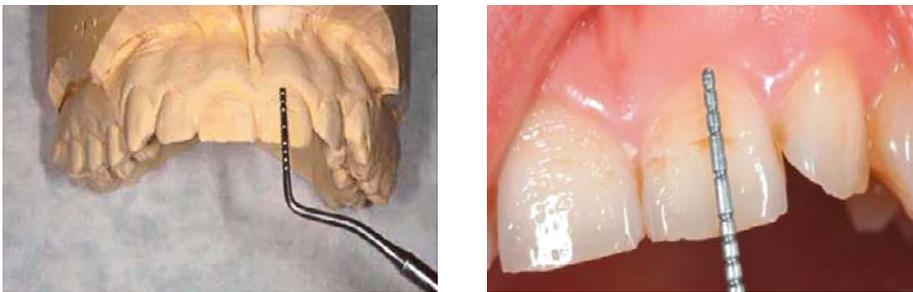


Intraoral scanners: Powerful tools for digital diagnostics?

There is emerging evidence that digital dental impressions may have profound potential to enhance the objective clinical monitoring and severity assessment of common restorative and orthodontic dental conditions. Historically, many of the dental practitioner's everyday clinical decisions were primarily based on subjective evaluation and interpretation of the clinical situation using analogue techniques.



Example of conventional clinical monitoring of tooth wear between 1999 (left) and 2004 (right) using analogue techniques.

Therefore, treatment decisions are often highly dependent on individual skills and experience rather than objective data. This makes it difficult for patients to really understand why a dentist is recommending a specific treatment or may make patients less likely to follow preventive advice.

Effective clinical management of tooth wear, periodontal disease and orthodontic conditions is facilitated by early detection and differential diagnosis. Moreover, it is essential to be able to reliably assess the outcome of preventive measures, restorative treatments or orthodontic procedures in order to make the right clinical decisions regarding the following steps in the patient journey.

A prime example is the decision of how to proceed with a patient whose teeth are affected by tooth wear. Slight changes might remain undetected by an inexperienced examiner and the current indices are not designed to determine the activity or quiescence of the erosive lesions. This can inadvertently cause delays in making clinical decisions due to uncertainty as to whether the condition is getting better, worse or staying the same. The early management of soft tissue changes such as gingival recession caused by periodontal disease is another example where early diagnosis of inflammatory tissues changes may prevent irreversible periodontal breakdown and even tooth loss.

Last but not least, post-endodontic restorative procedures are planned on the basis of a highly subjective evaluation of the remaining tooth structure after root canal treatment, whereas this could be objectively assessed with 3D diagnostic imaging.

Surface scanning

The use of intraoral scanners like the 3M™ True Definition Scanner opens opportunities to add value to the diagnostic process. The devices are capable of scanning the intraoral soft and hard tissue anatomy to visualize topographic relationships. Captured surfaces are displayed three-dimensionally and can be enlarged to view and analyse details. Focus groups have revealed that showing and discussing these scans with patients during a diagnostic consultation has great impact on patients, both in terms of understanding of their oral health and motivating them to adopt positive behaviour changes.

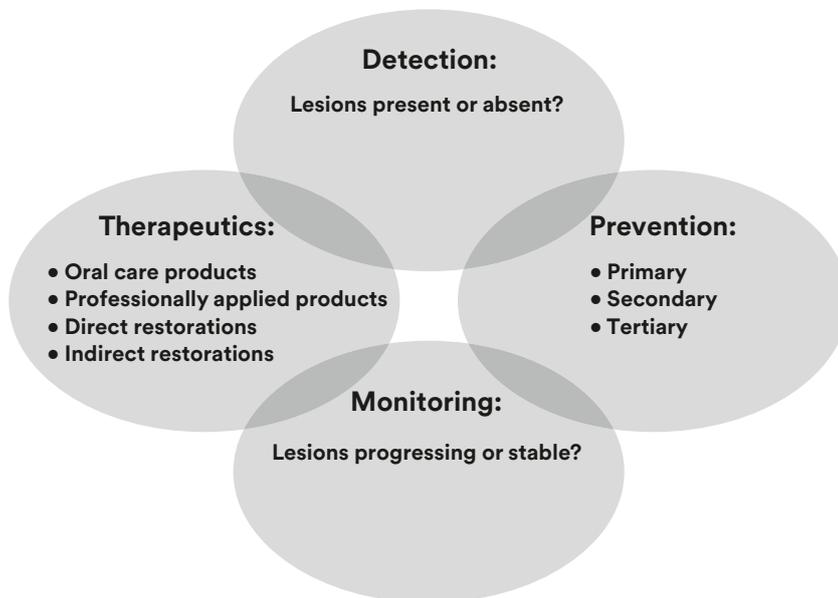
In addition, topographically related soft and hard tissue changes can be detected and quantified by chronological comparisons of the three-dimensional data. For this purpose, software like Geomagic® Control™ (3D Systems) may be used: Data sets taken at different time points can be compared by superimposition and changes are detected by differential analysis. This enables the user to quantify past changes in an objective and reproducible way which may aid the assessment of a patient's risk of ongoing tooth wear.

Furthermore, it may even be possible to predict future developments based on the information obtained from the comparisons.

Tooth wear

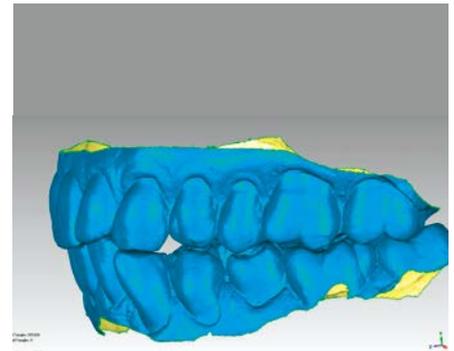
Taking a closer look at the clinical decisions to be made in the context of tooth wear, the benefits of using an intraoral scanner as adjunct to clinical screening may become evident. Tooth wear is a complex societal problem caused by different processes such as attrition, abrasion and erosion. In order to select a suitable treatment, the patient-specific risk factor has to be determined.

For patients with no risk, for example, primary preventive measures involving routine maintenance at three-year intervals are sufficient. When a low risk of tooth wear is detected, reviews every two years and additional dietary assessment as well as oral hygiene advice is recommended. For patients with a moderate risk, secondary prevention involving additional fluoride application is necessary and the recall intervals should be shorter (six to twelve months). The high-risk group may require direct or indirect restorative treatments, including both minimally invasive and conventional restorations.



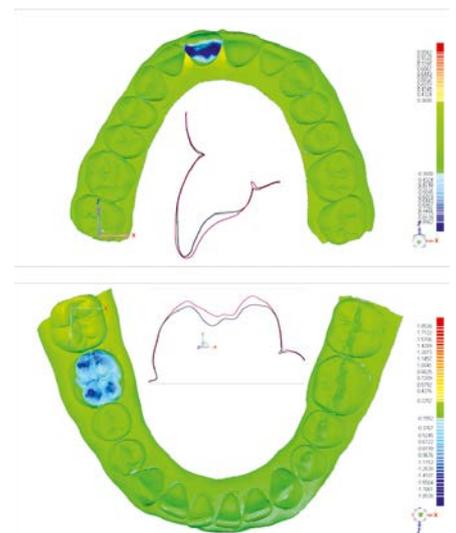
Management of tooth wear: The clinical decisions in the context of detection, prevention, monitoring and therapy of tooth wear are all based on subjective criteria.

There are many potential advantages in using digital dental impressions for both the diagnosis, treatment planning and treatment of conditions such as those stated above, in addition to using post-treatment scans to evaluate the long term success of the treatment and preventative advice. On the virtual models, it is possible for example to analyse the planar geometry of wear facets to differentiate between different causes of tooth wear (e.g. attrition versus erosion).



Scan in eccentric occlusal contact.

In addition, a comparison of data sets taken at different time points enables the practitioner to see where changes have occurred, how much tooth structure has been lost and if the wear processes are progressing at an accelerated speed. It is also possible to check if e.g. preventive measures such as dietary advice have been effective – i.e. slowed down the processes of wear.



Simulation showing measurement of wear processes on a maxillary central incisor and lower first molar using superimposed data sets captured with the 3M™ True Definition Scanner.

Scientific data

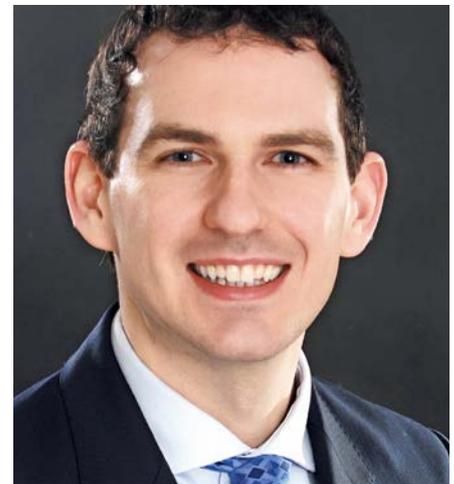
Currently, there is emerging scientific evidence available regarding the use of intraoral scanners for diagnostics of hard and soft tissue pathologies. A literature review showed that digital scanners in general are widely adopted for the measurement of hard and soft tissue changes^[1]. Often, an indirect workflow involving conventional impression taking, cast production and digitization with a laboratory scanner is employed. The main drawback of this procedure lies in the number of error-prone work steps of impression taking and casting. Many of these steps may be eliminated by the use of a direct digitization technique. Studies have revealed that the local accuracy of intraoral scanners is comparable to that of laboratory scanners^[2], while digital impressions are superior to conventional impressions in trueness and precision^[3]. There is, therefore, every indication that the method is suitable for use in diagnostics.

This fact is underlined by the results of two studies that focus on the measurement of soft tissue changes using intraoral scanners^[4,5]. Both investigations compare the digital procedure with traditional indexing methods. A specific advantage of intraoral scanning related to soft tissue lies in the optical nature of the acquisition procedure: The risk of displacing the tissues during impression taking is eliminated. A study conducted at the University of Zurich^[5] showed clear advantages of the digital technique over the conventional method. The reproducibility was enhanced and inter- and intra-individual measurement inconsistencies were reduced. The results were confirmed in an in-vitro study^[6].

Conclusion

Clinical experience and scientific evidence suggests that intraoral scanners are evolving to become valuable tools for the recording of intraoral soft and hard tissues and the monitoring of changes. With highly accurate digital data and objective measurement software at hand, the dental practitioner will be assisted in discussing with patients regarding their risk assessments and treatment decisions. In order to leverage the full potential of the technology, it may be useful to record the intraoral situation of all patients during routine visits and using these scans as a basis for discussions about a patient's oral health. In this way, they can more clearly understand the impact of behavioural choices on their oral health. These digitally-enhanced discussions are likely to help patients feel empowered to take the necessary steps to make positive changes in their oral care routine, in order to improve and maintain their long-term oral health.

- [1] Austin, RS, Skodra, E Diagnostic applications of digital dental impressions: A systematic review of the literature. (King's College London Dental Institute MSc Thesis, 2015).
- [2] Güth J-F, Keul C, Stimmelmayer M, Beuer F, Edelhoff D. Accuracy of digital models obtained by direct and indirect data capturing. *Clin Oral Investig*. 2013;17(4):1201-8.
- [3] Ender A, Mehl A. Full arch scans: conventional versus digital impressions--an in-vitro study. *Int J Comput Dent*. 2011;14(1):11-21.
- [4] Newby EE, Bordas A, Kleber C, Milleman J, Milleman K, Keogh R, et al. Quantification of gingival contour and volume from digital impressions as a novel method for assessing gingival health. *Int Dental J*. 2011;61 Suppl 3:4-12.
- [5] Schneider D, Ender A, Truninger T, Leutert C, Sahrman P, Roos M, et al. Comparison between clinical and digital soft tissue measurements. *J Esthet Restor Dent*. 2014;26(3):191-9.
- [6] Lehmann KM, Kasaj A, Ross A, Kammerer PW, Wagner W, Scheller H. A new method for volumetric evaluation of gingival recessions: a feasibility study. *J Periodontol*. 2012 Jan;83(1):50-4



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