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Clinical monitoring of tooth wear progression in patients over a period of one year using CAD/CAM

Running title: Monitoring tooth wear in patients using CAD/CAM

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Abstract

Objective: To clinically monitor the progression of tooth wear over a period of one year in a cohort of referred tooth wear patients through the use of a CAD/CAD scanner and a standardised scanning/ assessment methodology.

Methods: Polyether impressions were made of 11 participants (130 teeth) at baseline and one year. Impressions were poured in Type IV dental stone and anterior teeth 3D scanned. A surface matching software was used to compare one-year to baseline scans and identify any dimensional differences.

Results: Parafunctional habits were reported by all patients. All participants exhibited tooth wear ≥140μm in depth, and extending to ≥280μm in at least one tooth. Upper central incisors were the most commonly and severely tooth wear affected teeth.

Conclusion: The ability of the developed CAD/CAM scanning methodology in clinical monitoring of tooth wear was demonstrated. Further research is needed to assess its practicality in large-scale epidemiological tooth wear studies.

Introduction

Given the subjective nature of currently available tooth wear indices[1], and the limited evidence supporting various tooth wear management approaches and their long-term outcomes [2, 3]; developing a method for objectively quantifying tooth wear *in-vivo* becomes pertinent. As such, CAD/CAM scanning can offer a more accurate and reliable alternative for monitoring tooth wear progression in patients.

The aim of this study was to clinically monitor the progression of tooth wear over a period of one year in a cohort of patients through the use of a standardised 3D scanning and assessment methodology.

Methods and materials

Ethical approval was attained from the West of Scotland Research and Ethics Committee, REC: 10/S0709/59, R&D Ref: GN10DN412. Participants were recruited, between March 2011 – April 2012, through three Restorative Dentistry Consultants' clinics at Glasgow Dental Hospital and School (GDH&S). Participants completed a history questionnaire addressing their medical and dental history, lifestyle factors, habits and diet.

Study inclusion criteria:

- Consenting adults over the age of 16

- Patients referred solely for management of tooth wear

- Patients requiring management that only involved monitoring of tooth wear, dietary advice, oral hygiene instructions, and/or referral to hypnotherapy

The accuracy of the scanning system (3D scanner and dental stone casts) was previously assessed using a custom-made stainless steel model resembling the dimensions of the dental arch [4].

Initial and one-year recall visits involved making polyether impressions (Impregum™ Penta Soft – 3M™ ESPE™, MN, U.S.A) of participants' dentition. Retreieved impressions were visually inspected, and if deemed satisfactory, disinfected for 10 minutes (Perform®-ID, 3%, Schülke&Mayr GmbH, Norderstedt, Germany). After 24 hours, impressions were poured in Suprastone die stone (ISO Type IV dental stone, KerrLab, CA., U.S.A). Die stone was mixed according to manufacturer's recommendations.

At one month post-pouring, all anterior teeth were contact-scanned on the cast replicas using a CAD/CAM scanner (*incise*™, 1mm diameter ball-end probe, probing force of 0.5N/mm, Renishaw, Wotton under- Edge, Gloucestershire, UK), generating a stereolithography (STL) image, T^O (Figure 1a). The procedure was repeated at one-year, generating T^1 scan.

A surface matching software, Geomagic Qualify™ (Geomagic Inc., V.2012, N.C, U.S.A), was used to superimpose the experimental T^1 scan onto the reference scan, T^O, using Best-fit registration on an individual tooth basis. 3D deviation analysis was performed to calculate the mean step-height (square-mean-distance/ Euclidean-distance) difference between scans T^1 and T^O in the X, Y and Z coordinates (Figure 1b).

Results

Thirty patients were initially recruited. Eleven patients (n= 11/30) were available at the one-year recall; 6 males and 5 females (mean age: 47±13 years).

The majority of patients were aware of their tooth wear condition within the past 5 years (n= 8/11), and reported mental health risk factors, such as depression (n=7/11) (Table 1). All patients (n=11) reported positive attrition risk factors, in the form of parafunctional habits. Moreover, the majority of patients (n= 10/11) reported concurrent erosion and/or abrasion risk factors.

All participants (n=11) demonstrated anterior tooth wear of ≥140μm of depth affecting ≥1% of the scanned teeth surfaces (Figure 2). Furthermore, all participants (n=11) demonstrated tooth wear ≥260 - 500μm in one or more of their teeth.

Upper central incisors (UCI) were the most commonly and severely affected by wear, with 64% of all UCIs presenting ≥260μm of wear (Figure 3). They also exhibited the greatest surface area of wear with a mean affected surface area of 7% (StDev: ±4%).

Due to the small sample size further statistical analysis was not feasible.

Discussion

The findings of this pilot study demonstrate the feasibility and applicability of the developed 3D methodology in monitoring clinical wear. The pronounced one-year wear ($\geq 140 \mu m$) exhibited by the patient cohort is in agreement with findings of other studies demonstrating wear of $113 - 656 \mu m$ over a period of six months to one year [5, 6]. Such high wear values experienced by the patients can be explained by the presence of active parafunctional habits potentially triggered by underlying mental health disorders such as stress and depression.

The study does have limitations regarding operator training, and complexity of scanning/ analysis on an individual-tooth basis. However, the selection of specific teeth (central incisors, canines) as key indictors for monitoring tooth wear progression will assist in simplifying and expediting the process. Future employment of the methodology on a larger sample size with longer follow-up will offer a more population-representative description of tooth wear.

Conclusion

Over a period of one year, all patients presented anterior tooth wear $\geq 140\mu m$ in depth. The most commonly and severely affected teeth were the upper central incisors. The clinical feasibility and applicability of the developed CAD/CAM methodology in monitoring of tooth wear was demonstrated.

Disclosure

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3D Deviation
Max +/-: 0.53 / -0.55 mm
Average +/-: 0.02 / -0.03 mm
Standard Deviation: 0.05 mm
RMS Estimate: 0.05 mm
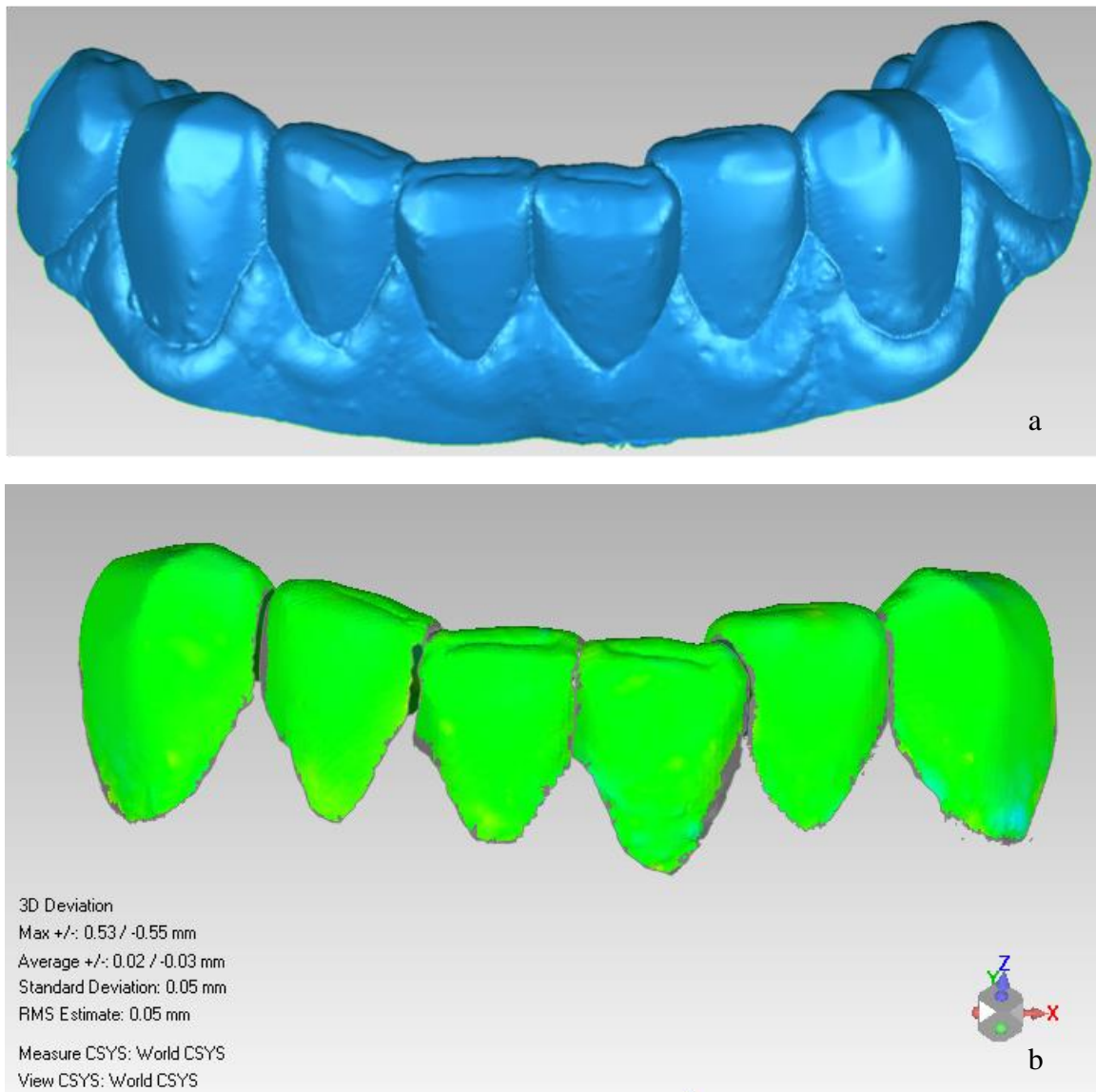
Measure CSYS: World CSYS
View CSYS: World CSYS

Figure 1: Stereolithography (STL) image of patient's anterior teeth acquired through contact scanning of Type IV dental stone cast poured from a polyether impression (a). Best-fit registration and 3D deviation analysis of scans taken of patient's dentition at baseline and after one year using a CAD/CAM profilometer to identify mean step-height differences. Soft tissues, and any impression and/or casting errors, have been trimmed from scans to facilitate accurate superimposition and comparison of 3D scans (b).

Table 1: Positive findings from patient history questionnaire covering medical, dental, dietary and lifestyle risk factors of tooth wear. Duration of awareness of tooth wear condition (DOA); Intrinsic erosion (Int Erosion); Extrinsic Erosion (Ext Erosion); Parafunctional habits (PH).

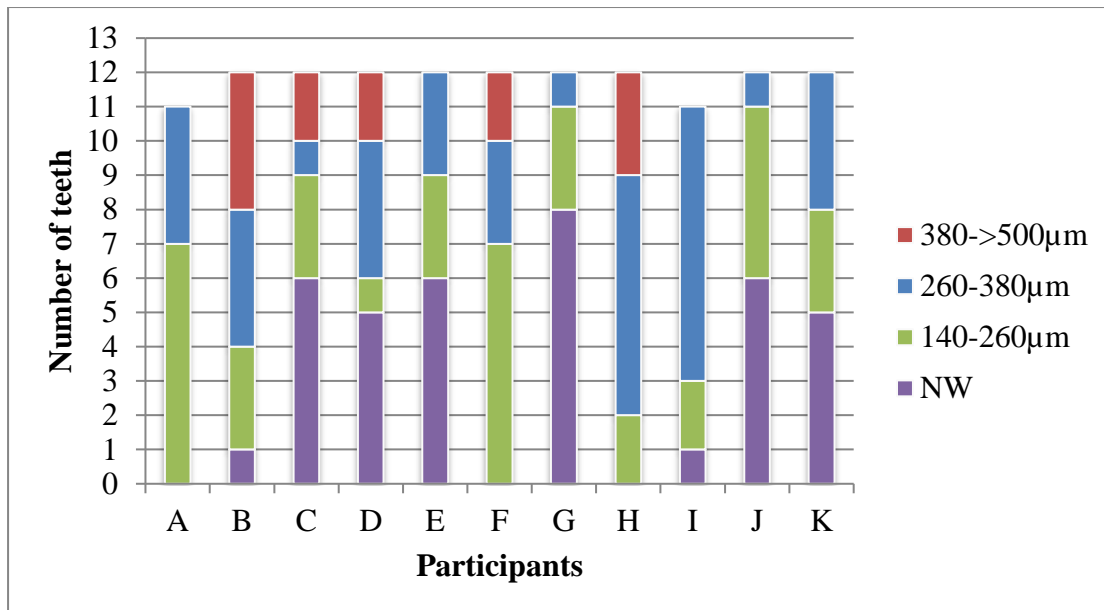| Patient	Gender	Age	DOA	PH	Int Erosion	Ext Erosion	Abrasion	Mental Health
A	M	69	>10yrs	Y	Y	Y	Y	Y
B	M	43	1-5yrs	Y	N	N	N	Y
C	F	56	1-5yrs	Y	N	N	Y	Y
D	M	26	1-5yrs	Y	Y	Y	Y	Y
E	F	31	1-5yrs	Y	N	Y	Y	N
F	M	50	1-5yrs	Y	N	N	Y	N
G	F	56	>10yrs	Y	Y	N	N	Y
H	F	48	<1yr	Y	N	Y	Y	N
I	M	55	1-5yrs	Y	N	Y	Y	Y
J	M	28	1-5yrs	Y	Y	N	N	Y
K	F	49	1-5yrs	Y	N	N	Y	N

Figure 2: The number of anterior teeth per participant demonstrating progressing depths of wear affecting ≥1% of scanned tooth surface over a period of one year (*n*=11 participants with a total number of 130 anterior teeth). Anterior tooth wear was monitored using indirect 3D contact scanning and comparison of images of dental casts taken of participants' dentition at baseline and after one year. NW= no detected wear.
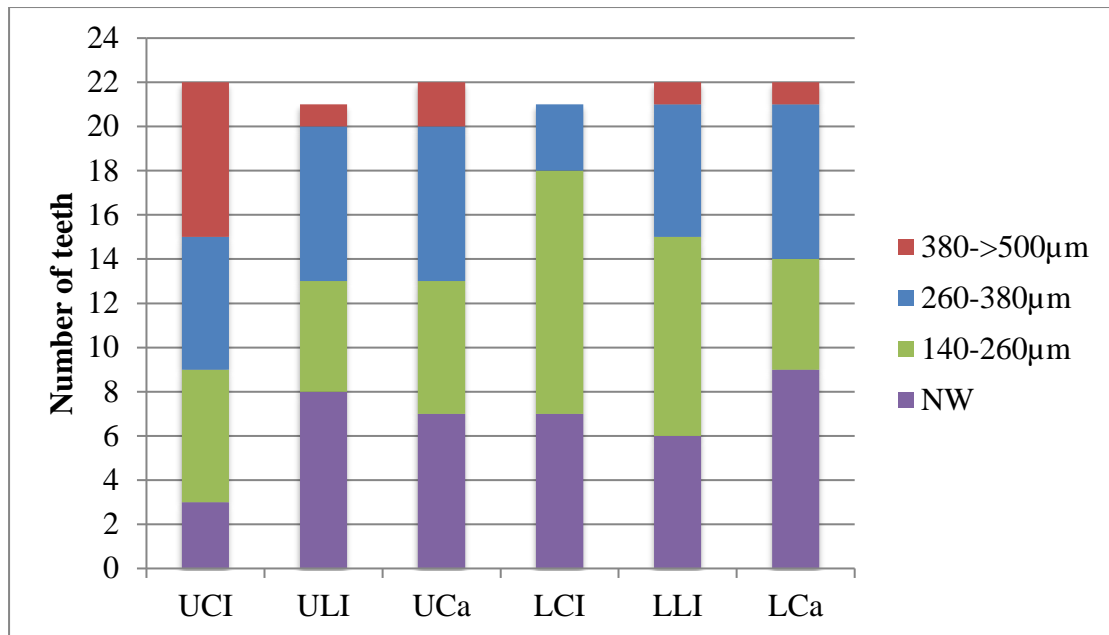
Figure 3: Distribution of depth of wear across different teeth groups (*n*=130 teeth). NW= no detected wear affecting ≥1% of scanned tooth surface. UCI= upper central incisors; ULI= upper lateral incisors; UCa= upper canines; LCI= lower central incisors; LLI= lower lateral incisors; LCa= lower canines.