Video Subtraction: Dynamic Temporal Change Versus Intrinsic Colour Instability

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Summary

Objectives: *To evaluate digital subtraction of still video images to show temporal change in a simulated oral hygiene effectiveness trial.*

Methods: *An acrylic stent was used for the accurate repositioning of a Stoma Vision (STV) video camera (Trophy Radiologie, Vincennes, France) to view the anterior teeth and gingivae of a DXTRR manikin (Dentsply/Rinn, Elgin, Illinois). Images were stored in binary form (16 bit: 5 red; 5 blue: 6 green) within the RVG/STV-PC software provided by the manufacturer of the camera. Red wax was applied to the manikin to simulate changes in the coverage of plaque disclosing solutions and gingival inflammation. Videos were also taken over time without manipulation of the model to evaluate intrinsic colour instability of the system. Image subtraction followed the formula:* $g(x_1,y)=f(x_1,y)-h(x_1,y)$, *computing the differences of corresponding pixel from f and h, given the new image y. Histogram analysis for each (red, blue and green) followed the discrete function* $P(r_k)=N_k/n$, *where* r_k *is the kth colour level,* N_k *is the number of pixels in the image with that color level and* $k=0,1,2,...L^{-1}$ *is range.*

Results: *Subtraction of video images provided solid evidence of dynamic temporal change where colour contrast was substantial (e.g. placing a wax red dot over the crown of a tooth). Intrinsic colour instability due to the temperature of light source among other factors was seen over time, especially when the STV was activated for more than one hour.*

Conclusions: *Video subtraction shows potential as a method to quantify changes in disclosed dental hygiene status or tooth coloration over time; however, changes due to colour temperature modification over time need to be factored.*

Key words: *dental hygiene, digital imaging, digital subtraction, image processing*

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Introduction

Subtraction is essentially a way to discover the differences between images by removing all features that do not change (1). If the linghting (or exposure and processing parameters for radiographic images) and the geometry of the view are consistent, the only differences in pixel values no changes occur are statistical variations in the brightness due to random noise. Photographic subtraction was first applied to medical diagnostic radiographs in 1934 (2). It was, however, used only to a limited extent for the next two decades up to the introduction of rapid serial angiography (3). Subsequently, this theory has been applied to dental diagnostic procedures including the detection of dental caries progression and the assessment of periodontal changes (4-6).

Gröndahl et. al. (1983) noted that the relative accessibility and stability of the teeth facilitate generation of geometrically identical radiographs over a period of time (7). They demonstrated the use of video capture and digitization of sequential radiographs followed by digital subtraction to reveal bone loss in periodontal disease, bone regeneration following priodontal surgery and induced defects in teeth and jaws. Subsequently, various investigators have used *in vitro* studies to demonstrate the value of subtraction radiography for the diagnosis of periodontal bone lesions in regions where bone level changes are normally difficult to detect radiographically, including buccal bone (8-11). Laurie et.al., also in 1983, used subtraction radiology to demonstrate crestal bone loss in an experimental model of marginal periodontitis in cynomolgus monkeys (10). The investigators suggested that subtraction might also be used for monitoring healing following endodontic therapy, osseointegration of dental implants, bone changes during orthodontic therapy and remineralization of carios lesions following fluoride applications. Nicopoulou-Karayianni et.al. (1991) found sensitivity for diagnosis of alveolar bone changes was doubled by the use of digital subtraction in comparison with use of non-subtracted conventional radiographs (12).

Hai-Xiong Sun et.al. (1991) showed that the accuracy of quantitative evaluation of bone changes for repair of periapical lesions was approximately within 10 per cent *in vitro* and was also accurate qualitatively *in vivo* (13,14). Katsarsky et.al.(1994) found cancellous alveolar bone defects to be much easier for observer to detect when digital subtraction was applied (15). Generalized changes in mineralization such as occurs in osteoporosis has been evaluated using *in vitro* studies and an acid demineralization model (16,17). Changes in the order of 5.3% were detectable in human anterior maxillary bone following digital subtraction.

Halse et al. (1990) used digital subtraction to visualize the effect of stannous fluoride treatment of carious lesions and found that even in cases with white spot lesions not visible on radiographs, subtraction images disclosed increased radiopacity following treatment (18). On the other hand, Halse et al. (1994) did not find digital subtraction improved the detection of well-defined lesions within the approximal enamel (19). Wenzel (1995) indicated that subtraction is useful for establishing a reproducible recording geometry that is needed for the valid comparison of images over time for clinical trials on dental caries progression (20). Farman et al. (1992) also showed the value of digital subtraction for the evaluation of the quality of telecommunicated images in comparison with the original digitized images (21).

The use of digital subtraction for the evaluation of dental implants has been reported by Engelke et al. (1990) (22). While they found subtraction radiography to hold potential clinical utility, they concluded that technical improvements were needed to yield qualitative data. Both Jeffcoat and Brägger et al. (1992) suggested that subtraction is of value for the longitudinal evaluation of bone changes surrounding dental implants (23,24). Ludlow et al.(1995) found that digitally subtracted tomographic images provided greater accuracy in the radiographic evaluation of implant-obscured bone than did subtracted periapical radiographs (25).

Studies of digital subtraction for temporomandibular joint imaging have been effected by Xu-Chen Ma et al. (1990), Tyndall et al. (1991), Ludlow et al. (1991), and Kapa et al. (1993) (26-29). These studies indicated that digital subtraction could be use provided a suitable cephalostat is used to permit relatively precise repositioning.

Subtraction CT has been shown to provide some indications for the differentiation of maxillary sinus cancer from chronic sinuitis. Both conditions evidence heterogeneous enhancement but, unlike cancer, sinuitis can also have areas of no enhancement or of linear enhancement (30). A useful overview of digital subtraction radiography was made by Reddy and Jeffcoat (1993) (31).

Clinical trials to evaluate the efficacy of dental hygiene products and tooth cleansing methodologies require quantification of disclosed dental plaque on the enamel surfaces. Indices of gingival inflammation require the assessment of redness, tissue oedema and bleeding. Studies concerning the progress of bleaching procedures to whiten the teeth also require judgment of colorimetric changes and the recording of such changes. Traditionally, much of the information needed has been recorded using 35 mm slide film exposed under standardized conditions. The present investigation evaluated the possible use of video image capture and the process of digital image subtraction to facilitate these evaluations. A preliminary report concerning this research was made only in abstract from at the Annual Session of the American Association of Dental Research, San Antonio (1995) (32).

Material and methods

An acrylic stent was used for the accurate repositioning of a Stoma Vision (STV) video camera (Trophy Radiologie, Vincennes, France) to view the anterior teeth and gingivae of a DXTRR manikin (Dentsply/Rim, Elgin, Illinois). Images were stored in binary form (16 bit: 5 red; 5 blue; 6 green) within the RVG/STV-PC software provided by the manufacturer of the camera. Red wax was applied to the manikin to simulate changes in the coverage of plaque disclosing solutions and gingival inflammation. Videos were taken over time without manipulation of the model to evaluate intrinsic colour instability of the system. Image subtraction followed the formula: $g(x_1,y)=f(x_1,y)-h(x_1,y)$, computing the differences of corresponding pixel from f and h, given the new image y. Histogram analysis for each colour (red, blue and green) followed the discrete function $P(r_k)=N_k/n$, where r_k is the kth colour level, N_k is the number of pixels in the image with that color level and $k=0,1,2,\ldots L^{-1}$ is the range.

Results

Subtraction of video images provided solid evidence of dynamic temporal change where colour contrast was substantial (e.g. placing a red wax area on the crown of a tooth). An example of a stimulated sequence for oral hygiene changes causing a reduction in disclosed plaque is shown in Figure 1.

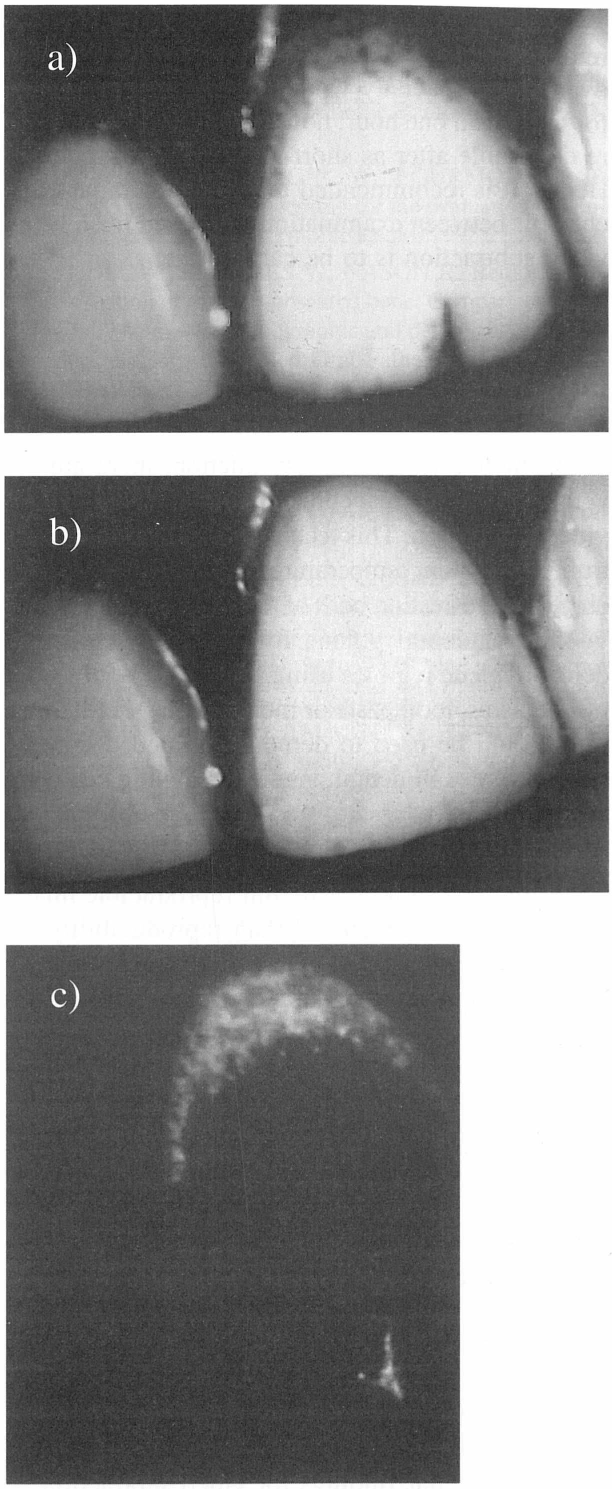

Figure 1. *a) Video image of simulated disclosed dental plaque at cervical margin of tooth*
b) Video image of same tooth following cleaning
c) Subtracted video image demonstrating change in plaque accumulation

Intrinsic colour instability due to the temperature of the light source among other factors was seen over time, especially when the STV was activated for more than one hour; however, slight changes were detectable after as short a period as 20 minutes. Hence, it is recommended that the camera be switched off between examinations and used fresh when video subtraction is to be carried out.

Discussion

As mentioned in the introduction, there are several applications that come immediately to mind for video subtraction. This technique, if adequately controlled for colour temperature, could improve the accurate quantification both of the area coverage of the volume of dental plaque following experimental dental hygiene regimes using new brushes, brushing mechanisms, toothpaste or mouth rinses. Furthermore, it could be used to demonstrate and document color changes in dental enamel following cosmetic bleaching procedures.

In the present study, an acrylic stent was custom made for the manikin to permit reproducible image geometry. It is recognized thah reproducibility requires either stent or the warping of images to match fiducial reference points. For digital intraoral radiography, film-holding instruments have been modified to provide reproducibility, generally by adding elastic impression material to the bite block of the film holding device (33,34). Ludlow and Peleaux (1994), however, found that impression materials could be eliminated by using a laser -and cephalostat-aligned periapical film-positioning technique (35). Davis et al. (1994) found that angular discrepancies of 1° or less had no appreciable effect on interpretation of subtracted radiographs; however, Jansen et al. found that an increase in angle discrepancy between radiographs resulted in a high percentage of false-positive decisions. (36,37). We anticipate similar findings for video subtraction.

Registration of images using projective geometry has been achieved using varying numbers of fiducial points, or projective point invariants (38). We are yet to attempt this for video subtraction, but in would seem to be equally applicable.

Conclusions

Video subtraction shows potential as a method to quantify changes in disclosed dental hygiene status or tooth coloration over time; however, changes due to colour temperature modification over time need to be factored.

References

1. RUSS JC. The image Processing Handbook, 2nd ed. Boca Raton: CRC press, 1995:272-273.
2. ZIEDSES DES PLANTES BG. Planigrafie en subtactie. Utrecht: Kemink en Zoom, 1934.
3. SJÖGREN SE, FREDZELL G. Apparatus for serial vertebral angiography. Acta Radiol 1953;40:361-368.
4. HARSTEDT C, WELANDER U. Photographic subtraction. I. Theory of the subtraction image. Acta Radiol (Diagn) 1975;16:559-564.
5. GRÖNDAHLL HG, GRÖNDAHLL K, OKANO T, WEBBER RL. Statistical contrast enhancement of subtraction images for radiographic caries diagnosis. Oral Surg 1982;53:219-223.
6. WEBBER RL. RUTTIMAN UE, GRÖNDAHLL HG. X-ray subtraction as a basis for assessment of periodontal changes. J Periodont Res 1982;17:509-511.
7. GRÖNDAHLL HG, GRÖNDAHLL K, WEBBER RL. A digital subtraction technique for dental radiography. Oral Surg 1993;55:96-102.
8. GRÖNDAHLL HG, GRÖNDAHLL K. Subtraction radiography for the diagnosis of periodontal bone lesions. Oral Surg 1983;55:208-213.
9. GRÖNDAHLL K, GRÖNDAHLL HG. Digital subtraction radiography for diagnosis of periodontal bone lesions with simulated high-speed systems. Oral Surg 1983;55:313-318.
10. LURIE AG, GREENBERG RJ, KORNMAN KS. Subtraction radiology demonstrates crestal bone loss in experimentally induced marginal periodontitis. Oral Surg 1983;55:537-541.
11. PUTNINS E, LAVELLE CLB, HOLTHUIS A. Detection of three-walled infrabony defects by subtraction radiography. Oral Surg Oral Med Oral Pathol 1988; 65:102-108.
12. NICOPOULOU-KARAYIANNI K, BRÄGGER U, BÜRGIN W, NIELSEN PM, LANG NP. Diagnosis of alveolar bone changes with digital subtraction images and conventional radiographs. Oral Surg Oral Med Oral Pathol 1991;72:251-256.
13. HAI-XIONG SUN, OKHI M, YAMADA M. Quantitative evaluation of bone repair of periapical lesions

using digital subtraction radiography. Part 1: Basic study. Oral Radiol (Japan) 1991;7:25-34.

14. HAI-XIONG SUN, OKHI M, YAMADA M. Quantitative evaluation of bone repair of periapical lesions using digital subtraction radiography. Part 2: Basic study. Oral Radiol (Japan) 1991;7:35-46.
15. KATSARSKY JW, LEVINE MS, ALEN KM, HAUSMANN E. Detection of experimentally induced lesions in subtraction images of cancellous alveolar bone. Oral Surg Oral Med Oral Pathol 1994;77:674-677.
16. SOUTHARD KA, SOUTHARD TE. Detection of simulated osteoporosis in dog alveolar bone with the use of digital subtraction. Oral Surg Oral Med Oral Pathol 1994;77:412-418.
17. SOUTHARD KA, SOUTHARD TE. Detection of simulated osteoporosis in human anterior maxillary alveolar bone with digital subtraction. Oral Surg Oral Med Oral Pathol 1994;78:655-661.
18. HALSE A, WHITE, ESPELID I, TVEIT AB. Visualization of stannous fluoride treatment of carious lesions by subtraction radiography. Oral Surg Oral Med Oral Pathol 1990;69:378-381.
19. HALSE A, ESPELID I, TVEIT AB, WHITE SA. Detection of mineral in approximal enamel by subtraction radiography. Oral Surg Oral Med Oral Pathol 1994;77:177-182.
20. WENZEL A. Current trends in radiographic caries imaging. Oral Surg Oral med Oral Pathol Oral Radiol Endod 1995;80:527-539.
21. FARMAN AG, FARAG AA, YEAP P. Teleradiology of direct digital dental images for consultation and treatment prior approval. In. S/CAR'92 Computer Application to Assist Radiology. Carlsbag: Symposia Foundation 1992:193-199.
22. ENGELKE W, De WALD S, RUTTIMANN U. The diagnostic value of subtraction radiography in the assessment of granular hydroxylapatite implants. Oral Surg Oral Med Oral Pathol 1990;69:636-641.
23. JEFFCOAT MK. Digital radiology for implant planning and evaluation. Dentomaxillofac Radiol 1992;21:203--217.
24. BRÄGGER U, BURGIN W, FOURMOUSSIS I, LANG NP. Image processing for the evaluation of dental implants. Dentomaxillofac Radiol 1992;21:208-212.
25. LUDLOW JB, GATES W, NASON R. Radiographic evaluation of implant-obscured bone. Comparison of digitally subtracted tomographic and periapical techniques. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1995;80:351-357.
26. XU-CHEN MA, ZHEN-KANG ZHANG, ZHAO-JU ZOU, GANG ZHANG, ZU-YANG ZHANG. Digital subtraction arthrography and arthrofluorographic dynamic observations on TMJ dysfunction syndrome. Oral Radiol (Japan) 1990;6:89-95.
27. TYNDALL DA, PHILLIPS C, MALONE-TRAHEY A, RENNER J. Validity of digital subtraction of plain films in quantification of positional changes of the mandibular condyle. Oral Surg Oral Med Oral Pathol 1991;71:748-755.
28. LUDLOW JB, SOLTMANN R, TYNDALL D, GRADY JJ. Digitally subtracted linear tomograms: three techniques for measuring condylar displacement. Oral Surg Oral Med Oral Pathol 1991;72:614-620.
29. KAPA SF, TYNDALL DA, ZULLO TG, BAGNELL CR. Assessing condylar changes with digital subtraction. Oral Surg Oral Med Oral Pathol 1993;75:247-252.
30. EGUCHI T, MAEDA K, SASAKI Y, TAKASE H. A trial of subtraction CT in the differentiation of maxillary cancer from chronic maxillary sinusitis. Oral Radiol (Japan) 1995;11:103-108.
31. REDDY MS, JEFFCOAT MK. Digital subtraction radiograph. Dent Clin N Amer 1993;37:553-565.

Video supstrakcija: dinamička privremena promjena prema unutrašnjoj nestabilnosti boje

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Sažetak

Svrha: *Vrjednovati metodu digitalnog oduzimanja mirujućih videoslika za prikaz promjena u pokusima djelotvornosti stimulirane oralne higijene.*

Metode: *Za točno premještanje videokamere tipa Stoma Vision (STV, -Trophy Radiologie, Vincennes, France) kod promatranja prednjih zuba i zubnoga mesa modela tipa DXTRR (Dentsply/Rinn, Elgin, Illinois) bio je upotrebljen akrilički fiksator. Slike su bile spremljene u binarnom obliku (16 bita: 5 za crveno, 5 za plavo, 6 za zeleno) unutar RVG/STV-PC softwarea što ga je isporučio proizvođač kamere. Za simuliranje promjena u prekrivanju sredstvima za razotkrivanje naslaga i uaple zubnoga mesa na model je nanesen crveni vosak. Izrađivane su video snimke tijekom stanovitoga vremena, ali bez manipuliranja modelom, da bi se procijenila prirođena nestabilnost boje sustava. Suptrakcija vrijednosti slika provodila se je po sljedećoj jednadžbi: $g(x_1,y)=f(x_1,y)-h(x_1,y)$, kojom se računaju rezlike odgovarajućih čestica slike (pixel) od f i h, što je dalo novu sliku y. Histogramske raščlambe za svaku od boja (crvena, plava i zelena) slijedile su diskretnu funkciju $P(r_k)=N_k/n$, gdje je r_k razina boje kth, N_k broj čestica u slici uz tu razinu boje i područje $k=0,1,2,\ldots L^{-1}$.*

Rezultati: *Suptrakcija videoslika pružila je solidan uvid u dinamičke privremene promjene kad je kontrast boje bi znatan (npr. na krunu zuba stavljena točkica crvenoga voska). Između ostalih čimbenika, opažena je unutarnja nestabilnost boje tijekom vremena, zbog promjene temperature izvora svjetla, osobito kada je STV bila sktivirana više od jednoga sata.*

Zaključci: *Video suptrakcija pokazuje potencijal kao metoda za kvantificiranje promjena razotkrivanja statusa dentalne higijene ili promjena boje zuba tijekom vremena; no zbog nestalnosti temperature boje tijekom vremena, treba faktorirati promjene.*

Ključne riječi: *dentalna higijena, digitalna suptrakcija, procesiranje slike.*

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Uvod

Suptrakcija je esencijalno način za otkrivanje razlika između slika, uklanjanjem svih raščlambi koje se nisu promijenile (1). Ako su rasvjeta (ili ekspozicija i parametri procesiranja za radiografičke slike) i geometrija pogleda konzistentni, jedine razlike u vrijednostima čestice slike (pixel) kod koje nisu nastale promjene jesu statističke varijacije u sjaju zbog slučajnoga šuma. Fotografska suptrakcija prvi je put primijenjena godine 1934. u radiogramima medicinske dijagnostike (2). U sljedeća dva desetljeća ona se je, međutim, samo ograničeno upotrebljavala, sve do uvođenja brze serijske angiografije (3). Ta teorija postupno se primijenjivala na procedure dentalna dijagnostike, uključujući otkrivanje progresa dentalnoga karijesa i procjene periodontalnih promjena (4-6).

Gröndahl i suradnici (1983.) opazili su da relativna pristupačnost i stabilnost zuba omogućuje generiranje geometrijski identičnih radiografija tijekom nekog razdoblja (7). Oni su demonstrirali upotrebu videosnimanja i digitiziranja sekvencijskih radiografija praćenih digitalnom suptrakcijom da otkriju gubitak kosti kod periodontalne bolesti, regeneraciju kosti nakon periodontalne operacije i induciranih defekata u zubima i čeljustima. Postupno, mnogi su istraživači primijenili studije *in vitro* da demonstriraju vrijednost suptrakcijske radiografije za dijagnoze periodontalnih ozljeda kosti u regijama u kojima je obično teško radiografski detektirati promjene razine kosti, uključujući bukalnu kost (8-11).

Lurie i suradnici, također godine 1983. upotrijebili su suptrakcijsku radiologiju da demonstriraju gubitak krestalne kosti u ekperimentalnome modelu marginalnoga periodontitisa majmuna vrste cynomolgus (10). Ti su istraživači sugerirali da se suptrakcija također može primijeniti za nadziranje liječenja nakon endodoničke terapije, oseointegracije dentalnih implantata, promjena u kostima tijekom ortodontičke terapije i remineraliziranja ozljeda zbog karijesa nakon fluoridnih aplikacija.

Nicopoulou - Karayianni i suradnici (1991.) našli su da se primjenom digitalne suptrakcije udvostručila osjetljivost za dijagnoze promjena alveolarne kosti, u usporedbi s primjenom konvencionalnih radiografije bez oduzimanja (12).

Hai - Xiong Sun i suradnici (1991.) pokazali su da je točnost kvantitativne procjene promjena na kosti za popravak periapikalnih ozljeda bila približno unutar 10 posto *in vitro* i da je također kvalitativno točno *in vivo* (13,14).

Katsarsky i suradnici (1994.) našli su da je, kad je bila primijenjena digitalna suptrakcija, promatračima bilo mnogo lakše detektirati defekte kancelozno alveolarne kosti (15). Uopćene promjene u mineralizaciji kakve nastaju kod osteoporoze bile su vrjednovane primjenom studija in vitro i modela s kiselom demineralizacijom (16,17). Primjenom digitalne supstrakcije mogle su se otkriti promjene reda 5,3% u ljudskoj prednjoj čeljusnoj kosti.

Halse i suradnici (1990.) uporabili su digitalnu suptrakciju za vizualiziranje učinaka tretmana kositrenim fluoridima na ozljede zbog karijesa i pronašli su da čak u slučajevima s ozljedama bijelih točkica, nevidljivih na radiografiijama, slike nastale suptrakciijom otkrivaju povišeni radiopacitet nakon tretmana (18). S druge strane, Halse i suradnici (1994.) nisu pronašli da digitalna suptrakcija poboljšava otkrivanje dobro izraženih ozljeda unutar aproksimalne cakline (19).

Wenzel (1995.) je naznačio da je suptrakcija upotrebljiva za ustanovljavanje ponovljive zapisne geometrije koja je potrebna za valjanu usporedbu slika tijekom vremena, za kliničke procjene napredovanja dentalnoga karijesa (20).

Farman i suradnici (1992.) također su pokazali vrijednost digitalne suptrakcije za vrjednovanje kakvoće slika primljenih sredstvima za telekomuniciranje, u usporedbi s izvornim digitaliziranim slikama (21).

Engelke i suradnici (1990.) izvijestili su o uporabi digitalne suptrakcije za vrjednovanje dentalnih implantata (22). Osim što su pronašli da suptrakcijska radiografija ima potencijal kliničkoga sredstva, zaključili su kako su potrebna daljnja tehnička poboljšanja da bi se dobivali vrsni podatci.

Jeffcoat i Brägger sa suradnicima (1992.) sugerirali su da suptrakcija ima vrijednost pri longitudinalnoj ocjeni promjena kosti koje okružuju dentalne implantate (23,24).

Ludlow i suradnici (1995.) pronašli su da tomografske slike podvrgnute digitalnoj suptrakciji daju veću točnost u radiografskom ocjenjivanju implantatom maskirane kosti od one postignute periapikalnom radiografijom i suptrakcijom (25).

Studije digitalne suptrakcije slikanja temporomandibularnoga spoja proveli su Xu-Chen Ma i suradnici (1990.), Tyndall i suradnici (1991), Ludlow i suradnici (1991.) te Kapa i suradnici (1993.) (26-29). Te su studije pokazale da digitalna suptrakcija može biti upotrebljiva uz uvjet da se upotrijebi prikladni cefalostat, koji omogućuje razmjerno precizno premještanje.

Suptrakciijski CT bio je prikazan da pruži nešto pokazatelja za diferenciranje raka čeljusnoga sinusa od kroničnoga sinuitisa. Oba stanja pokazuju heterogena obogaćenja, ali za razliku od raka, sinusitis može imati i područja bez obogaćenja ili linearno obogaćenje (30).

Vrlo upotrebljiv pregled digitalne suptrakcijske radiografije napravili su Redsy i Jeffcoat (1993.) (31).

Kliničke prosudbe za vrjednovanje djelotvornosti proizvoda za dentalnu higijenu i metodologije čišćenja zuba zahtijevaju kvantifikaciju otkrivenih dentalnih naslaga na caklinskim površinama. Indeksi upale zubnoga mesa zahtijevaju procjenu crvenila, edem tkiva i krvarenje. Studije koje se bave napredovanjem procedura za bijeljenje zuba također zahtijevaju prosudbu kolorimetrijskih promjena i bilježenje takvih promjena. Tradicionalno, većina potrebnih informacija bila je snimljena uporabom tražnih filmova 35 mm, eksponiranih pod standardnim uvjetima. Ovo istraživanje vrjednovalo je mogućnost upotrebe videosnimanja i proces digitalne suptrakcije slika za provedbu tih vrjednovanja. Preliminarno izvješće koje obuhvaća to istraživanje bilo je samo u obliku sažetka s godišnje sjednice Američke udruge dentalnih istraživača, San Antonio (1995.) (32).

Materijal i metode

Za točno premještanje videokamere tipa Stoma Vision (STV, - Trophy Radiologie, Vincennes, France) kod promatranja prednjih zuba i zubnoga mesa modela tipa DXTRR (Dentsply/Rinn, Elgin, Illinois) bio je upotrebljen akrilički fiksator. Slike su bile spremljene u binarnom obliku (16 bita: 5 za crveno, 5 za plavo, 6 za zeleno) unutar RVG/STV-PC softwarea isporučenog od proizvođača kamere. Za simuliranje promjena u prekrivanju sredstvima za razotkrivanje naslaga i upale zubnoga mesa na model je nanesen crveni vosak. Izrađivane su videosnimke tijekom stanovitoga vremena, ali bez manipuliranja modelom, da bi se procijenila prirođena nestabilnost boje sustava. Suptrakcija vrijednosti slika provodila se je po sljedećoj jednadžbi: $g(x_1,y)=f(x_1,y)-h(x_1,y)$, kojom se računaju razlike odgovarajućih čestica slike (pixel) od f i h, što je dalo novu sliku y. Histogramske raščlambe za svaku od boja (crvena, plava i zelena) slijedile su diskretnu funkciju $P(r_k)=N_k/n$, gdje je r_k razina boje kth, N_k broj čestica u slici uz tu razinu boje i područje $k=0,1,2,\ldots L^{-1}$.

Rezultati

Suptrakcija videosnimka pružila je solidan uvid u dinamičke privremene promjene kad je kontrast boje bio znatan npr. na krunu zuba stavljena točkica crvenoga voska). Primjer simulirane sekvence za promjene zbog oralna higijene koja je uzrokovala redukciju otkrivene zubne naslage prikazan je na Slici 1.

Između ostalih čimbenika, opažena je unutarnja nestabilnost boje tijekom vremena zbog promjene temperature izvora svjetla, osobito kada je STV bila aktivirana više od jednoga sata; međutim, nakon kratkog razdoblja od 20 minuta bilo je moguće otkriti samo male promjene. Zbog toga se preporučuje da se kamera isključuje između ispitivanja i upotrijebi kada treba izvršiti videosuptrakciju.

Rasprava

Kao što je spomenuto u uvodu, video suptrakcija ima više primjena koje lako padaju na pamet. Ako se temperatura boje prikaldno nadzire, ta tehnika može poboljšati točnost kvantificiranja u oba slučaja: otkrivanja površine i volumena dentalne naslage nakon eksperimentalnih režima dentalne higijene upotrebom novih četkica, mehanizama za četkanje, zubnih pasta ili sredstava za ispiranje usta. Osim toga, suptrakcija se može upotrijebiti kako bi se demonstrirale i dokumentirale promjene boje zubne cakline nakon postupaka kozmetičkog izbjeljivanja.

Da se postigne ponovljiva geometrija slike, u ovoj smo studiji izradili akrilički fiksator za model. Došli smo do zaključka do ponovljivosti zahtijeva fiksatore ili vitoperenje slika, kako bi se poravnale pouzdane referentne točke. Za digitalnu intraoralnu radiografiju bili su modificirani instrumenti za držanje filma, tako da osiguravaju ponovljivost, općenito dodavanjem elastičnog utisnog materijala na blok za držanje naprave s filmom (33,34). No, Ludlow i Peleaux (1994.) su pronašli da se utisni materijal može eliminirati uporabom laserski i cefalostatski prilagođenom periapikalnom tehnikom postavljanja filma (35). Davis i suradnici (1994.) otkrili su da kutna odstupanja od 1° ili manje nisu imala zamjetljiv učinak na interpretaciju suptracijskih radiografija; međutim, Jansen i suradnici pronašli su da povećanjo kutno odstupanje između radiografija ima za posljedicu velik postotak pogrešno - pozitivnih odluka (36,37). Mi smo anticipirali slična otkrića za videosuptrakciju.

Registracija slika bila je postignuta upotebom projektivne geometije i primjenom promjenljivih brojeva pouzdanih točaka, ili nepromjenljivih točaka (38). Bili smo spremni to pokušati za videosuptrakciju, ali se činilo jednako primjenljivim

Slika 1. a) Video snimka simuliranog vidljivog zubnog plaka na vratu zuba

b) Video snimka istoga zuba nakon čišćenja

c) Suptrakcijska video snimka pokazuje promjenu u nakupljanju plaka

Zaključci

Videosuptrakcija pokazuje potencijal kao metoda za kvantifikaciranje promjena u razotkrivanju statusa dentalne higijene ili promjena boje zuba tijekom vremena; no zbog nestalnosti temperature boje tijekom vremena, promjene treba faktorirati.