Tooth wear: A systematic review of treatment options

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Statement of problem. Treatment of tooth wear is increasing. Because no evidence-based guidelines are available, the clinician may have difficulties deciding which treatment option to choose to resolve complex situations.

Purpose. The purpose of this systematic review was to identify similarities among treatment options for generalized tooth wear and to develop an approach to rehabilitation based on the best evidence available.

Material and methods. A Medline and Cochrane search (for articles published from January 31, 2003, to January 31, 2013) was conducted. Minimally invasive and fully described treatments for generalized tooth wear with esthetically satisfying results were included. Five steps within the treatment procedures were analyzed: diagnostic waxing (DW), occlusal positioning (OP), vertical dimension increase (VDI), restoration, and follow-up.

Results. Common threads were established within the 5 treatment steps. Nine studies used DW, and 6 performed diagnostic tooth arrangement (DTA). Centric relation was used in 5 studies, and VDI was tested in 8 studies, 5 of which used a removable appliance. Seven studies implemented a provisional stage, and 5 used composite resin at that time. For definitive treatment, composite resin (6 studies) and glass ceramic (6 studies) were used. Seven studies applied a protective appliance, and 5 scheduled regular posttreatment evaluation as means of aftercare.

Conclusions. Within the limitations of this systematic review, the present evidence is not strong enough to form conclusions, and the presented similarities cannot be substantiated with evidence. Therefore, comprehensive clinical research into the designated treatment of generalized tooth wear is recommended. (J Prosthet Dent 2014;112:752-759)

Clinical Implications

The available evidence advises the use of diagnostic waxing and diagnostic tooth arrangement. The use of centric relation is advised for the occlusal positioning for rehabilitation. Testing of the vertical dimension increases with a removable appliance and the use of a provisional stage before definitive treatment is recommended. Both composite resin and glass ceramic are indicated, and a protective appliance with regular posttreatment evaluation is advised for follow-up.

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The prevalence of the pathological loss of calcified tooth substance in a mechanical but particularly in a chemical way is globally perceived as an increasing problem.[1,2] Tooth wear affects tooth anatomy, and all kinds of complications may arise if it is left untreated. These complications result from the loss of mineralized tooth substance and include a higher risk of tooth sensitivity, pulpal complications, and discoloration.[3,4] Probably even more important is the loss of function and esthetics. The loss of occlusal vertical dimension may result in dentoalveolar compensation or an increased interocclusal rest space.[5] This will affect the neuromusculature, efficiency of masticatory function, and esthetics as the position of the smile line, the horizontal occlusal plane, and the incisal edge position changes.[4-6] Loss of anterior guidance and canine protection may increase horizontal stresses in the posterior occlusal surfaces and thereby cause loss and fracture of restorations.[4] Moreover, instability of the occlusion will decrease masticatory function and increase the incidence of cheek and tongue biting.[3,5,7] The described loss of tooth substance influences not only teeth and masticatory system but also quality of life.[8]

Dentists should therefore use adequate diagnostic tools and indices to identify tooth wear while straightforward treatment is still possible.[5,7,8] Accurate monitoring and use of diagnostic casts, indices, and/or intraoral photographs are recommended.[7,9] At a certain stage, the restorative treatment of tooth wear is necessary to prevent the negative effects previously described.

The restoration of teeth with severe wear is complex. Several approaches that use different materials and techniques to restore worn dentition have been described.[3,4,9] Unfortunately, no evidence-based guidelines are available to help clinicians choose the most appropriate therapy.[10] At present, only expert opinions guide the clinician.

The objective of this systematic review was to identify different treatment options for generalized tooth wear according to modern, and in particular minimally invasive, dentistry. Is there a common thread in these treatment possibilities? In order to ensure a useful approach, the treatment should be simple, stepwise, adjustable, repairable, and cost-effective. Contemporary adhesive techniques meet most requirements. Remaining tooth structure needs to be preserved, and less experienced dentists should be able to treat the patient with satisfactory results.[11]

Important steps to look into are the need for diagnostic waxing (DW), chosen occlusal position (OP), vertical dimension increase (VDI), restorations, and follow-up. Similarities or differences in treatment options are established analyzing these 5 treatment steps. Common similarities within different treatment options could be considered as the best available evidence for the choice of treatment for generalized tooth wear.

MATERIAL AND METHODS

Selection criteria

The purpose of the inclusion criteria was to select articles that described modern adhesive techniques and practical techniques for clinicians to use in the best interest of their patients. These criteria included fully described treatment for generalized tooth wear with data related to the clinical outcome. Both broad and detailed inclusion criteria were used. According to the broad inclusion criteria (Table I), the treatment should be minimally invasive, esthetically satisfying, and performed without the use of long-term removable dentures. Studies were considered minimally invasive when restorative procedures were performed with as little removal of healthy tissue as reasonably possible.[12] This implies the use of adhesive procedures. Treatments were found to be esthetically satisfying when the original tooth proportions, smile line, horizontal plane of occlusion, and incisal edge position were restored.[4,5,13] Treatments of wear that had progressed into the dentin were included.

Table I. Broad inclusion criteria

1. Generalized tooth wear.
2. Complete description of treatment.
3. Wear into dentin.
4. Minimally invasive.
5. No removable dentures.
6. Esthetically satisfying.
7. Minimal edentulous spaces prior to treatment.

After the broad selection, detailed inclusion criteria (Table II) were applied. Studies were included that described simple, stepwise, adjustable, repairable, and cost-effective treatments. Treatment was considered simple when the procedures were clearly explained and easy to execute, stepwise when treatment could be transferred step by step from a long-term interim restoration to a definitive stage or when a technique with direct composite resin was used, adjustable and repairable when adhesive techniques were used, and cost-effective when a segmented transfer was possible or a direct composite resin was used.

Furthermore, only English-language articles concerning humans published in dental journals in the last 10 years were included. Because only adhesive techniques could meet the selection criteria, the literature search was limited to the past 10 years.[4,14] This period was expected to contain the best evidence available because the prevalence (and as a result probably the treatment) of tooth wear is increasing.[1,2] Studies describing highly invasive, esthetically disappointing, complicated, nonadjustable, nonrepairable, or expensive treatments were excluded. Studies describing the treatment of only posterior or anterior dentition or incomplete

Table II. Detailed inclusion criteria

1. Simple.
2. Stepwise treatment.
3. Adjustable and repairable.
4. Cost-effective.

TABLE III. Search conducted in Medline and Cochrane databases

Database	Search No.	Search Terms	No. of Results
Medline (up to January 31, 2013)	1	"Tooth Wear/therapy"[MeSH]	1366
	2	#1 AND ("last 10 years"[PDat] AND Humans [MeSH] AND English[lang] AND jsubsetd [text])	518
Cochrane (up to January 31, 2013)	1	MeSH descriptor: [Tooth Wear] explode all trees and with qualifier(s): [Therapy-TH]	63
	2	#1 AND "last 10 years" (manual)	32

treatment descriptions were also excluded.

Search methodology

A literature search of the Medline and Cochrane databases (from articles published from January 31, 2003, to January 31, 2013) was performed to identify studies for inclusion. The Medical Subject Heading (MeSH) "Tooth Wear" linked to the MeSH subheading "therapy" was used ("Tooth Wear/therapy" [MeSH]). The Cochrane database search was designed as a permutation of the Medline search strategy by manually selecting the studies of the last 10 years. To ensure a highly sensitive search strategy, only the MeSH term "Tooth Wear/therapy" [MeSH] was used. This MeSH term also covers tooth abrasion, tooth attrition, and tooth erosion.

The results of the search were extended by hand searching. Hand searching was performed by citation mining and expert recommendations. The performed searches are shown in Table III.

Data collection

All 550 identified titles were assessed for subject relevance and screened for inclusion. The abstracts were then obtained from 111 appropriate titles and assessed for inclusion according the broad inclusion criteria (Table I). Then 36 full texts were obtained and assessed according to the broad and detailed inclusion criteria (Table II). This selection process was chosen to prevent unjustified exclusion at an early stage. Twenty publications were excluded.

To support the use of the inclusion criteria, some excluded articles will be explained. The study by Meyers[15] was excluded because the esthetic result was disappointing and the original tooth proportions were not restored. The study by Avinash[16] was also excluded because of the invasive treatment procedures performed, even though enough space was available for noninvasive restorative treatment. The study by Fradeani et al[17] was excluded because the treatment was considered to be neither stepwise nor cost-effective.

Citation mining was performed by checking the reference lists of retrieved articles against the selection criteria; no new articles were found. All articles recommended by experts had already been analyzed or included. Because some studies consisted of multiple publications, those publications were merged (Table IV, Fig. 1). A total of 11 studies, consisting of 16 publications, were included in this review.

Data analysis

The included studies were analyzed and described. The year, type of study, number of patients, follow-up period of the definitive treatment stage, and publishing journal of the studies are listed in Table V. The 11 different treatments for generalized tooth wear were also assessed by analyzing the 5 different treatment steps: DW, occlusal position (OP), VDI, restoration, and follow-up.

These steps were chosen because they provide the basics of treatment procedures, depend as little as possible on the preference of the practitioner, and are probably well described in most studies. More detailed procedures (such as, interocclusal record registration) depend more on practitioner preference. Each step was analyzed by means of research questions, and the results were schematized on a chart. To determine a common thread in different treatment steps, there should be similarity in at least 5 studies.

Seven research questions were asked about each included study in accordance with the 5 different treatment steps, as shown in Table VI.

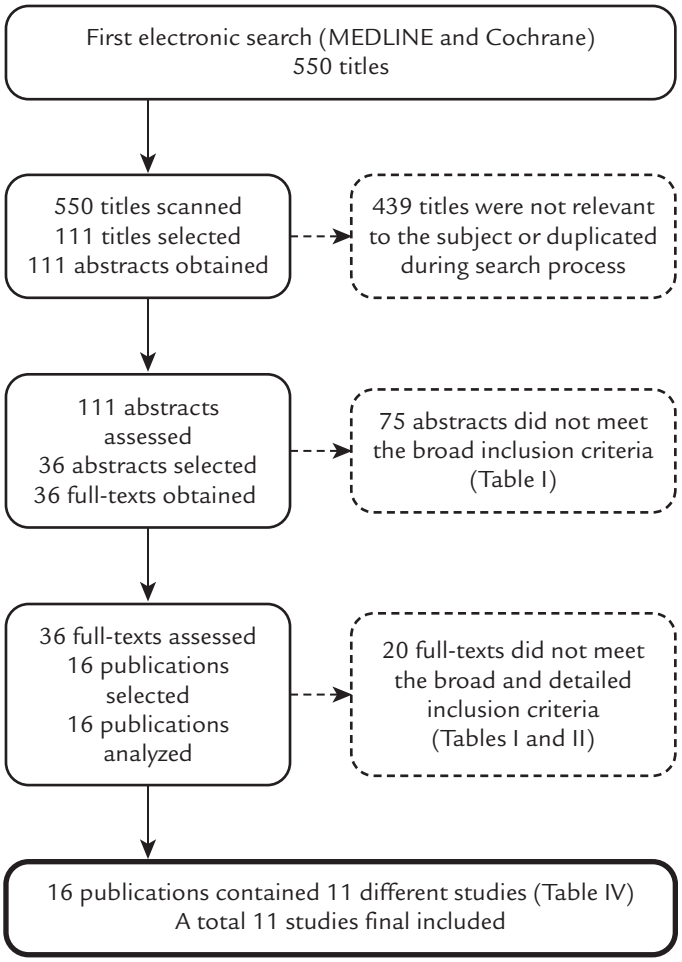
RESULTS

Description of studies

A total of 16 publications on the treatment of generalized, completearch tooth wear met the inclusion criteria (Table IV). By merging substudies, a total of 11 studies were included and analyzed.

TABLE IV. Selection process used during data collection

Assessment	Inclusion Criteria	No. of Results
Titles	Relevant topic	111
Abstracts	Broad inclusion criteria (Table I)	36
Full text	Broad and detailed inclusion criteria (Table II)	16
Included studies	Combining substudies	11



1 Schematic representation of searching process.

All included studies were case reports (8 studies) or case series (3 studies) that studied between 1 and 4 patients and were published between 2007 and 2012 (Table V). The follow-up period after the definitive treatment stage ranged from 0 to 20 months. The follow-up of the interim stage was not included.

Results of analysis

The 5 treatment steps and potential similarities between the treatment options were analyzed by following the specific research questions. The results of the analysis are described below and are shown in Table VII.

DW was used in 9 studies for communication with both the patient and the dental laboratory, for the fabrication of templates, for diagnostic tooth arrangements (DTA), and for interim and definitive restorations. One study used computer-aided design (CAD) waxing. Both diagnostic and anatomic waxings were used. Six studies performed a DTA with templates and (temporary) composite resin to evaluate the treatment outcome and, if needed, to make adjustments.

Centric relation (CR) was the occlusal position of choice for rehabilitation in 5 studies, and maximum intercuspation (MI) was used in 2 studies. The remaining studies did not mention the use of the occlusal position.

The VDI was tested before treatment in 8 of 11 studies. Five studies used a removable appliance, one of which combined it with anterior composite resin. Four studies used a fixed method with different materials, including (in) direct composite resin and metal interim restorations. The overall period of testing ranged from 1 to 3 months, but 1 study used an extended period of 6 months. When using a removable device, the study authors recommended 24 hours of use a day.

Seven studies used an interim stage before the definitive treatment. Composite resin was the most used restorative material for this stage and was used in 5 studies; 2 studies used it with a direct technique and 2 studies with an indirect technique, and 1 study combined both the direct and indirect techniques. Furthermore CAD/CAM-fabricated high density polymethyl methacrylate (PMMA) was used in 2 studies. One study used interim metal and acrylic resin restorative materials.

For the definitive treatment procedure, composite resin and glass ceramics were the most commonly used restorative materials. Six studies used composite resin; 2 studies used it directly, 2 studies used it indirectly, and 2 studies combined both techniques. Glass ceramics were used in 6 studies, 3 of which explicitly used lithium disilicate. Furthermore, 4 studies used gold, 2 studies used metal ceramic, 1 study used metal resin, and 1 study used zirconia ceramic.

Seven studies prescribed a protective appliance (hard acrylic resin), and 2 studies specifically advised a Michigan-type protective appliance. Five studies advised regular evaluations to modify the occlusion. In 4 studies, a (partial) provisional state was accomplished, and a step-by-step replacement of the interim restorations with definitive restorations was recommended; 3 studies clearly explained their 2-phase technique (interim and definitive stage) and the restorative materials used for definitive restoration; 1 study recommended the transfer only when necessary. Which restorative material was recommended was unclear; therefore, the presented treatment was considered to be the definitive treatment.

DISCUSSION

Key findings

The objective of this systematic review was to identify recent treatment options for generalized tooth wear and to identify within these treatment options a common thread of 5 important

TABLE V. Overview of included studies

Study	Year	Type of Study	No. of Patients	Follow-up Period (mo)	Journal
Dietschi[18]	2011	Case report	*	*	Eur J Esthet Dent
Edelhoff[19]	2012	Case report	1	0	Quintessence Int
Mizrahi[23]	2008	Case report	1	0	Eur J Esthet Dent
Spreafico[27]	2010	Case report	1	9	Eur J Esthet Dent
Mehta[22]	2012	Case series	2	0	Br Dent J
Schwarz[26]	2011	Case report	1	6	J Prosthet Dent
Vailati[29-32]	2008, 2011, 2012	Case series	4	0-12	Eur J Esthet Dent, J Adhes Dent
Reston[24,25]	2010, 2012	Case series	2	0	Oper Dent
Stumbaum[28]	2010	Case report	1	0	Int J Comput Dent
Garcia[20]	2009	Case report	1	20	Bull Tokyo Dent Coll
Hayashi[21]	2007	Case report	1	12	Oper Dent

*No result could be established.

treatment steps. These findings could guide the clinician through the complex treatment of generalized tooth wear.

Level of evidence

All included studies were case reports or case series with small numbers of patients and short or no follow-up treatment. Assessing the included studies on the rating of the publishing journals is not possible, and therefore no study quality rating was performed. The case reports and case series should be accepted as proof of principles and provide the best evidence to guide the clinician during treatment. Nevertheless, the present evidence is not strong enough to form conclusions (low level of evidence).[10]

Interpretation of results

DW and DTA were frequently used (in more than 5 studies) so a common thread was determined. During the treatment of severe tooth wear, the use of DW and DTA may benefit the clinician in the following ways: it allows the treatment outcome to be previewed while adaptations are still possible; it informs the patient; it aids the fabrication of templates that are advantageous during adhesive foundations and preparation; and it provides better communication between dentist, patient, and dental technician.[4,14,23,29,30] The disadvantages are the costs and time associated with DW and DTA.[33]

CR was most frequently used and was determined to be a common thread. Although the use of CR may help the clinician during treatment, considering the molar occlusion in the decision whether to choose MI or CR is probably wise.[29,34] Moreover, determining CR may be difficult, and combined with an unfavorable molar occlusion, it may lead to an unnecessary increase in the horizontal overlap.[29] In contrast, CR is often recommended because of its reproducibility.[34] Changes in the occlusal scheme appear not to cause temporomandibular disorder-related problems when absent before treatment.[35]

The VDI was tested before treatment in most studies; this step was determined to be a common thread. In most patients, testing was performed with a removable occlusal appliance. The similarity was sufficient to use this treatment step as a useful direction. According to previous studies, testing the VDI is only needed when the remaining interocclusal rest space after rehabilitation will be less than 2 to 3 mm.[6,22] Increasing the occlusal

TABLE VI. Research questions

Treatment Step			Research Question
1	DW	1	Was DTA performed?
		2	Was DW used for treatment or treatment planning?
2	DW	3	Was CR or MI used as occlusal position before treatment?
3	VDI	4	Was VDI tested before treatment?
		5	If so, how and for how long?
4	Restoration	6	Which restorative materials were used, including possible provisional and definitive restoration?
5	Follow-up	7	How was follow-up performed?

CR, centric relation; DTA, diagnostic tooth arrangement; DW, diagnostic waxing; MI, maximum intercuspation; VDI, vertical dimension increase.

Table VII. Overview of analyzed treatment steps

	DW			VDI			Restoratives		
Study	DW	DTA	OP	VDI	Method	Wk	Interim	Definitive	Follow-up
Dietschi[18]	Yes	*	MI	*	*	*	None	Composite resin (direct/indirect), lithium disilicate	Protective device regular check-ups
Edelhoff[19]	Yes	Yes	CR	Yes	Occlusal device	12	High-density PMMA (CAD/CAM)	Lithium disilicate	Clinical evaluation and modification, segmented transfer
Garcia[20]	Yes	*	CR	Yes	Occlusal device	*	None	Composite resin (direct), metal resin, gold	Protective device
Hayashi[21]	Yes	*	*	Yes	Acrylic resin (anterior), metal (posterior)	26	Acrylic resin, metal	Gold, glass ceramic	Protective device, 3 mo recall
Mehta[22]	Yes	Yes	CR	Yes	Occlusal device	4	Composite resin (indirect)	Gold, metal ceramic, composite resin (indirect)	Protective device (Michigan type)
Mizrahi[23]	Yes	Yes	CR	Yes	Direct composite resin (anterior), occlusal device (posterior)	8	Composite resin (direct/indirect)	Glass ceramic, gold, metal ceramic	Protective device (Michigan type)
Reston[24,25]	*	*	*	*	*	*	None	Composite resin (direct)	Protective device, segmented transfer (when necessary)
Schwarz[26]	Yes	Yes	*	Yes	Direct composite resin	12	Composite resin (direct)	Lithium disilicate	Evaluation of occlusion, oral hygiene instruction
Spreafico[27]	Yes	Yes	*	*	*	*	None	Composite resin (direct/indirect)	Evaluation of occlusion
Stumbaum[28]	*	*	CR	Yes	Occlusal device	4-8	High-density PMMA (CAD/CAM), composite resin (indirect)	Zirconia ceramic	Protective device, segmented transfer to zirconia ceramic
Vailati[29-32]	Yes	Yes	MI	Yes	Direct composite resin (posterior)	4	Composite resin (direct)	Composite resin (indirect), glass ceramic	Segmented final restoration posterior

CR, centric relation; DTA, diagnostic tooth arrangement; DW, diagnostic waxing; MI, maximum intercuspation; OP, occlusal positioning; PMMA, polymethyl methacrylate; VDI, vertical dimension increase.
*No result could be established.

vertical dimension seems to be a safe procedure (signs and symptoms tend to be self-limiting) and well accepted up to 5 mm.[34,36] The testing periods varied in this study. If necessary, testing the VDI for a period of at least 1 month for 24 hours a day is probably advised.[5,22] In addition, Abduo[34] concluded that testing patient acceptance or adaptation with a removable method is less predictable than with a fixed method. In this review, 4 studies used a fixed method; therefore, this method was not considered to be a common thread.

The majority used an interim stage before definitive treatment. The implementation of an interim stage during the treatment of generalized tooth wear was established to be a parallel within 7 studies and could be used as guidance. The implementation of this stage is performed to evaluate treatment outcome and patient acceptance.[14,19] Changes in esthetics and

function can still be made with little effort and without consequences before starting the definitive restorative phase. This simplifies the rehabilitation and creates the opportunity to perform a stepwise treatment and to spread accompanying costs over several years.[19,30] In contrast, implementing an interim stage does lengthen the treatment period and increase total treatment costs. In this review, composite resin was established to be the restorative material of choice during the interim phase.

For the definitive treatment procedure, both composite resin and glass ceramics were the most commonly used restoratives and were used in at least 5 of the included studies.

According to the recent literature, composite resin seems to be a suitable restorative material for restoring worn dentition.[33,37,38] Jaeggi et al recommend the use of an indirect restorative material when the VDI exceeds 2 mm because restoring the anatomy and occlusion is difficult and depends on the sculpting skills of the dentist.[3] In the long term, there seems to be little difference between direct and indirect composites.[39] Therefore, other indirect materials are indicated for long-term stability; glass ceramic (lithium disilicate) and gold are preferred.[33,40-43]

Both a protective appliance and regular posttreatment evaluations were found to be a common thread in the treatment procedures and could be used as guidance. An appliance protects the restored dentition from nonfunctional (damaging) habits during the night.[4,7]

Limitations

The literature research was limited to the period of 2003 to 2013 to simplify the data collection and to exclude studies based on nonadhesive techniques. Studies based on adhesive techniques published before 2003 may have been excluded, but all included articles were published in 2007 or later, indicating that suitable studies are likely to have been published in the last 10 years.

The selection criteria used limited the reproducibility of this review. By using examples of exclusion, this was obviated as much as possible. Assessing the outcome of the studies was almost impossible because most studies did not provide useful photographs. For example, the study performed by Smales and Berekally[44] did not provide any photographs for judgment.

Only 5 treatment steps were analyzed in this review. Obviously, the treatment procedure consists of many more treatment steps. For example, making a facebow registration was not included. Only 1 researcher performed data collection and data analysis. Therefore, the selection and analysis procedure was not controlled by a second researcher and may have been biased.

This review identifies and summarizes different treatment options for treating generalized tooth wear. Common similarities in different treatment steps may be considered as the best evidence available to guide the clinician in these steps. Unfortunately, evidence-based guidelines are still unavailable.[10]

CONCLUSIONS

Within the limitations of this systematic review, it can be concluded that the present evidence is not strong enough to form firm conclusions, and the presented similarities cannot be substantiated with evidence. Therefore, comprehensive research into the designated treatment of generalized tooth wear is highly recommended.

The similarities established within various treatment steps may still be helpful to the clinician. The present available evidence advises the use of DW and DTA and the use of CR as the OP for rehabilitation. Furthermore, testing of the VDI with a removable appliance and the use of a provisional stage before definitive treatment is recommended. Both composite resin and glass ceramic are indicated materials for final treatment. A protective appliance with regular evaluation is indicated for follow-up.

REFERENCES

1. Kreulen CM, Spijker A, Rodriguez JM, Bronkhorst EM, Creugers NH, Bartlett DW. Systematic review of the prevalence of tooth wear in children and adolescents. Caries Res 2010;44:151-9.
2. Jaeggi T, Lussi A. Prevalence, incidence and distribution of erosion. Monogr Oral Sci 2006;20:44-65.
3. Jaeggi T, Grüninger A, Lussi A. Restorative therapy of erosion. Monogr Oral Sci 2006;20:200-14.
4. Dietschi D, Argente A. A comprehensive and conservative approach for the restoration of abrasion and erosion. Part I: concepts and clinical rationale for early intervention using adhesive techniques. Eur J Esthet Dent 2011;6:20-33.
5. Davies SJ, Gray RJM, Qualtrough AJE. Management of tooth surface loss. Br Dent J 2002;192:11-23.
6. Turner KA, Missirlian DM. Restoration of the extremely worn dentition. J Prosthet Dent 1984;52:467-74.
7. Mehta SB, Banerji S, Millar BJ, Suarez-Feito JM. Current concepts on the management of tooth wear. Part I: assessment, treatment planning and strategies for the prevention and the passive management of tooth wear. Br Dent J 2012;212:17-27.
8. Al-Omiri MK, Lamey PJ, Clifford T. Impact of tooth wear on daily living. Int J Prosthodont 2006;19:601-5.
9. Johansson A, Johansson AK, Omar R, Carlsson GE. Rehabilitation of the worn dentition. J Oral Rehabil 2008;35:548-66.
10. Hurst D. What is the best way to restore the worn dentition? Evid Based Dent 2011;12:55-6.
11. Hemmings K, Darbar U, Vaughan S. Tooth wear treated with direct composite at an increased vertical dimension; results a 30 months. J Prosthet Dent 2000;83:287-93.
12. Ericson D. The concept of minimally invasive dentistry. Dent Update 2007;34:9-18.
13. Morley F, Eubank J. Macroesthetic elements of smile design. JADA 2001;132:39.
14. Vailati F, Belser UC. Full-mouth adhesive rehabilitation of a severely eroded dentition: the three-step technique part 1. Eur J Esthet Dent 2008;3:30-44.
15. Meyers IA. Diagnosis and management of the worn dentition: conservative restorative options. Ann R Australas Coll Dent Surg 2008;19:31-4.
16. Avinash SB. Fixed prosthodontic rehabilitation in a wear patient with Fabry's disease. J Prosthodont 2011;20:S2-8.
17. Fradeani M, Barducci G, Bacherini L, Brennan M. Esthetic rehabilitation of a severely worn dentition with minimally invasive prosthetic procedures (MIPP). Int J Periodontics Restorative Dent 2012;32:135-47.
18. Dietschi D, Argente A. A Comprehensive and conservative approach for the restoration of abrasion and erosion, part II: clinical procedures and case report. Eur J Esthet Dent 2011;6:142-59.

19. Edelhoff D, Beuer F, Schweiger J, Brix O, Stimmelmayr M, Goth J. CAD/CAM-generated high-density polymer restorations for the pretreatment of complex cases: a case report. Quintessence Int 2012;43:457-67.
20. Garcia AR, Sundfeld RH, Alexandre de RS. Reestablishment of occlusion with prosthesis and composite resin restorations. Bull Tokyo Dent Coll 2009;50:91-6.
21. Hayashi M, Shimizu K, Takeshige F, Ebisu S. Restoration of erosion associated with gastroesophageal reflux caused by anorexia nervosa using ceramix laminate veneers: a case report. Oper Dent 2007;30:306-10.
22. Mehta SB, Banerji S, Millar BJ, Suarez-Feito JM. Current concepts on the management of tooth wear. Part III: active restorative care 2: the management of generalised tooth wear. Br Dent J 2012;212:121-7.
23. Mizrahi B. Combining traditional and adhesive dentistry to reconstruct the excessively worn dentition. Eur J Esthet Dent 2008;3:270-89.
24. Reston EG, Closs LQ, Busato ALS, Broliato GA, Tessarollo FR. Restoration of occlusal vertical dimension in dental erosion caused by gastroesophageal reflux: case report. Oper Dent 2010;35:125-9.
25. Reston EG, Corba VD, Broliato G, Saldini BP, Stefanello Busto AL. Minimally invasive intervention in a case of a noncarious lesion and severe loss of tooth structure. Oper Dent 2012;37:324-8.
26. Schwarz S, Kreuter A, Rammelsberg P. Efficient prosthodontics treatment in a young patient with long-standing bulimia nervosa: a clinical report. J Prosthet Dent 2011;106:6-11.
27. Spreafico RC. Composite resin rehabilitation of eroded dentition in a bulimic patient: a case report. Eur J Esthet Dent 2010;5:28-48.
28. Stumbaum M, Konec D, Schweiger J, Gernet W. Reconstruction of the vertical jaw relation using CAD/CAM. Int J Comput Dent 2010;13:9-25.
29. Vailati F, Belser UC. Full-mouth adhesive rehabilitation of a severely eroded dentition: the three-step technique part 2. Eur J Esthet Dent 2008;3:128-46.
30. Vailati F, Belser UC. Full-mouth adhesive rehabilitation of a severely eroded dentition: the three-step technique part 3. Eur J Esthet Dent 2008;3:236-57.
31. Vailati F, Belser UC. Palatal and facial veneers to treat severe dental erosion: the three-step technique and the sandwich approach. Eur J Esthet Dent 2011;6:268-78.
32. Vailati F, Vaglio G, Belser UC. Full-mouth minimally invasive adhesive rehabilitation to treat severe dental erosion: a case report. J Adhes Dent 2012;14:83-92.
33. Mehta SB, Banerji S, Millar BJ, Suarez-Feito JM. Current concepts on the management of tooth wear. Part IV: an overview of the restorative techniques and dental materials commonly applied for the management of tooth wear. Br Dent J 2012;212:169-77.
34. Abduo J. Safety of increasing the VDO: a review. Quintessence Int 2012;43:369-80.
35. Pullinger AG, Seligman DA. Quantification and validation of predictive values of occlusal variables in temporomandibular disorders using a multifactorial analysis. J Prosthet Dent 2000;83:66-75.
36. Abduo J, Lyons K. Clinical considerations for increasing occlusal vertical dimension: a review. Aust Dent J 2012;57:2-10.
37. Schmidlin PR, 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.
38. 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;19:151-5.
39. Wassell RW, Wall AW, McCabe JF. Direct composite inlays versus conventional composite restorations; 5-year follow-up. J Dent 2000;28:375-85.
40. Guess PC, Zavanelli RA, Silva NR, Bonfante EA, Coelho PG, Thompson VP. Monolithic CAD/CAM lithium disilicate versus veneered Y-TZP crowns: comparison of failure modes and reliability after fatigue. Int J Prosthodont 2010;23:434-42.
41. Clausen JO, Abou Tara M, Kern M. Dynamic fatigue and fracture resistance of non-retentive all-ceramic full-coverage molar restorations. Influence of ceramic material and preparation design. Dent Mater 2010;26:533-8.
42. King PA. The use of adhesive restorations in the management of localised anterior tooth wear. Prim Dent Care 1999;6:65-8.
43. Hacker CH, Wagner WC, Razzoog ME. An in vitro investigation of the wear of enamel on porcelain and gold in saliva. J Prosthet Dent 1996;75:14-7.
44. Smales RJ, Berekally TL. Long-term survival of direct and indirect restorations placed for the treatment of advanced tooth wear. Eur J Prosthodont Rest Dent 2007;15:2-6.

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