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## **A novel cervical tooth wear and recession index, The Cervical Localisation Code, and its application in the prevention and management of dentine hypersensitivity**

### **Abstract**

**Objectives:** To design and validate a new index to assess tooth wear (TW) in the cervical region and its association with gingival recession (GR), for use both in research studies and as resource in General Dental Practice, with focused prevention and management strategies particularly related to aetiology of dentine hypersensitivity provided for each Code score.

**Methods:** Codes to reflect clinical presentations of the cervical region in health and disease recording both TW and GR were defined. Validation of the Code was undertaken by 3 trained examiners who scored buccal and lingual surfaces of eligible teeth in 42 adult healthy volunteers. Each volunteer underwent 4 identical clinical examinations, being assessed twice by the examiner who performed the first and last exam.

**Results:** Cervical Localisation Code definitions were A: no GR, no coronal TW, B: no GR, distinct coronal TW, C: GR but no coronal TW, D: GR with distinct coronal and root TW. For validation 2073 eligible tooth surfaces were scored. There were only 57 within and 201 between examiner disagreements, the most common being between scores C and D.

**Conclusions:** The Cervical Localisation Code was used reproducibly by three independent examiners, ~~and~~ it will provide focussed data on the cervical region in research studies allowing the association of patient reported dietary and lifestyle factors with specific lesion types, and a tool to aid the management of clinical scenarios, specifically those that lead to dentine hypersensitivity in general dental practice.

### **Clinical Significance**

Exposure of dentine at the cervical margin by TW and/or GR often results in dentine hypersensitivity, however current TW indices do not record TW location or GR presence. The Cervical Localisation Code captures both parameters and suggests likely aetiology for dentine hypersensitivity and guide clinical management of the cervical region.

## Introduction

A child born today in the UK may well live to see their one hundredth birthday [1] and with improved oral hygiene, the chances of keeping their own vital teeth throughout life is ever-increasing [2].

Although the preventative dentistry era has strived to bring caries and periodontitis under control, the 21<sup>st</sup> century lifestyle has resulted in the emergence of other conditions now frequently seen in general dental practice. Erosive tooth wear, dentine hypersensitivity and gingival recession are now all recognised as common inter-related problems, with the exposure of dentine due to tooth wear and/or recession increasing the risk of dentine hypersensitivity, their common pain symptom [3-6]. Data suggests that dentine hypersensitivity is increasingly common [7]. Dentine hypersensitivity has been shown to affect quality of life in sufferers [8], which can be reversed following treatment [9] and yet it has been reported to be one of the most painful but poorly managed chronic ailments of teeth [10].

Tooth wear indices capture and classify the severity of dental surface loss for use in prevalence studies, aiding diagnosis, indicating risk factors and helping management of the condition. The Basic Erosive Wear Examination (BEWE) is probably the most well-known tooth wear index [11]. The BEWE is deliberately simple to allow comparison with other indices and uses a 4 point scale, the cumulative score obtained from the most severely affected surfaces in each sextant being matched to risk profile. Thus the BEWE aids the management of tooth wear, however, it does not allow appreciation of whether the tooth wear is located occlusally or cervically, or whether dentine has been exposed. Erosive tooth wear has been demonstrated as an aetiological agent for dentine hypersensitivity, and often occurs in combination with gingival recession [5,12]. Recording both the localisation of the tooth wear and any accompanying gingival recession would assist the clinician in interpreting the aetiology and risk of associated dentine hypersensitivity symptoms related to soft tissue loss (gingival recession) or hard tissue loss (tooth wear). In separating out aetiological factors, the clinician would be encouraged to address all contributory causes and tailor their management strategy accordingly. It appears there is much variability in the management of cervical tooth wear, gingival recession and associated dentine hypersensitivity by dental practitioners [13,14] and so it would be useful to have a management tool as a guide in primary dental care. A tool that facilitates the recording of both the localisation of tooth wear and the presence of gingival recession at the cervical margin would also be useful in research where, when coupled with data about participant diet and lifestyle, it could help confirm risk factors associated with the different types of cervical lesions recorded.

To date, no index relates tooth wear to its role in the localisation of dentine hypersensitivity. The Cervical Localisation Code of the present study is a novel index designed specifically to assess tooth wear on the anatomical crown and root in the cervical region and capture exposure of radicular dentine (gingival recession), to recognise the multifactorial aetiology of dentine hypersensitivity in this region. Importantly, a management section is incorporated which has been developed to provide the clinician with focused prevention and management strategies for each index score.

The aim of this study was to define the criteria of a simple index that can be used under varying conditions- for example magnification, light and hydration state of the tooth 'the Cervical Localisation Code' and to validate its use by assessing examiner reproducibility and determining the relative distribution of each score. Further, it is the intention to implement this index nationally in the primary care setting to help focus future management of the cervical area.

## **Materials and Methods**

### *Overall study design*

The Cervical Localisation Code was developed by a group, consisting of academics, clinicians and specialists in periodontics. The group was tasked with establishing a set of codes to reflect the different clinical presentations of the cervical region, in health and with hard and soft tissue loss in non carious cervical lesions. After defining the Codes in descriptive terms, an interpretation of the hard and/or soft tissue loss was determined followed by a detailed management section for each code. Once determined the-validation study was undertaken in which intra- and inter-examiner reliability were assessed between 3 clinicians. The clinical interpretation and management of the codes were also agreed by group consensus and are presented in tabular form in the results.

This validation study was conceived as a preliminary phase of an epidemiological study examining the prevalence of tooth wear, dentine hypersensitivity and recession amongst other indices. Cervical Localisation Code was just one of many indices which were recorded buccal and palatal/lingually for all eligible tooth surfaces. The full results of this study are beyond the scope of this paper and will be reported in a subsequent publication. The validation study was conducted within the a UK dental school. Ethical approval was obtained from the London - Queen Square Research Ethics Committee (REC Reference: 18/LO/1418; IRAS ID: 225373) and this study was carried out in accordance with good clinical practice guidelines.

### *Validation phase*

Study participants were healthy adult volunteers aged 18 or over, recruited from hospital clinics. Following informed consent volunteers were screened for eligibility and randomised equally into

examination regimens using a block randomisation scheme (Table 1). Each participant underwent a sequence of four identical clinical examinations. These were performed independently by three investigator dentists who scored the Cervical Localisation Code visually without magnification both buccally and palatal/lingually on all eligible surfaces of standing teeth of both arches excluding 3<sup>rd</sup> molars. Teeth with gross caries or fixed orthodontic appliances, surfaces covered by crown and bridge work, and restorations in proximity of the CEJ were also excluded.

The investigator who completed the first examination rescored the participant approximately 30 minutes after the initial examination and without reference to previous scores, enabling assessment of intra-examiner reliability. The investigators were instructed not to confer with one another throughout to ensure that all scores were derived independently. The same investigators were used throughout the study.

#### *Statistical analyses for the validation phase*

The relative frequencies of the 4 categories observed on all scoreable tooth surfaces were calculated for each scoring. Disagreements between repeat scorings by the same examiner and between examiners were identified by producing crosstabulations. For each of the 6 possible disagreements ratios of the actual ÷ the expected, calculated on the null hypothesis of independence using pooled marginal frequencies, were calculated. An actual ÷ expected ratio approaching 1 indicated poorly repeatable discrimination between the two scores concerned. Similar crosstabulations were constructed to find disagreements between scorings by each pair of examiners.

## **Results**

### *Definition phase*

The consensus Cervical Localisation Code definitions are shown in Table 1. This includes the interpretation of each code and its suggested management in routine general practice, which was agreed after discussion, debate and voting, achieving a 75% of above majority vote for consensus with the clinical research team comprising of 8 members.

### *Validation phase*

All forty-two participants who gave informed consent completed the study, amounting to a total of 2352 possible tooth surfaces, 279 of which were deemed ineligible.

Table 2 displays the initial scores and repeated scores by the same examiner. The distributions at rescoring, shown in the final row, were very similar to those at the initial scoring, shown in the penultimate column. 97.3% of sites (2016) were rated identically when scored and rescored by the

original examiner, these agreements are highlighted in the shaded cells. The kappa statistic for intra-examiner agreement was 0.9445.

Table 3 summarises the within-examiner disagreements, obtained by comparing initial and repeated scores for all 3 examiners together, for all 42 participants. The highest actual disagreement counts are for scores C & D and for scores A & C and the lowest for scores B & D and A & D. When judged in relation to the abundance of scores of A or C and the scarcity of scores D and B, by far the greatest rate of disagreements was between scores of C and D. This applied similarly for all 3 examiners.

Table 4 summarises the disagreements between examiners, obtained by merging disagreement results for examiners 1 & 2, 2 & 3 and 3 & 1. Similarly, in absolute terms the highest disagreement counts were for scores C & D and for scores A & C, but when judged relative to the overall frequencies of each score, the greatest rate of disagreements was between scores of C and D. This pattern was seen across all 3 pairs of examiners. Kappa statistics for inter-examiner agreement were 0.9236 examiner 1 vs 2, 0.9468 examiner 2 vs 3, 0.9350 examiner 3 vs 1.

## **Discussion**

This study addressed the common problem of identifying and classifying hard and soft tissue loss in the cervical region by devising and validating a new index, the Cervical Localisation Code. The purpose of the code is firstly; to provide a tool that in general dental practice can, by indicating the likely aetiology of an exposed enamel-dentine junction, help with the management of the lesion and any subsequent dentine hypersensitivity and secondly; to help confirm risk factors for the different presentations of cervical lesions when used in conjunction with participant questionnaires that ask about dietary/lifestyle factors in research studies. The code was designed to be easy and straightforward to record, capturing changes in all hard and soft tissue that are possible. The definitions of the codes were pondered at length, discussed and voted upon to reach consensus opinion according to current protocol [165].

The aim of the current study was to ensure that all four codes in the index were distinguishable as separate clinical entities, not an ordinal scale, which could be reproducibly scored by a number of examiners while also determining the relative distribution of each score. The results above indicate that the index satisfied these aims, with good intra-examiner and inter-examiner reproducibility demonstrated.

Code A was the most scored, meaning approximately two thirds of sites were 'healthy' (no recession and no distinct tooth wear). This is in line with findings from the 2013 European study in which the combined prevalence of BEWE 0 and 1 was 70.6% [4], the slightly lower figure in the present study

likely due in part to the fact that Code C also captures this degree of tooth wear. Code B (no recession but distinct coronal tooth wear) was the second least common code (7.7%) confirming that these 2 conditions usually occur together [5,12]. Gingival recession was a prerequisite for Codes C and D to be scored, and these were most commonly reported buccally, in consistence with other studies in the literature which also report a heavier concentration of recession on buccal aspects of the teeth [6,169,2017]. It is difficult for a clinician to distinguish between no coronal wear (code C) and early but distinct wear (code D) in this region if only a very small amount of wear has taken place as it not easily visible to the eye, hence lack of frequency of this code was demonstrated.

The current gold standard for assessing tooth wear internationally is the BEWE [11]. It has been demonstrated that the cumulative BEWE score for a whole mouth provides an accurate representation of the scores as recorded separately on all tooth surface, with the best relationship observed for BEWE 2 [18]. However, as the Cervical Localisation Code is novel in recording the presence and absence of both tooth wear and gingival recession, it cannot be directly compared in a validation study to the BEWE or any other index that records tooth wear alone. Tooth wear in the presence of recession defects has previously been considered in an index by Pini-Prato et al [19], in the context of mucogingival surgery outcomes. They describe a classification of dental surface defects in areas affected by gingival recession (but not in gingival health), focusing on the presence or absence of the CEJ and whether there is a distinct dental step defect caused by abrasion. In their validation study, intra-examiner agreement was high but inter-examiner agreement was only moderate. Further the index was primarily used to assess periodontal surgery treatment needs [19]. The Cervical Localisation Code presented in the current study not only assesses the root surface but also records the presence or absence of tooth wear on the anatomical crown when there is clinical gingival health, making it a more suitable alternative for patients in general dental practice rather than those anticipating periodontal surgery.

The specific use of the Cervical Localisation Code to record gingival recession and tooth wear in dentine hypersensitivity studies would give the advantage over the BEWE that it would allow analysis of whether hard or soft tissue loss (or both) is most commonly associated with dentine hypersensitivity symptoms in the cervical region. Currently, guidance on the conduct of dentine hypersensitivity trials is set out by Holland et al [20] with the focus on how to clinically identify dentine hypersensitivity such as the stimuli which should be used and how they should be scored. Introducing the Cervical Localisation Code as a gold standard to record the clinical presentation of teeth with dentine hypersensitivity symptoms will allow the potential aetiology of the symptoms to be assessed as well as encouraging standardisation of how gingival recession and tooth wear are detailed in these studies, allowing easier comparison.

The management section of the Cervical Localisation Code has been designed to aid practitioners in primary dental care and it is suggested that it will complement the use of the BEWE in general dental practice. The joint use of these codes would give a better appreciation of where tooth wear is located, with the BEWE giving an indication of general severity of wear across the whole tooth surface or mouth. The Cervical Localisation Code being used when patients indicate that they are suffering dentine hypersensitivity to record more detail of specific lesions as it also notes any soft tissue defect which may be associated, providing more detail on possible aetiology. Dentine hypersensitivity can be treated successfully and treatment improve quality of life [9] thus determining aetiology in these cases is important. The management guide for each code encourages practitioners to recognise the possible aetiology of lesions early, allowing a preventative approach to halt their progression and ideally avoid the need for restorative intervention.

Although the inter- and intra-examiner reliability for this study was good, a level of discrepancy was seen for scores C & D which distinguish between gingival recession with or without cervical tooth wear restricted to the anatomical root (code C), and gingival recession where cervical tooth wear of both the anatomical crown and root is evident (code D). For these scores, for the level of disagreement both intra-examiner and inter-examiner assessment were relatively high, indicating examiners experienced some difficulties in discriminating between these codes. Clinically, this could be reflected in the difficulties in determining the position of the CEJ once there has been gingival recession or cervical tooth wear as there is loss of root surface cementum, with further damage to the region by abrasive or erosive tooth wear leaving the CEJ indiscernible [21,22]. The loss of this anatomical landmark demarcating the boundary between the root and crown makes codes C and D harder to distinguish. In addition, once enamel has been lost, further coronal tooth wear can result in a clear demarcation separating the coronal dentine and enamel which can be mistaken for the anatomic CEJ [23] and lead to the crown and root being wrongly identified. It is also possible that in cases of recession and healthy gingiva examiners may have presumed an abrasive aetiology and therefore consciously or subconsciously may have been more likely to score a D. The in vitro literature on the study of the amelocemental junction is also complex. It has been documented that there are three variants on tissue junction in this area, edge-to-edge relationship of enamel to cementum, an overlap of cementum onto the cervical enamel and a gap between enamel and cementum. However the latter has subsequently been proven to be as a result of tissue shrinkage in specimen preparation [24] rather than natural dentine exposure. Interestingly non-carious cervical lesions (NCCLs) are mostly located apical to the cemento enamel junction suggesting that this type of lesion on the root of the tooth is not due to breakdown of the thin cervical enamel but another as yet unidentified cause [25]. Such lesions would be classed as a C in the Cervical Localisation Code.



The difficulty identifying the correct anatomical CEJ in areas of gingival recession is not a new clinical issue in dentistry. Several researchers have suggested ways in which to arrive at a correct diagnosis, from using the CEJ measurements on adjacent or contralateral teeth [19] to careful observation under magnification to distinguish the more curved and convex CEJ from a flatter abrasion line [23]. For the purpose of this index, perhaps it must be made more obvious that a distinct defect is required both on coronal and radicular dentine in order to score code D. One might expect that a code C should have the CEJ still intact whereas for a code D it will have disappeared, however as we define that there must be a distinct defect coronally for a code D to be scored, the CEJ may have also already been lost in a code C.

Although miscoding of C and D was observed, clinically the management for both codes is similar. The main difference for code D is the emphasis on dietary advice due to the likely erosive component. If there is clinical doubt which code is most appropriate, lifestyle questions can readily be used to determine if there is a likely dietary or abrasive element which needs addressing. For the use of this index in clinical research, this distinction between codes is of greater importance, yet in a study setting there is more opportunity for examiner training focusing on how to relocate the original CEJ and it is practical for magnification to be provided. This level of training would be considered excessive and impractical for everyday general practice.

In conclusion, in this preliminary validation study, the Cervical Localisation Code has been used reproducibly by three independent examiners and results are similar if not better than other studies investigating similar indices in the literature. It has a place both in general dental practice, guiding practitioners in the appropriate management of each clinical scenario, and in clinical studies investigating tooth wear, dentine hypersensitivity and gingival recession. Its novel approach to record these two increasingly common conditions will help to improve diagnosis and patient management.

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## Tables

**Table 1.** Cervical Localisation Code

Code	Description	Interpretation	Example	Management
<b>A</b>	No gingival recession, <b>and</b> No distinct tooth wear on crown in cervical region	Health  No recession and no distinct cervical tooth wear		<ul style="list-style-type: none"> <li>• Reinforce continuation of good oral hygiene</li> <li>• Routine maintenance and observation</li> <li>• Prevention – ensure patient awareness of aetiology of tooth wear</li> </ul>
<b>B</b>	No gingival recession, <b>and</b> Distinct tooth wear on crown in cervical region	Enamel loss in cervical area- Erosion/abrasion		<p>Identify main aetiological factor and implement strategies to eliminate:</p> <ul style="list-style-type: none"> <li>• Diet diary and analysis with individually focused advice: highlight dietary acids and recommend decrease frequency of consumption and keep to mealtimes</li> <li>• Explore intrinsic acid sources- vomiting, reflux, eating disorders: refer to GMP if required</li> <li>• Recommend fluoridation measures to increase resistance of tooth surface to erosion: use of fluoride mouthrinse during day, stannous fluoride toothpaste reinforcing spit don't rinse.</li> <li>• Address any traumatic toothbrushing habits, a low abrasive toothpaste could be suggested, ensure brushing is not straight after acidic insult. Consider brushing before breakfast</li> <li>• Treat dentine hypersensitivity using twice daily desensitising toothpaste advising spit don't rinse</li> <li>• Ideally avoid restorations if possible. If required for aesthetics/ function/ pain, stabilise causative factors prior to restorative rehabilitation, consider referral</li> </ul>
<b>C</b>	Gingival recession with or without distinct tooth wear on root in cervical region, <b>and</b> No distinct tooth wear on crown in cervical region	Recession (main causes)- Traumatic brushing Periodontal disease Treated periodontitis  No distinct tooth wear cervically on crown		<p>Identify main aetiological factor:</p> <ul style="list-style-type: none"> <li>• Traumatic brushing – tailored toothbrush instruction, ensure brushing no more than twice daily and no scrubbing action, consider use of electric toothbrush .</li> <li>• Periodontitis – periodontal treatment, warning that recession is likely to increase once inflammation has subsided</li> <li>• Treated periodontitis – ensure brushing is atraumatic on exposed root surface whilst maintaining excellent oral hygiene.</li> <li>• Treat dentine hypersensitivity using twice daily desensitising toothpaste – advising spit don't rinse</li> <li>• Consider referral to specialist for mucogingival surgery if sufficient interdental bone</li> <li>• Ideally do not restore root surface as likely to exacerbate condition due to plaque retention</li> </ul>
<b>D</b>	Gingival recession with distinct tooth wear on root in cervical region, <b>and</b> Distinct tooth wear on crown in cervical region	Recession (main causes) Traumatic brushing Periodontitis Treated periodontitis  <b>and</b> tooth wear- Erosion/abrasion		<p>Identify main aetiological factors and implement strategies to eliminate:</p> <ul style="list-style-type: none"> <li>• Diet diary and analysis with individually focused advice: highlight dietary acids and recommend decrease frequency of consumption and keep to mealtimes</li> <li>• Explore intrinsic acid sources- vomiting, reflux, eating disorders – refer to GMP if required</li> <li>• Recommend fluoridation measures to increase resistance of tooth surface to erosion: use of fluoride mouthrinse during day, stannous fluoride toothpaste reinforcing spit don't rinse.</li> <li>• Reinforce oral hygiene instruction, address any traumatic toothbrushing habits, ensure brushing no more than twice daily, consider use of electric toothbrush , ensure brushing is not straight after acidic insult. Consider brushing before breakfast</li> <li>• Treat dentine hypersensitivity using twice daily desensitising dentifrice – advising spit don't rinse</li> <li>• Ideally avoid restorations if possible. If required for aesthetics/ function/ pain, stabilise causative factors prior to restorative rehabilitation, consider referral</li> </ul>

**Key Notes:** Distinct tooth wear=a 'step' or 'scooped-out' defect, visible to the eye and detectable when running a probe over the tooth surface. **Crown**=anatomical crown **Root**=anatomical root

**Table 2.** Scores at initial and repeated scorings by the same examiner, based on combined data from all examiners for all 42 participants.

		Repeated score (30 min later)				Total count for initial scoring	Percent of each score at initial scoring
		A	B	C	D		
Initial Score	A	1377	6	6	0	1389	67.0%
	B	4	151	4	0	159	7.7%
	C	12	3	426	11	452	21.8%
	D	1	0	10	62	73	3.5%
	Total count for repeated scoring	1394	160	446	73	2073	100.0%

**Table 3.** Within-examiner disagreements for study population- all 3 examiners combined.

Disagreement between scores	Disagreement count		Actual ÷ expected
	Actual	Expected	
A & B	10	214	0.047
A & C	18	603	0.030
A & D	1	98	0.010
B & C	7	69	0.101
B & D	0	11	0.000
C & D	21	32	0.664

**Table 4.** Pairwise disagreements between all 3 examiners combined

Disagreement between scores	Disagreement count		Actual ÷ expected
	Actual	Expected	
A & B	43	659	0.065
A & C	53	1784	0.030
A & D	6	309	0.019
B & C	37	211	0.176
B & D	2	37	0.055
C & D	60	99	0.606