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3 1 **Impact of dentine hypersensitivity on oral health-related quality of life in**  
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5 2 **individuals receiving supportive periodontal care**  
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2 quality of life in individuals under supportive periodontal care. J Clin Periodontol

#### 3 4 **Abstract**

5 **Aim:** To determine the prevalence and impact of dentine hypersensitivity (DH) on oral  
6 health-related quality of life (OHRQoL) in individuals receiving supportive periodontal care  
7 (SPC).

8 **Materials and Methods:** One hundred and two adults receiving SPC were recruited for a  
9 cross-sectional study. Subjects were categorized into those who self-reported DH (DH1) or  
10 did not (DH0). Impact of DH on OHRQoL was assessed using the Chinese Condition-  
11 Specific Oral Impact on Daily Performance questionnaire (CS-OIDP). Evaluation of DH  
12 included tactile-stimulation followed by air-blast, and recorded using a Visual Analogue  
13 Scale (VAS).

14 **Results:** Sixty-one (59.8%) subjects self-reported DH with mean air-blast VAS score of 29.4  
15  $\pm$  21.3mm and mean tactile-stimulation VAS score of 10.9  $\pm$  14.7mm. Fifty (49%) subjects  
16 reported impact on OHRQoL (mean CS-OIDP score = 4.7  $\pm$  6.3). The most affected  
17 performance was cleaning the mouth (35.3%). Positive expression of DH and worse  
18 OHRQoL were associated with higher air-blast and tactile-stimulation VAS scores, and use  
19 of desensitizing agents. The minimally important difference (MID) in CS-OIDP scores was  
20 2.0 points. Approximately 30% of subjects reported CS-OIDP scores above the MID.

21 **Conclusions:** Dentine hypersensitivity affects OHRQoL in patients undergoing SPC. The  
22 extent of impact was associated with severity of DH.

23  
24 Word count: 196

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3 1 Dentine hypersensitivity (DH) is defined as a transient pain arising from denuded dentine,  
4  
5 2 usually in response to tactile, thermal, chemical or osmotic stimulation that cannot be  
6  
7 3 explained as arising from any other form of dental deformity or pathology (Dowell & Addy,  
8  
9 4 1983). DH is one of the most common complaints reported among dental patients (Irwin &  
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11 5 McCusker, 1997, Bekes et al., 2009) especially after periodontal treatment (Tammaro et al.,  
12  
13 6 2000, Rees et al., 2003, Lin & Gillam, 2012) occurring in more than half after non-surgical  
14  
15 7 periodontal therapy (Chabanski et al., 1997, von Troil et al., 2002, Lin & Gillam, 2012), and  
16  
17 8 more common after surgical procedures (Lin & Gillam, 2012). In a Chinese community, the  
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19 9 prevalence of DH was 67.7% among patients from a hospital periodontology clinic in Hong  
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21 10 Kong (Rees et al., 2003).

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24  
25 11 Previous studies on DH were often aimed at recording patient's response to stimuli in  
26  
27 12 terms of quantifiable results such as a global visual analogue scale (VAS) score (Al-Wahadni  
28  
29 13 & Linden 2002, Rees & Addy 2002), and these may have evaluated a situation in which DH  
30  
31 14 was artificially stimulated and was not a patient complaint. Patient-centred outcome measures  
32  
33 15 such as oral health-related quality of life (OHRQoL) may offer additional information when  
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35 16 used in conjunction with clinical evaluations to estimate the impact of DH on daily function  
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37 17 (Bekes et al., 2009, Goh et al., 2015).

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40 18 Studies on the effects of DH on OHRQoL are lacking (Boiko et al., 2010, Lin &  
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42 19 Gillam, 2012, Bekes & Hirsch, 2013). One clinical study observed that most patients seeking  
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44 20 treatment for DH reported substantial impact on their OHRQoL and were often limited in  
45  
46 21 eating, drinking and oral hygiene habits (Bekes et al., 2009). DH has been shown to increase  
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48 22 immediately after periodontal therapy and gradually reduce over time (Lin & Gillam, 2012,  
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50 23 Mantzourani & Sharma, 2013). However, the long term impact of DH on the OHRQoL of  
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52 24 treated periodontitis patients remains unclear. The aim of this study was to determine the  
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1 impact of DH on the OHRQoL of patients undergoing supportive periodontal care (SPC). The  
2 null hypothesis was that DH would have no effect on the OHRQoL of patients under SPC.

## 4 **Materials and Methods**

### 5 **Study design**

6 The study design was a convenient sample cross-sectional study.

### 8 **Subjects**

9 A target of 100 individuals undergoing SPC at the Periodontology Clinic, Prince Philip  
10 Dental Hospital (PPDH), The University of Hong Kong was set. Convenient sampling was  
11 carried out over 18 months (May 2013 - October 2014). Records of subjects scheduled for  
12 SPC were screened with assent from the clinician prior to their appointments.

13 The subjects' inclusion criteria, modified from guidelines by Holland et al. (1997),  
14 were: (1) treated periodontitis subjects aged 18-75 years under SPC with at least 4 standing  
15 non-molar teeth, (2) subjects with no remaining pockets  $\geq$  6mm, (3) no suppuration, (4)  
16 bleeding on probing (BOP)  $\leq$  25% sites, (5) plaque accumulation (measured as plaque index,  
17 PI)  $\leq$  30% sites, (6) satisfactory oral function. The exclusion criteria were: (1) medical and  
18 pharmacotherapeutic histories that may alter the response to pain stimuli, (2) expectant  
19 mothers, (3) history of eating or systemic disorders predisposing to DH, (4) evidence of  
20 increased dietary exposure to acids (assessed with a diet sheet and intra-oral examination for  
21 dental erosion), (5) having received root surface debridement or periodontal surgery within  
22 the past six months. Subject recruitment procedure is summarized in Figure 1.

23 Further details regarding sample size determination, personal data protection, clinical  
24 examination, selection of teeth for assessment of DH, and the OIDP index are shown in  
25 Appendix S1.

1

2 **Assessment of DH**

3 From each subject, two closely matched non-molar teeth were selected for tactile-stimulation  
4 and air-blast test.

5 Tactile-stimulation was carried out with a standard periodontal probe tip (Williams  
6 probe, Hu Friedy®, Chicago, IL, USA) directly connected to an electronic pressure sensor.  
7 The probe tip was run perpendicular across the CEJ until the subject experienced discomfort,  
8 or when a 70g load was reached. Discomfort at a pressure more than 70g was not considered  
9 DH and not recorded. This cut-off point has not been confirmed by any studies but follows  
10 previous research (Ide et al., 2001). No attempt was made to record the specific load at which  
11 the stimulus was triggered. Due to the design of the customized pressure sensitive probe,  
12 which needed the probe and sensor to be perpendicular to the tooth, molars had to be  
13 excluded.

14 Air-blast test was carried out with a standard dental triple syringe at a maximal  
15 pressure of 90psi and at environmental temperature of 19.5-25.1 (mean  $21.6 \pm 1.3$ ) degrees  
16 Celsius. A one-second air current was applied perpendicular to the buccal root surface 5mm  
17 away, as measured with a periodontal probe. Adjacent teeth were shielded with rubber dam  
18 strips.

19 The interval between both tests was set at five minutes though an appropriate time  
20 frame has yet to be confirmed (Holland et al., 1997). Subjects scored pain intensity for both  
21 tests on a 100mm Visual Analogue Scale (VAS) ranging from 0 mm = "no pain" to 100 mm  
22 = "agonizing pain" immediately after pain was triggered (Ide et al., 2001).

23 As the sampling unit was at a subject level, average of each DH test per subject was  
24 calculated by summation of the VAS scores from the two teeth evaluated then divided by two.

1 No cut-off point for DH was set as the aim of this study was to evaluate the impact of DH on  
2 OHRQoL regardless of DH severity.

#### 3 4 **OHRQoL assessment**

5 OHRQoL was assessed using the validated Chinese version of the Oral Impact on Daily  
6 Performances (OIDP) index (Zeng et al., 2010) in a condition-specific form (CS-OIDP).  
7 Calculation of CS-OIDP scores, extent and intensity follows the previous reported standard  
8 protocol (Tsakos et al., 2010, Zeng et al., 2010).

#### 9 10 **Data analysis**

11 Data were analyzed using the statistical package SPSS 22.0 (SPSS, Chicago, IL, USA).  
12 Subjects were categorized into those who complained of DH (DH1) and those who did not  
13 (DH0). Standard statistical analyses were conducted to compare subject's demographic and  
14 clinical data. A  $p < 0.05$  was considered statistically significant.

15 Effect size (ES) and the systemic error of measurements (SEM) were calculated to  
16 estimate the minimally important difference (MID) for CS-OIDP scores using a distribution-  
17 based approach (Tsakos et al., 2012). The ES was expressed as a ratio and interpreted  
18 through benchmark values of small (0.2), moderate (0.5) and large (0.8) effect (Cohen, 1988)  
19 The SEM was calculated through multiplying the standard deviation of the mean CS-OIDP  
20 score by the square root of one minus the reliability of the OIDP index. A difference in score  
21 less than the SEM is probably a measurement error. The SEM value is taken as the MID  
22 (Tsakos et al., 2010), and scores above the SEM/MID are regarded as clinically meaningful.

23 Backward stepwise logistic regression was performed to determine any associations  
24 between: whether a subject complained of DH, and 14 independent variables. The  
25 independent variables were: (i) continuous data – age, remaining standing teeth, mean full-

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3 1 mouth PPD, REC, CAL, PI%, BOP%, CS-OIDP score, SPC duration, air-blast and tactile-  
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5 2 stimulation VAS; (ii) categorical data – gender, tooth brushing frequency and use of  
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7 3 desensitizing toothpaste. The significance level for retention of a variable in the model was  
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9 4 0.05. Associations between CS-OIDP and the aforementioned independent variables were  
10  
11 5 determined through analysis of covariance (ANCOVA).  
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## 7 **Ethics**

8 The study protocol was approved by the Institutional Review Board of the University of  
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10 9 Hong Kong/Hospital Authority Hong Kong West Cluster (IRB reference number: UW 13-  
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12 10 228).  
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## 29 **Results**

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32 13 A total of 102 subjects completed all evaluations. Demographic and clinical data of 102  
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34 14 subjects are summarized in Table 1. Sixty-one (59.8%) subjects self-reported DH (DH1).  
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36 15 Subjects who did not report DH (DH0) were slightly older (Table 1). No significant  
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38 16 differences were detected between groups in terms of gender distribution, plaque (PI)%,  
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40 17 bleeding on probing (BOP)%, mean full-mouth clinical attachment level (CAL), probing  
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42 18 pocket depth (PPD), recession (REC), SPC duration and number of standing teeth. The mean  
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44 19 full-mouth CAL for the study population was  $3.0 \pm 0.6$ mm, indicating moderate attachment  
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46 20 loss (Genco et al., 1999, Ng & Leung, 2006).  
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50 21 Among the 61 DH1 subjects, 59 (96.7%) reported discomfort from the air-blast test  
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52 22 with a mean VAS score of  $30.4 \pm 21.0$ mm while only 44 (72.1%) responded to the tactile-  
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54 23 stimulation test with a mean VAS score of  $15.1 \pm 15.4$ mm. Two DH1 subjects reported DH  
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56 24 only on their molars and did not respond when non-molar teeth were tested. However, they  
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1 reported impacts on OHRQoL. Nine (22.0%) DH0 subjects reported discomfort from the air-  
2 blast test with a mean VAS score of  $11.4 \pm 15.3$ mm, while four (9.8%) responded to tactile-  
3 stimulation test with a mean VAS score of  $6.5 \pm 5.3$ mm. All tactile-stimulation test positive  
4 subjects were air-blast test positive.

5 Oral impacts due to DH were common, 50 (82.0%) of the 61 DH1 subjects reported  
6 impacts (mean CS-OIDP score =  $5.7 \pm 6.6$ ) while 11 (18%) did not report any impact. The  
7 mean air-blast VAS score for those reporting impacts was  $31.3 \pm 21.6$ mm, mean tactile-  
8 stimulation VAS score was  $11.6 \pm 15.6$ mm. The mean air-blast VAS score for the 11 subjects  
9 who reported no impacts was  $21.0 \pm 18.6$ mm, mean tactile-stimulation VAS score was  $7.6 \pm$   
10  $9.2$ mm, difference in mean air-blast VAS scores ( $p = 0.15$ ) and mean tactile-stimulation  
11 scores ( $p = 0.42$ ) between both groups were not statistically significant. No DH0 subjects  
12 reported impact on OHRQoL.

13 Of the 50 DH1 subjects who reported impacts, cleaning the mouth was the most  
14 common daily performance affected ( $n = 36, 35.3\%$ ), followed by eating ( $n = 35, 34.3\%$ ),  
15 emotional stability ( $n = 11, 10.8\%$ ), social contact ( $n = 6, 5.9\%$ ), going out ( $n = 5, 4.9\%$ ),  
16 sleeping/relaxing ( $n = 2, 2.0\%$ ), smiling ( $n = 2, 2.0\%$ ) and speaking ( $n = 2, 2.0\%$ ) (Figure 2).  
17 None reported impact upon doing light physical activities. Among reported impacts, 17.2%  
18 scored an intensity of “very little”, 50.5% scored an intensity of “little”, 25.2% scored  
19 “moderate”, and 7.1% scored “severe”. None reported intensity of “very severe”. Nineteen  
20 (18.6%) subjects reported one impact, 19 (18.6%) reported two impacts, six (5.9%) reported  
21 three impacts and six (5.9%) reported four impacts. None reported more than four impacts.

22 The ES was determined at 0.75 which showed a moderate effect size and the  
23 SEM/MID was determined as 2.0 points. Thirty-one (30.4%) subjects had CS-OIDP scores  
24 above the MID with mean score of  $8.4 \pm 7.1$ . This group of subjects showed a slightly  
25 different prevalence in impacts with 25 (80.6%) reporting impact on eating, 22 (71.0%)

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3 1 cleaning the mouth, 10 (32.3%) emotional stability, six (19.4%) social contact, five (16.1%)  
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5 2 going out, two (6.5%) speaking, two (6.5%) smiling, two (6.5%) sleeping/relaxing.  
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7  
8 3 Due to inability to effectively assess the air-blast and tactile-stimulation VAS scores  
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10 4 of two DH1 subjects with DH only on molars, they were excluded from multivariate analyses.  
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12 5 Results of the logistic regression analysis are summarized in Table 2. When considering  
13  
14 6 factors that influenced whether a subject complained of DH, only three independent variables  
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16 7 remained in the final model. These were air-blast VAS score, tactile-stimulation VAS score  
17  
18 8 and the use of desensitizing agent. Higher CS-OIDP score was associated with higher air-  
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20 9 blast and tactile-stimulation VAS score, age and using desensitizing agents (Table 3).  
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23 10 For patients identified as possible subjects through clinical records, 45 upon contact  
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25 11 had just received root surface debridement and could not partake in the study. Thirty-three  
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27 12 could not attend the clinical examination or reschedule their SPC to fit our data collection, of  
28  
29 13 these, 26 (78.8%) agreed to answer questions regarding their DH status over the phone  
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31 14 (Figure 1). Fourteen (53.8%) did not experience DH while 12 (46.2%) did. Of the 12 subjects  
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33 15 that complained of DH, 11 (91.7%) had DH for more than six months, of these, two (18.2%)  
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35 16 reported impacts on daily performances due to DH with mean CS-OIDP score of  $8.9 \pm 7.6$ .  
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37 17 Both subjects reported difficulty in cleaning the mouth due to DH, one reported impact on  
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39 18 relaxing, none reported impacts on any other daily performances.  
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## 45 20 **Discussion**

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47 21 Prevalence, severity and impact of DH on subjects under SPC have so far remained  
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49 22 unreported. Though DH may be moderate in intensity and transient in duration (Tammaro et  
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51 23 al., 2000, von Troil et al., 2002, Lin & Gillam, 2012), this present study found 59.8% of  
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53 24 subjects who have been undergoing SPC for a mean duration of  $53.0 \pm 57.3$  months had a  
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55 25 complaint of DH. Similarly, previous research within general Chinese communities found  
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3 1 subjects having endured DH for five years or more (Liu et al., 1998, Wang et al., 2012). A  
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5 2 high prevalence of DH in Chinese SPC patients may be due to considerable attachment loss,  
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7 3 frequent scaling during SPC, long-term retention of DH prone periodontitis affected anterior  
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9 4 teeth, differences in cultural norms and a highly erosive diet (Taani & Awartani, 2002, Rees  
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11 5 et al., 2003, Chu et al., 2010, Wang et al., 2012).

14 6 The mean age of the present study population was  $52.1 \pm 10.9$  years, and the SPC  
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16 7 subjects complaining of DH over the past six months were relatively younger. Earlier studies  
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18 8 reported a peak in DH between 40 and 50 years of age, with DH reducing after the fifth  
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20 9 decade (Rees et al., 2003, Chu et al., 2011). This may be attributed to age-related alterations  
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22 10 within the pulpal space in particular, degeneration of odontoblasts, calcifications, and  
23  
24 11 formation of reactionary dentine (Morse et al., 1993, Espina et al., 2003, Bartold, 2006).

27 12 Of the 61 subjects who had a complaint of DH, 59 had clinically detectable DH with  
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29 13 the air-blast test while only 44 responded to the tactile-stimulation test. When factors that  
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31 14 potentiated DH clinically were evaluated, evaporative stimuli was found to be the most  
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33 15 effective stimulus for DH, while a lower percentage of sensitive teeth responded to tactile  
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35 16 stimuli (Chabanski et al., 1997, Rees et al., 2003). Among the 41 DH0 subjects, nine (22.0%)  
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37 17 responded to the air-blast test and four (9.8%) responded to the tactile-stimulation test. These  
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39 18 subjects, though having experienced DH before, may have become accustomed to DH over  
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41 19 time and did not register having a problem until tested. This observation points toward the  
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43 20 differences in individual pain perception and tolerance which may influence DH experience  
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45 21 (Bekes & Hirsch, 2013). A previous study had reported that subjects respond to DH test even  
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47 22 when their teeth were completely obscured (Addy et al., 2007). Since subjects in this study  
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49 23 could hear the air-blast and see the probe being used, they may have anticipated pain and  
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51 24 responded reflexly. Such phenomenon may be true across the entire sample in any DH study,  
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1 which reflects the importance of including patient-centered outcome measures in assessing  
2 DH. CS-OIDP of zero for DH0 subjects indicate that they were not affected by DH.

3 Analyzing the impact of DH on OHRQoL can be complex, with limited studies  
4 having addressed the impact of DH on OHRQoL (Bekes et al., 2009, Boiko et al., 2010). DH  
5 is highly prevalent among periodontitis patients; therefore a condition-specific questionnaire,  
6 the OIDP (Adulyanon et al., 1996, Bernabe et al., 2009a&b, Tsakos et al., 2010) translated  
7 into the Chinese language (Zeng et al., 2010), was selected for the current study. Condition-  
8 specific OHRQoL measures have narrower focuses which increase acceptability by including  
9 only important dimensions. A focussed instrument may provide more insights into the  
10 consequences of specific oral conditions rather than evaluating overall quality of life in  
11 relation to general oral health (Bernabe et al., 2009a, Tsakos et al., 2010, Hvaring et al.,  
12 2014). Though a Dentine Hypersensitivity Experience Questionnaire has been developed  
13 (Boiko et al., 2010), and translated into the Chinese language (He et al., 2012), it was not  
14 available at the start of this study and has not been as widely used as the CS-OIDP.

15 This study found that the overall mean CS-OIDP score of DH1 subjects was  $4.7 \pm 6.3$ .  
16 Fifty (82.0%) DH1 subjects reported experiencing impacts while 11 (18.0%) did not. Though  
17 all 11 responded to the air-blast test and nine responded to the tactile-stimulation test, they  
18 seemed to have become adapted to DH. Adaptation was described as an attempt to normalize  
19 the effects of extreme and continuous stimuli (Allison et al., 1997). The effects of a stimulus  
20 (DH) are lessened in the short term and reduced in the long term (Allison et al., 1997). The  
21 three most reported impacts due to DH were cleaning the mouth (35.3%), eating (34.3%),  
22 followed by emotional stability (10.8%), all of which affected subjects from an intensity of  
23 “very little” to “severe”. Impacts on social contact, going out, relaxing, smiling and speaking  
24 were lesser. While DH exerts significant hindrance on the physical performances of the oral  
25 structures and influences an individual’s emotional state, the impact on other daily functions

1 appears less pronounced. Results from a previous study employing the generic-OIDP within a  
2 Chinese population (Zeng et al., 2010) differed slightly from the current observations. That  
3 study found that eating was the most prevalent daily performance affected (Zeng et al., 2010).  
4 This is similar for other OIDP studies where eating was the most affected performance  
5 (Gherunpong et al., 2004, Kida et al., 2006). Though the difference between number of  
6 subjects complaining of difficulty in cleaning the mouth and eating in this study was not  
7 extensive, no other studies employing the OIDP had, to the extent of our knowledge, reported  
8 difficulty in cleaning the mouth to be the most prevalent oral impact. This observation was  
9 true even for two non-participating subjects contacted by phone who reported impacts, on  
10 whom cleaning the mouth was the most frequent complaint due to DH. This reflects the  
11 minor yet significant difference between using a generic-OIDP and a CS-OIDP. Indeed,  
12 cleaning the mouth would be a major concern among this group of subjects and the use of the  
13 CS-OIDP indicated as such.

14 Description of the intensity and extent of impacts have previously been used to report  
15 oral impacts using the OIDP (Gherunpong et al., 2004, Kida et al., 2006, Zeng et al., 2010).  
16 Intensity refers to the highest severity score on any performances which does not consider the  
17 aggregate score of all performances but concentrates on the performances that had been most  
18 severely affected. Extent of impacts refers to the number of daily performances affected by  
19 oral conditions. Such indicators allow differentiation between subjects with a similar overall  
20 OIDP score but distinct patterns of impacts on OHRQoL (Zeng et al., 2010). Among the 50  
21 subjects who reported impacts, the most reported intensities were “little” (50.5%) and  
22 “moderate” (25.2%). Most subjects reported only one or two impacts on their daily lives,  
23 with none reporting effects on more than four performances.

24 To date there are no guidelines to determine whether a subject with a specific  
25 OHRQoL-outcome pattern or score is mildly, moderately or severely compromised by his /

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2  
3 1 her condition (Tsakos et al., 2012). The MID may provide better interpretability for the  
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5 2 results gathered. The MID is the smallest score or difference in score that is considered  
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7 3 important from the patient's or the clinician's point of view (Tsakos et al., 2010). In the  
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9 4 context of this study, the difference in mean CS-OIDP score between the two groups was 4.7.  
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11 5 The ES for this difference was 0.75, which was moderate; while the SEM/MID was  
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13 6 approximately 2.0 points. The difference in CS-OIDP scores between groups exceeded the  
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15 7 SEM/MID considerably and this was considered clinically meaningful (Tsakos et al., 2012).  
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17 8 The CS-OIDP scores for the DH0 group were consistently zero, as such, it can be interpreted  
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19 9 that those reporting a CS-OIDP score above 2.0 (n = 31, 30.4%) had indeed experienced  
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21 10 worse OHRQoL due to DH compared to those who did not. However, this group of subjects  
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23 11 reported eating to be the most affected daily performance, an observation that was somewhat  
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25 12 different from the entire subject pool. A reason for this finding cannot be explained from the  
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27 13 current data. Perhaps future research may shed some light on such results.  
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32 14 Factors that select for experiencing DH are unclear (Tammaro et al., 2000, Al-  
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34 15 Wahadni & Linden, 2002, Amarasena et al., 2010, West et al., 2013). Meticulous oral  
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36 16 hygiene before periodontal therapy significantly reduced DH (Tammaro et al., 2000) and  
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38 17 more tubular openings were found to be occluded when plaque control was good (Suge et al.,  
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40 18 2006). Conversely, increase in prevalence of DH was associated with tooth brushing with  
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42 19 toothpaste due to removal of the smear layer (Addy & West, 2013). When subjects with  
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44 20 periodontal disease were studied, DH was associated with increased gingival recession (Rees  
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46 21 & Addy, 2002, Costa et al., 2014) and radiographic bone loss (Fischer et al., 1991). In the  
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48 22 SPC patients studied having a high prevalence of DH, the distribution of DH appeared to be  
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50 23 unaffected by these aforementioned parameters. Both groups (DH0 and DH1) showed no  
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52 24 differences in full-mouth plaque accumulation, gingival bleeding, oral hygiene habits,  
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54 25 gingival recession and attachment loss, but reported different DH experiences, reinforcing the  
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3 1 assumption that causes of DH are multi-factorial and complex (Al-Wahadni & Linden, 2002,  
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5 2 Taani & Awartani, 2002, West et al., 2013). From the logistic regression analysis, reporting  
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7 3 DH was associated with greater discomfort from the air-blast and tactile-stimulation tests,  
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9  
10 4 which was unsurprising. Though the higher percentage of subjects in DH1 using desensitising  
11  
12 5 agents was understandable, the relatively high odds ratio (17.8) for experiencing DH if using  
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14 6 desensitizing agents was quite unexpected. However, since subjects in both groups reported  
15  
16 7 using a variety of self-applied desensitizing agents, no definite conclusion could be drawn  
17  
18 8 from this observation. The CS-OIDP scores give a quantitative estimate of how DH  
19  
20 9 undermines OHRQoL. Factors that were found to be associated with the severity of impact  
21  
22 10 on subjects' daily lives were air-blast VAS score, tactile-stimulation VAS score, age and the  
23  
24 11 use of desensitizing toothpaste. Increases in air-blast and tactile-stimulation VAS scores were  
25  
26 12 associated with corresponding increases in CS-OIDP scores, suggesting that the severity of  
27  
28 13 clinically tested DH was linked to worse OHRQoL. Though both the air-blast and tactile-  
29  
30 14 stimulation tests may be used to estimate the impact of DH on OHRQoL, results must be  
31  
32 15 interpreted with caution as the increases in CS-OIDP scores were minimal. Increasing age  
33  
34 16 was associated with greater impact on OHRQoL due to DH. This was similar to a previous  
35  
36 17 research which found older adults reporting worse OHRQoL due to DH (Bekes et al., 2009).  
37  
38 18 The use of desensitizing agents also predicted higher CS-OIDP scores. When the results of  
39  
40 19 this study are viewed in their entirety, subjects with greater severity of DH clinically and  
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42 20 using desensitizing products had a greater tendency to report DH and experienced worse  
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44 21 OHRQoL.

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49 22 Due to the cross-sectional design of this study, certain factors (e.g. previous  
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51 23 periodontal treatment, desensitizing therapy, SPC duration) could not be controlled. A  
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53 24 longitudinal study with subjects grouped according to type of periodontal therapy received,  
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55 25 evaluated for DH and monitored for an appropriate period may be able to reduce such

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3 1 limitations. Another limitation of this study was difficulty in subject recruitment. Within the  
4  
5 2 confines of the selection criteria, subjects suitable for the study were constrained. Many  
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7 3 potential subjects who showed recurrent periodontal disease and insufficient oral hygiene  
8  
9 4 through their records and during examination were excluded from the study. This may be due  
10  
11 5 to the fact that patients recommended for regular SPC in a teaching-hospital usually have  
12  
13 6 higher periodontal disease risk (Leung et al., 2006). A longer duration for subject recruitment  
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15 7 in future research might prove beneficial. As molars were excluded in the DH test, use of  
16  
17 8 alternative DH assessment procedures to allow evaluation of molars may be considered.  
18  
19 9 However, to date, control and reproducibility of many DH assessment methods are limited  
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21 10 (Holland et al., 1997, Ide et al., 2001).  
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## 28 **Conclusion**

29  
30 13 This study evaluated the impact of DH on OHRQoL among patients receiving SPC. Within  
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32 14 the limits of this study, DH appears to undermine the OHRQoL of patients who had  
33  
34 15 completed periodontal treatment. The extent of impact is positively associated with the  
35  
36 16 clinical severity of DH. The minimally important difference in CS-OIDP scores was 2.0  
37  
38 17 points, with approximately one third of patients experiencing poorer OHRQoL due to DH.  
39  
40 18 The most affected daily performance was cleaning the mouth, an observation that is pertinent  
41  
42 19 in the delivery of SPC care for treated patients. Though DH tends to reduce in intensity after  
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44 20 periodontal treatment, its mild but prolonged presence may negatively affect the daily lives of  
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46 21 patients. More research is warranted to clarify this relationship and identify the best  
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48 22 therapeutic protocol to minimize negative effects of DH.  
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## 55 **Acknowledgement**

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2 Grants Council of the Hong Kong Special Administrative Region, China (HKU 772110M).  
3 We acknowledge Dr. Xiaojuan Zeng who provided us with the Chinese version of the OIDP  
4 questionnaire.

5  
6 Words count (except Acknowledgement): 4026  
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## 8 **Supporting Information**

9 Additional Supporting Information may be found in the online version of this article:  
10 AppendixS1. Materials and Methods; The Oral Impact on Daily Performances (OIDP) index  
11  
12

## 13 **Clinical Relevance**

14 *Scientific rationale for the study:* Prevalence and impact of DH on OHRQoL in patients  
15 under SPC remains unreported.

16 *Principal findings:* A majority of patients under SPC experience DH and reports worse  
17 OHRQoL. The MID for CS-OIDP scores was 2.0 points with approximately 30% of subjects  
18 reporting a higher value. The most affected performance was cleaning the mouth.

19 *Practical implications:* Patients may experience prolonged DH after periodontal treatment  
20 which impairs OHRQoL. Clinicians should pay attention towards patients who self-report  
21 such symptoms during SPC, apply and advise use of desensitizing agents, and develop better  
22 desensitizing strategies to counter such effects.  
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24 Words count: 98  
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1 **Legend**

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3 Fig. 1. Flow chart on subject recruitment. All patients regardless of study participation,  
4 continued their SPC in the Periodontology Clinic.

5 Fig. 2. Frequency and intensity of oral impact on daily performances (n = 102)

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For Peer Review



Table 1. Characteristics of subjects, with (DH1) or without (DH0) a complaint of dentine hypersensitivity ( $n = 102$ )

Characteristics	Categories	Subject groups		test	$p$ - value
		DH1 $n = 61$ (59.8)	DH0 $n = 41$ (40.2)		
Age (years)		$50.0 \pm 9.7$	$55.3 \pm 12.0$	$t$	0.016
Gender ( $n$ )	Male	22 (21.6)	20 (19.6)	$\chi^2$	0.200
	Female	39 (38.2)	21 (20.6)		
No. of standing teeth		$25.7 \pm 3.3$	$24.5 \pm 4.3$	$t$	0.130
Plaque (%)		$13.2 \pm 6.0$	$13.8 \pm 5.3$	$t$	0.550
Bleeding on probing (%)		$11.7 \pm 6.3$	$11.9 \pm 5.7$	$t$	0.850
Full-mouth PPD (mm)		$2.0 \pm 0.1$	$2.0 \pm 0.1$	$t$	0.402
Full-mouth REC (mm)		$1.0 \pm 0.5$	$0.9 \pm 0.6$	$t$	0.765
Full-mouth CAL (mm)		$3.0 \pm 0.5$	$3.0 \pm 0.6$	$t$	0.973
Tooth brushing habit ( $n$ )	<2 per day	0	3 (2.9)	Fisher	0.062
	$\geq 2$ per day	61 (59.8)	38 (37.3)		
Used desensitizing agent ( $n$ )	Yes	41 (40.2%)	15 (14.7%)	$\chi^2$	0.002
	No	20 (19.6%)	26 (25.5%)		
SPC Duration (months)		$57.3 \pm 60.2$	$45.9 \pm 52.4$	$t$	0.419
Clinically detectable DH ( $n$ )					
<i>Response to air-blast</i>	Yes	59 (57.8)	9 (8.8)	Fisher	< 0.001
	No	2 (2.0)	32 (31.4)		
<i>Response to tactile stimulation</i>	VAS score (mm)	$29.4 \pm 21.3$	$2.5 \pm 8.3$	$t$	< 0.001
	Yes	44 (43.1)	4 (3.9)	Fisher	< 0.001
No	17 (16.7)	37 (36.3)			
	VAS score (mm)	$10.9 \pm 14.7$	$0.6 \pm 2.4$	$t$	< 0.001

Affects OHRQOL (n)	Yes	50 (49.0)	0	Fisher	< 0.001
	No	11 (10.8)	41 (40.2)		
	CS-OIDP score	4.7 ± 6.3	0.0	<i>t</i>	< 0.001

Values are shown as mean ± SD; percentage in parenthesis unless stated otherwise; *t*: T-test,  $\chi^2$ : Pearson's Chi square test, Fisher: Fisher's exact test; level of significance set at  $p < 0.05$ . VAS: Visual analogue scale; OHRQoL: Oral health-related quality of life; Affects OHRQoL: Subjects with CS-OIDP score > 0.

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Table 2. Results of logistic regression analysis on factors affecting whether a subject does or does not complain of DH ( $n = 100$ )

Factor	$\beta$ (SE)	Odds Ratio (95% CI)	$p$ -value
Air-blast VAS score	0.20 (0.06)	1.22 (1.09-1.36)	< 0.001
Tactile-stimulation VAS score	0.24 (0.11)	1.27 (1.02-1.57)	0.034
Use of desensitizing agent <sup>a</sup>	2.88 (0.99)	17.80 (2.56-123.52)	0.004
Constant	-3.99 (1.08)	0.019	< 0.001

<sup>a</sup>Not using desensitizing agent as reference group

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Table 3. Results of Analysis of Covariance on factors that affected CS-OIDP score ( $n = 100$ )

Factor	Estimate	SE	$p$ -value
Air-blast VAS score	0.10	0.02	< 0.001
Tactile-stimulation VAS score	0.13	0.03	< 0.001
Use of desensitizing agent <sup>a</sup>	1.77	0.66	0.009
Age	0.06	0.03	0.046
Intercept	-4.44	1.81	0.016

Adjusted  $R^2 = 0.476$ ,  $F = 23.474$ ,  $p < 0.001$

<sup>a</sup>Not using desensitizing agent as reference group

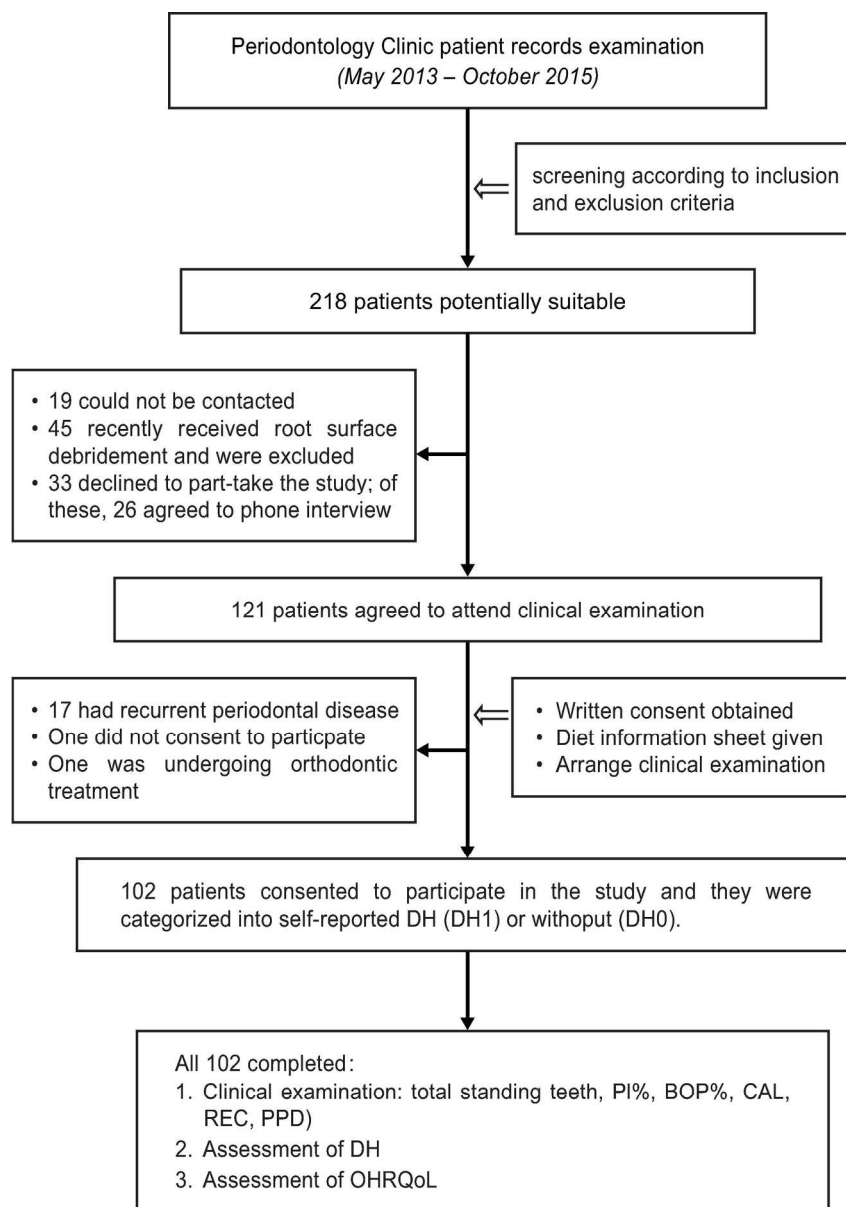


Fig. 1. Flow chart on subject recruitment. All patients regardless of study participation, continued their SPC in the Periodontology Clinic.  
163x232mm (300 x 300 DPI)

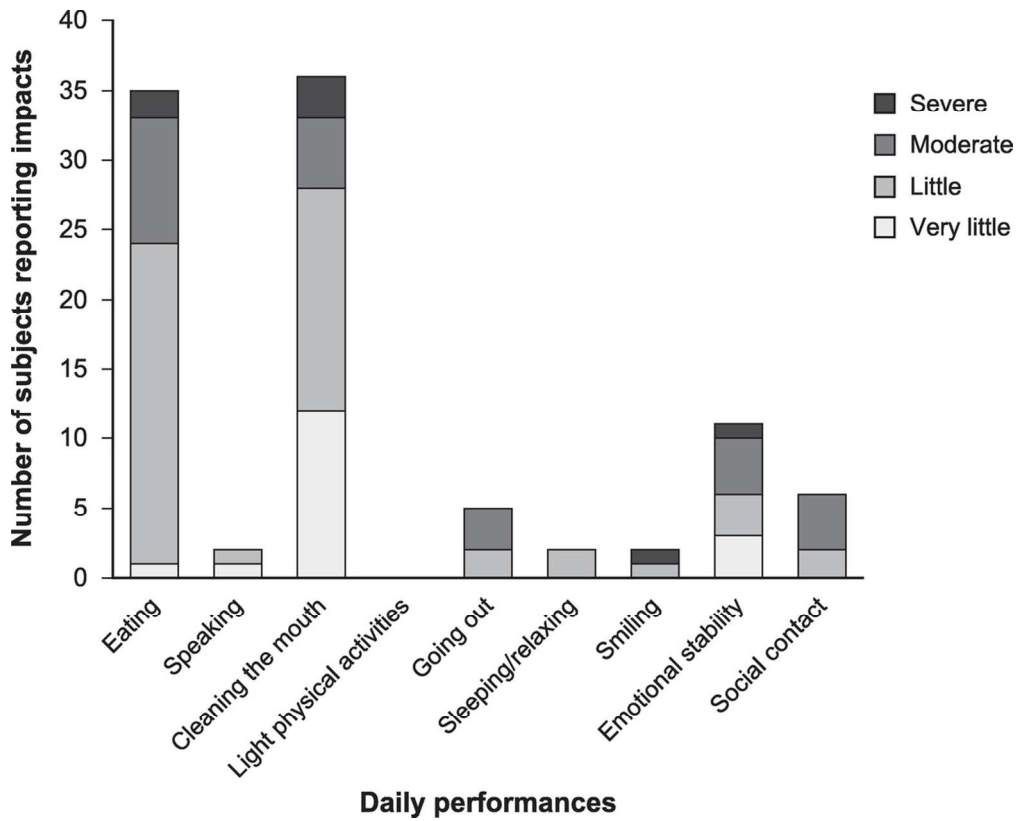


Fig. 2. Frequency and intensity of oral impact on daily performances (n = 102)  
104x84mm (300 x 300 DPI)

## 1 **Materials and Methods**

### 2 **Sample size determination**

3 The sample size was estimated as follows: Based on an earlier report on OHRQoL in  
4 periodontitis patients (Aslund et al., 2008), 251 subjects were sufficient for a cross-sectional  
5 study using the Basic Periodontal Examination and a general OHRQoL questionnaire.  
6 Considering the more intricate data collection procedures, and that approximately 70% of the  
7 local periodontal clinic attendees were affected by DH (Rees et al., 2003), a cohort of 100  
8 periodontitis subjects undergoing SPC was considered appropriate when confidence interval  
9 was set at  $\pm 5\%$ , with estimated error of 0.1%, and estimated prevalence of impact on  
10 OHRQoL of 50%.

### 12 **Personal data protection**

13 The PPDH is a university affiliated teaching-hospital. All patients had during admission  
14 signed a consent form agreeing to have their records accessible for clinical training and  
15 research purposes. As such, access to patient records was pre-consented. Nevertheless, the  
16 study protocol including the periodontal patient records screening was approved by the  
17 appropriate Institutional Review Board. Collected data were all stripped of personal  
18 identifiers.

### 20 **Clinical examination**

21 Clinical assessment included an update on each subject's medical, dental and treatment  
22 history, use of self-applied desensitizing agents, oral hygiene practices and DH experience  
23 within the previous six months. Clinical examination included number of standing teeth, PI%,  
24 BOP%, clinical attachment level (CAL), recession (REC) and probing pocket depth (PPD)  
25 measured at six sites (mesio-buccal, mid-buccal, disto-buccal, mesio-lingual, mid-lingual,

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2  
3 1 disto-lingual) on each tooth according to previous protocols (Wong et al., 2012). All  
4  
5 2 examinations were carried out by a single operator (VG).  
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#### 4 **Selection of teeth for assessment of DH**

5 From each subject, two closely matched non-molar teeth were selected for tactile-stimulation  
6 and air-blast test. Non-molar teeth directly identified by the subject as being sensitive were  
7 given priority for testing. To reduce the chances of non-response being due to possible pulpal  
8 causes, only teeth responding to pulp sensibility test were selected. The inclusion criteria for  
9 teeth selection were: (1) non-molar teeth, (2) responsive to pulp sensibility test, (3) absence  
10 of radiographic periapical pathology. Exclusion criteria were: (1) teeth or supporting  
11 structures with potentially pain-related pathology e.g. caries, increased mobility, (2) teeth  
12 with history of trauma, (3) abutments for fixed or removable prostheses, and (4) heavily  
13 restored teeth. The teeth were selected from the upper or lower arch only (decided by a coin  
14 toss; heads: maxilla, tails: mandible), from contralateral quadrants, with tooth type matched  
15 as closely as possible. If more than one non-molar tooth was sensitive, the most severely  
16 affected tooth was selected and matched with its contralateral counterpart. If the subject was  
17 unable to pinpoint sensitive teeth or had no sensitive teeth, the test teeth were randomly  
18 selected with a dice (e.g. dice roll of no. 5 = second premolars). This was performed until  
19 suitable non-molar teeth were selected. Presence and location of any molar teeth with DH  
20 were recorded as well.  
21

#### 22 **The Oral Impact on Daily Performances (OIDP) index**

23 The Oral Impact on Daily Performances (OIDP) evaluates oral impacts on nine basic daily  
24 performances: (1) eating, (2) speaking, (3) cleaning the mouth, (4) light physical activities, (5)  
25 going out, (6) sleeping/relaxing, (7) smiling, (8) emotional state, and (9) social contact. The



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3 1 OIDP was designed to associate specific oral health problems with impacts on daily life,  
4  
5 2 thereby linking such impacts to the specific oral condition of interest (Bernabe et al., 2009a).  
6  
7 3 This has enabled the OIDP to be used as a condition-specific OHRQoL measure (Bernabe et  
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10 4 al., 2009a&b, Tsakos et al., 2010, Hvaring et al., 2014).

11  
12 5 Higher CS-OIDP scores represent worse OHRQoL. The CS-OIDP extent was calculated  
13  
14 6 as the number of performances affected by impacts, ranging from none to nine. The CS-OIDP  
15  
16 7 intensity was estimated as the highest severity of impact on any of the nine daily  
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18 8 performances, ranging from none to very severe (Zeng et al., 2010).  
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## 11 **References**

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STROBE Statement—Checklist of items that were included in the current *cross-sectional study*

	Item No	Recommendation
<b>Title and abstract</b>	1	<p><i>(a) Study design</i></p> <p>Page 2, Abstract, under the heading: Materials and Methods, line 2 : cross-sectional study</p> <hr/> <p><i>(b) Balanced/informative abstract</i></p> <p>Page 2, Abstract given in the format of: 1) Aim, 2) Materials and Methods, 3)Results, 4) Conclusions</p>
<b>Introduction</b>		
Background/rationale	2	<p><i>Explain the scientific background and rationale for the investigation being reported</i></p> <p>Definition and prevalence of dentine hypersensitivity as well as findings from previous studies explained under introductory paragraphs (See main text, paragraphs 1, 2 and first part of 3) on page 3.</p> <p>Rationale for study explained in paragraph 3, page 3&amp;4.</p>
Objectives	3	<p><i>State specific objectives, including any prespecified hypotheses</i></p> <p>See text, page 3, last line – page 4, lines 1-2.</p>
<b>Methods</b>		
Study design	4	<p><i>Present key elements of study design early in the paper</i></p> <p>See text, page 4, under Materials and Methods: Study Design</p>
Setting	5	<p><i>Describe the setting, locations, and relevant dates, including periods of recruitment, and exposure</i></p> <p>See text, page 4, under Materials and Methods, Subjects</p> <p><i>Describe follow-up</i></p> <p>Cross sectional study, no follow up appointments were given. Subjects continued with scheduled SPC.</p> <p>Refer to: Figure 1. Flow chart on subject recruitment. All patients regardless of study participation, continued their SPC in the Periodontology Clinic.</p> <p><i>Describe data collection</i></p> <p>Please see text, Materials and Methods, under the headings: 1) Subjects, 2) Assessment of DH, 3) OHRQoL assessment; and AppendixS1, under Materials and Methods, 1) Clinical examination, 2) Selection of teeth for assessment of DH</p>
Participants	6	<p><i>Eligibility criteria for participants</i></p> <p>Please see text, Materials and Methods, under the headings: 1) Subjects</p> <p><i>Sources and methods of selection of participants</i></p> <p>Please see text, Materials and Methods, under the headings: 1) Subjects</p>
Variables	7	<p><i>Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers.</i></p> <p>Please see text, Materials and Methods, under the headings: 1) Subjects, 2) Assessment of DH, 3) OHRQoL assessment, 4) Data analysis; and AppendixS1, under Materials and Methods, under 1) Clinical examination, 2) Selection of teeth for assessment of DH</p> <p><i>Give diagnostic criteria, if applicable</i></p> <p>Please see text, under: Assessment of DH, page 5 line 23-24, page 6, line 1-2.</p>
Data sources/ measurement	8*	<p><i>For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group</i></p> <p>All demographic data, clinical variables, assessment protocols and measurements are</p>

described in detail under:

- See text, Materials and Methods 1) Subjects, 2) Assessment of DH, 3) OHRQoL assessment, 4) Data analysis (Pages 4-7); and
- AppendixS1, Materials and Methods, 1) Clinical examination, 2) Selection of teeth for assessment of DH, 3) The Oral Impact on Daily Performances Index (Page 1-3).

Grouping of subjects are explained in Data analysis; summarized in Table 1.

Bias	9	<p><i>Describe any efforts to address potential sources of bias</i></p> <ul style="list-style-type: none"> <li>- See text, Materials and Methods, under Subject selection, regarding explanation on inclusion and exclusion criteria to minimize confounding factors; the study followed specific published guidelines on dentine hypersensitivity research (Holland et al., 1997, Ide et al., 2001, Tsakos et al., 2010, Zeng et al., 2010).</li> <li>- Also in AppendixS1, under the heading: Clinical examination (All examinations were carried out by a single operator: VG)</li> <li>- Use of a condition-specific OHRQoL questionnaire may reduce potential bias due to effects from other conditions as discussed under: Discussion, page 11, lines 3-14</li> <li>- Molar teeth were excluded (see text, Assessment of DH, page 5, lines 11-13)</li> </ul>
Study size	10	<p><i>Explain how the study size was arrived at</i></p> <p>Please see AppendixS1, page 1, Materials and Methods, under the heading: Sample size determination</p>
Quantitative variables	11	<p><i>Explain how quantitative variables were handled in the analyses.</i></p> <p>See main text, Materials and Methods, page 6, under the heading: Data analysis</p> <p><i>If applicable, describe which groupings were chosen and why</i></p> <p>See text, Materials and Methods, page 6, under the heading: Data analysis, first paragraph.</p> <p>See also attached Table 1. for all variables assessed.</p>
Statistical methods	12	<p>(a) <i>Describe all statistical methods, including those used to control for confounding</i></p> <p>See text, Materials and Methods, page 6, under the heading: Data analysis</p> <p>(b) <i>Describe any methods used to examine subgroups and interactions</i></p> <p>See text, Materials and Methods, page 6, under the heading: Data analysis; see also Tables 1, 2, 3</p> <p>(c) <i>Explain how missing data were addressed</i></p> <p>Not applicable, no missing data from participating subjects.</p> <p>26 dropout subjects were interviewed by phone (see text, page 9, lines 10-18). This data was not included in the analysis</p> <p>(d) <i>If applicable, describe analytical methods taking account of sampling strategy</i></p> <p>Not applicable</p> <p>(e) <i>Describe any sensitivity analyses</i></p> <p>Not applicable</p>
<b>Results</b>		
Participants	13*	<p>(a) <i>Report numbers of individuals at each stage of study—e.g. numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed</i></p> <p>See text, Results, page 7, lines 13-15</p> <p>See text, Results, page 9, lines 10-18 (Final paragraph for Results)</p> <p>See also Figure 1. Flow chart on subject recruitment</p> <p>(b) <i>Give reasons for non-participation at each stage</i></p> <p>See text, Results, page 9, lines 10-18 (Final paragraph for Results)</p> <p>See also Figure 1. Flow chart on subject recruitment</p> <p>(c) <i>Consider use of a flow diagram</i></p> <p>See Figure 1. Flow chart on subject recruitment</p>

1 2 3 4 5 6 7	Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders See Table 1 <hr/> (b) Indicate number of participants with missing data for each variable of interest No missing data for participating subjects
8 9	Outcome data	15*	Report numbers of outcome events or summary measures See Table 1
10 11 12 13 14 15 16 17 18 19	Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g. 95% confidence interval). Make clear which confounders were adjusted for and why they were included Not applicable <hr/> (b) Report category boundaries when continuous variables were categorized See Table 1 <hr/> (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period Not applicable
20 21 22 23 24 25 26	Other analyses	17	Report other analyses done—e.g. analyses of subgroups and interactions, and sensitivity analyses Please see text, Materials and Methods, under the heading: Data analysis (page 6) See Tables 1, 2, 3; See also text, Results (page 9, lines 3-9) for explanation about the multivariate analyses and interactions between variables
27	<b>Discussion</b>		
28 29 30 31 32 33 34 35	Key results	18	Summarise key results with reference to study objectives See text, under: Discussion (page 9). All results are discussed with appropriate reference to study objective/aim See page 11, line 3-25, page 12, line 1-23. Key results on impacts of DH on OHRQoL are discussed in detail. See also Table 2. for results on factors influencing DH experiences. See also Table 3. for results on factors affecting OHRQoL.
36 37 38	Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias See text, page 14 lines 22-25, page 15, lines 1-10 (limitations discussed in detail)
39 40 41 42 43 44 45 46 47 48	Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence See text, under Discussion, page 9: All results are discussed and explained within the limits of this study with appropriate references as support (if available); See text, under Conclusion, page 15: All results including prevalence of dentine hypersensitivity (DH), factors affecting a complaint of DH, factors affecting impairments in OHRQoL, severity and areas of OHRQoL affected by DH and generalization of results are given; See text, under Clinical Relevance, Practical implications, page 16
49 50	Generalisability	21	Discuss the generalisability (external validity) of the study results See text, under Clinical Relevance, Practical implications, page 16
51	<b>Other information</b>		
52 53 54	Funding	22	See text, page 1, under: Conflict of interest and sources of funding statement. See also main text, under Acknowledgement, page 15, line 24, page 16, lines 1-4

\*Give information separately for exposed and unexposed groups.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely

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available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

For Peer Review