. *Br Dent J.* 2016;220(4):209–10.
19. Hamburger JT, Opdam NJM, Bronkhorst EM, Kreulen C, Roeters JJM, Huysmans M. Clinical Performance of Direct Composite Restorations for the Treatment of Severe Tooth Wear. *J Adhes Dent.* 2011;13(6).
20. Milosevic A. Toothwear: Management. *Dent Update.* 1998;25:50–5.
21. Poyser N, Porter R, Briggs P, Kelleher M. Demolition experts:management of the parafunctional patient :2.Restoration management strategies. *Dent Update.* 2007;34:262–8.
22. Bartlett D. The role of erosion in toothwear:aetiology ,prevention and management. *Int Dent J.* 2005;55:277–84.
23. Redman C, Hemmings K, Good J. The survival and clinical performance of resin-based composite restorations used to treat localised anterior tooth wear. *Br Dent J.* 2003;194:566–72.
24. Attin T, Filli C, Imfeld C, Schmidlin P. Composite vertical bite reconstructions in eroded dentitions after 5.5 years: a case series. *J Oral Rehabil.* 2012;39:73–9.
25. Bevenius J, Evans S, L'Estrange P. Conservative Management of erosion-abrasion.A system for the general practioner. *Aus Dent J.* 1994;39:4–10.
26. Briggs P, Djemal S, Chana H, Kelleher M. Young adult patients with established dental erosion-what should be done? *Dent Update.* 1998;25:166–70.
27. Gow A, Hemmings K. The Treatment of Localised Anterior Tooth Wear with Indirect

- Artglass Restorations at an Increased Occlusal Vertical Dimension. Results After Two Years. *Eur J Prosthodont Rest Dent*. 2002;10(3):101–5.
28. Mehta S, Banerji S, Millar B, Suarez-Ferito J. Current concepts on the management of toothwear: Part 4 . An overview of the restorative techniques and the dental materials commonly applied for the management of tooth wear. *Br Dent J*. 2012;212:169–77.
 29. Gulamali A, Hemmings K, Tredwin C, Petrie A. Survival analysis of composite Dahl restorations provided to manage localised anterior tooth wear(ten year follow-up). *Br Dent J*. 2011;211.
 30. Bartlett D, Sundaram G. An Up to 3- Year Randomized Clinical study Comparing Indirect and Direct resin Composites Used to restore worn Posterior Teeth. *Int J Prosthodont*. 2006;19:613–7.
 31. Smales RJ, Berekally TL. Long-term survival of direct and indirect restorations placed for the treatment of advanced tooth wear. *Eur J Prosthodont Restor Dent*. 2007;
 32. Milosevic A. The survival of zirconia based crowns(LAVA) in the management of severe anterior tooth wear up to 7 -years follow-up. *Oral Biol Dent*. 2014;2.
 33. Magne P, Magne M, Bleser U. Adhesive restorations,centric relation,and all the Dahl principle : minimally invasive approaches to localized anterior tooth erosion. *EurJ Esthet Dent*. 2007;2:260–73.
 34. Aristidis G, Dimitra B. Five year clinical performance of porcelain laminate veneers. *Quintessence Int*. 2002;33:185–9.
 35. Oh W, DeLong R, Anusavice K. Factors affecting enamel and ceramic wear:a literature

- review. *J Prosthet Dent.* 2002;87:451–9.
36. Al-Khayatt A, Ray-Chaudhuri A, Poyser N, Briggs P, Porter R, Kelleher M, et al. Direct composite restorations for the worn mandibular anterior dentition: a 7 year follow-up of a prospective randomised controlled split-mouth clinical trial. *J Oral Rehabil.* 2013;40:389–401.
 37. Hemmings K, Darbar U, Vaughan S. Tooth wear treated with direct composite restorations at an increased vertical dimension : Results at 30 months. *J Prosthet Dent.* 2000;
 38. Aljawad A, Rees J. Retrospective Study of the Survival and Patient Satisfaction with Composite Dahl Restorations in the Management of Localised Anterior Tooth Wear. *Eur J Prosthodont Rest Dent.* 2016;24:222–9.
 39. Muts EJ, van Pelt H, Edelhoff D, Krejci I, Cune M. Tooth wear: a systematic review of treatment options. *J Prosthet Dent.* 2014;
 40. Ahmed KE, Murbay S. Survival rates of anterior composites in managing tooth wear: Systematic review. *Journal of Oral Rehabilitation.* 2016.
 41. Mesko M, Sarkis-Onofre R et al. Rehabilitation of Severely Worn Teeth. *J Dent.* 2016;48:9–15.
 42. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gotzsche PC, Ioannidis J. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. *J Clin Epidemiol.* 2009;62:1–34.
 43. Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015

- statement. Syst Rev. 2015 Dec 1;4(1):1.
44. Schmidlin P, Filli T, Imfeld C, Tepper S, Attin T. Three-year Evaluation of Posterior Vertical Bite Reconstruction Using Direct Resin Composite - A Case Series. Oper Dent. 2009;34:102–8.
 45. Redman CDJ, Hemmings KW, Good JA. The survival and clinical performance of resin–based composite restorations used to treat localised anterior tooth wear. Br Dent J. 2003;
 46. Vailati F, Gruetter L, Belser U. Adhesively restored anterior maxillary dentitions affected by severe erosion :upo 6 year results of a prospective clinical study. Eur J Esthet Dent. 2013;8(4):506–30.
 47. Ramseyer ST, Helbling C, Lussi A, ST R, Helbling C, Lussi A. Posterior Vertical Bite Reconstructions of Erosively Worn Dentitions and the ‘Stamp Technique’ - A Case Series with a Mean Observation Time of 40 Months. J Adhes Dent. 2015;
 48. Bartlett D, Varma S. A retrospective audit of the outcome of composites used to restore worn teeth. Br Dent J. 2017;223:33–6.
 49. Milosevic A. Clinical guidance and an evidence-based approach for restoration of worn dentition by direct composite resin. Br Dent J. 2018;224(5):301–10.

APPENDIX I



Date: 30/09/2017

Dear Dr.Disha Vajani

Re: Your research protocol

Titled: Systematic Review of Restorative Treatment Modalities for Tooth Wear

Thank you for submitting your research protocol to the Research and Ethics committee of the Hamdan Bin Mohammed College of Dental Medicine, MBRU.

It was considered at the meeting held on: 21st May 2017

My apologies for the late reply.

The only comment the committee had was that the review questions under the materials and methods section should be expressed as a question. You have this revised accordingly. Since this is a systematic review of the literature, ethical approval is not required.

The committee would like to remind you that it is a requirement of the programme that you complete a research dissertation, which comprises 15% of credits within the 3-year MSc programme.

Wishing you every success with your study.

Yours sincerely,

Prof A Milosevic

Chair, Research and Ethics Committee, HBMCDM