Full-mouth rehabilitation of a severe tooth wear case: a digital, esthetic and functional approach

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Abstract

The proliferation of digital technology is progressively changing dentistry. Thanks to continual improvements in CAD/CAM devices and dental materials, it is possible nowadays to carry out a treatment plan for oral rehabilitations with fully digital approaches and noninvasive concepts. The availability of digital resources allows clinicians to increase the predictability of enhanced esthetics and good functional results. There is an increasing number of patients today who are affected by excessive tooth wear and may benefit from these kinds of treatments. This article provides a step-by-step documentation of a full-mouth rehabilitation performed with a digital approach and additive CAD/CAM composite resin restorations. An innovative functional evaluation is also documented and discussed. The initial situation was assessed and compared with the rehabilitation project through a snap-on device. After the intraoral adjustment and validation, the final rehabilitation was performed according to the information obtained in the provisional phase and digitally transmitted to the laboratory.

**Introduction**

Tooth wear is a multifactorial phenomenon due to the interaction of mechanical, chemical, and tribological factors that provoke irreversible loss of dental hard tissue. Tooth wear is commonly considered a physiological process that occurs throughout life, but in some cases it can accelerate and become the cause of various patient complaints such as tooth sensitivity or poor esthetics.

The etiology of the loss of hard dental tissue may be multifactorial, combining different processes such as erosion (due to acids), abrasion (a mechanical process involving foreign substances or objects), attrition (defines wear through direct tooth-to-tooth contact, and generally relates to parafonctions such as bruxism), and abfraction (loss of hard tissue in the cervical tooth area due to tensile or compressive stress). Due to its etiology, excessive tooth wear is considered challenging by practitioners: it is difficult to determine and eliminate its causes successfully and permanently, especially in the case of parafonctions.

Recently, a European consensus was published on the management of severe tooth wear cases. Although conventional prosthodontic treatments such as full crowns with or without root canal treatment (RCT) followed by post and cores still remain the standard treatment, minimally invasive or noninvasive approaches, complemented by preventive measures, are recommended in this consensus. The treatment should be simple, stepwise, adjustable, repairable, and cost effective. Contemporary adhesive techniques in conjunction with composite materials meet the requirements stated above and allow for maximum preservation of the remaining tooth structure.

Different minimally invasive and adhesive clinical techniques have been well documented and described over the past decade. Such protocols guide the clinician to obtain a predictable result and a high success rate in terms of esthetic and functional benefits for the patient. Moreover, the rapid development of digital technologies in recent years has increasingly opened up new treatment modalities. This allows for better predictability and more trust in the analysis of the esthetic and functional aspects of the case.

Case reports on full-mouth rehabilitations that follow a fully digital workflow have been published. They present different types of in-lab, chairside or mixed workflows, proposing models of rehabilitation with many clinical advantages. Although knowledge of digital dentistry is still limited, it is continually increasing in conjunction with the evolution of digital technologies. The same is true for CAD/CAM materials in the form of blocks or blanks that, from a mechanical point of view, are generally more resistant than their manually manufactured counterparts.

This article presents a clinical case where a full-mouth rehabilitation was planned and executed with an adhesive and no-prep approach using a fully digital workflow.

**Clinical report**

A 46-year-old male patient (Fig 1a to c) consulted with a group of microinvasive esthetic dentists at the dental clinic of the University of Geneva as he suffered from a severely worn dentition. His main desire was to improve his esthetic appearance as his teeth were no longer visible when smiling. The patient also complained of biting difficulty due to his worn anterior teeth (Fig 1d to f). He reported good general health but mentioned a past history of acidic alimentation. A detailed discussion with the patient about his dietary habits revealed that the dental hard tissue loss was mainly due to a combination of abrasion, erosion, and attri-
Fig 1  (a to f) Extraoral preoperative photographs.
The intraoral examination revealed a generalized excessive loss of dental hard tissue, particularly in the maxillary anterior teeth (Fig 2). The diagnosis of decay was also confirmed by radiographic analysis (Fig 3). The excessive tooth wear led to the exposure of dentinal tissue. The patient had previously had RCT on tooth 24 as well as caries activity: nine decayed primary teeth and old infiltrated fillings on teeth 17, 16, 15, 14, 24, 25, 26, 36, 37, and 45 as well as one old infiltrated amalgam restoration on tooth 27. The patient was classified as having a high-risk level of decay (DMFT > 12). He did not show any signs of temporomandibular disorders and did not complain of orofacial pain. Palpation and auscultation of the temporomandibular joints (TMJs) did not reveal any signs of clicking.
First, the patient received a professional tooth cleaning and oral hygiene instructions. All cavities were treated and the infiltrated fillings replaced. The exposed dentin was covered following the principle of immediate dentin sealing (IDS). For these adhesive procedures, the dentin was slightly ground with a multiblade tungsten carbide bur to expose the fresh dentin. Then, an etch-and-rinse adhesive system (OptiBond FL; Kerr) was applied, following the manufacturer’s instructions. A microhybrid composite resin (Tetric EvoCeram; Ivoclar Vivadent) was used to cover the entire dentin area and fill the mayor undercuts without provoking any change to the occlusion (Fig 4). The irregular margins of enamel were then smoothened.

**Planning phase**

The patient was classified as ACE class IV, since there was extended dentin exposure on the palatal aspect and a loss of tooth length (> 2 mm), although there was a preservation of facial enamel. The European consensus guidelines for severe tooth wear state that monitoring is the primary management strategy in this situation, unless the patient requests treatment. Preventive measures were given to the patient prior to the treatment, and arrangements were made for monitoring. However, due to the stabilization of the patient’s wear condition and his request for an aesthetic and functional rehabilitation, it was decided to implement restorative measures.

**Fig 3** Diagnosis of decay confirmed by the radiographic analysis.
Following a fully additive approach, the teeth were not prepared at all.

The digital collection of data started with jaw movement tracking that was performed with a kinesiographic computerized system (BIO-key; Bioket) (see Figs 15 and 16). Optical impressions were taken with a Trios 4 (3Shape) intraoral digital scanner, and the exported open STL files were transferred to the dental technician.

A digital wax-up was planned with laboratory CAD/CAM dental design software (Trios Design Studio; 3Shape). The main planning guideline was to treat the case as conservatively as was reasonably achievable (Fig 5). Therefore, a no-prep approach was chosen, and an increase in the vertical
dimension of occlusion (VDO) was performed. The VDO augmentation was carried out by increasing the incisal tip by 4 mm on the digital articulator. This allowed for the design of the anterior restorations to obtain a correct natural width-length ratio. Once the digital wax-up was accepted, it was decided to test it in the mouth with an additional mock-up and in the form of a snap-on, which is a double-milled removable orthodontic appliance made of an elastic resin material (Multistratum Flexible A3; Zirkonzahn) (Fig 6).

The prosthetic project was evaluated and the usual phonetic, functional, and esthetic analyses were carried out, as with a traditional diagnostic mock-up (Fig 7). The facial aspects, smile lines, gingival level, and dental contours were checked. The interpupillary line was used as a reference to establish the horizontal plane. Next, the midfacial line was drawn, based on facial references such as the glabella, nose, and chin. The patient’s face was assessed and the length of the upper lip in a forced smile was checked to determine the gingival characteristics. After this primary facial analysis, the occlusal plane, interocclusal distance, and static and dynamic occlusion were checked and adjusted.

A second jaw-tracking examination with the snap-on in place was performed (see Figs 15 and 16) and the results were compared with the initial situation. A few occlu-
CAM composite resin blocks (Lava Ultimate, 3M) were used to fabricate all the restorations. After milling, their adaptation was tested and verified on 3D-printed casts (Fig 8a to c). The anterior restorations (teeth 13, 12, 11, 21, 22, 23, 33, 32, 31, 41, 42, and 43) were modified to improve their esthetic outcome, following the technical protocol described by Magne.19 The technique consists of a cutback of the buccal surface of the anterior restoration (Fig 8c) and subsequent customization by manual stratification of composite resin materials of varying shades and translucencies (Inspiro SW and blue effect; Edelweiss DR) (Fig 8e). A personalized characterization of the buccal surface of tooth 36 was also proposed to the patient (Fig 8f).
Fig 8  (a and b) Laboratory phase: milled restoration from the occlusal view. (c) Milled restoration from the anterior view. (d) View of the buccal cutback of the anterior restorations. (e) Final result after the procedure of stratification of the esthetic composite resin on the anterior teeth, from teeth 13 to 23 and teeth 33 to 43. (f) Characterization of tooth 36.
Restorative phase

In the restorative phase, each quadrant was treated separately. It was decided to rehabilitate the posterior teeth first to obtain a stable occlusion.

First, the overlays were tried in the patient’s mouth to check the proximal contact surfaces and marginal fit. Next, adhesive conditioning of the restorations began by sandblasting the inner surface of each overlay with 27 μm alumina powder, followed by the application of silane (Monobond Plus; Ivoclar Vivadent) for 60 s, which was dried with compressed air. Finally, bonding resin adhesive (OptiBond FL) was applied for 20 s and thinned out without being polymerized. The restorations were kept away from ambient light to avoid the premature curing of the bonding resin.

After isolation of the operatory field with rubber dam, adhesive procedures were performed on each tooth separately. The first step of the procedure consisted of protecting the adjacent teeth with metallic strips. The surface of the tooth was first cleaned by sandblasting with 27 μm Al₂O₃ (Fig 9a). In the next step, the enamel was etched with 37% orthophosphoric acid gel for 30 s (Fig 9b). Thereafter, bonding resin was applied to the conditioned surface with a microbrush for 15 s and spread with air for 5 s without light curing (Fig 9c). A sufficient amount of preheated restorative light-curing hybrid composite resin (Tetric EvoCeram) was spread on the entire surface of the preparation. The composite overlay was set manually and then pressed into the definitive position with an ultrasonic plastic tip (Fig 9d). Excess luting composite was removed with a periodontal probe and floss (Oral-B SuperFloss; Procter & Gamble) in the interdental area. Full polymerization was achieved by light curing with a powerful LED unit for at least 60 s per cured surface (occlusal, buccal, and palatal). Once the lut-
ing was completed, the restoration margins were finished and polished. Next, the rubber dam was removed from the quadrant being treated, and the same luting procedure was followed to restore the remaining three quadrants (Fig 9 e). Once all the posterior restorations were luted at the end of the appointment, the static and dynamic occlusion were checked. After some minor adjustments, the patient went away with stable posterior contacts and an open anterior bite.

The digitally milled snap-on used as a mock-up was modified to be used as a provisional by slicing it distally to the canines.

The same luting procedure was applied on the anterior restorations the following day. After rubber dam isolation, luting started with teeth 11 and 21 in order to obtain a correctly positioned midline. Luting was then applied to the neighboring teeth in a symmetrical manner until all the maxillary restorations were adhesively bonded (Fig 10). Major undercuts were previously filled during the IDS procedure (see above). The remaining minor undercuts were managed and filled during the adhesive phases using composite resin as a cement. The same procedure and strategy were performed on the mandibular anterior teeth.

The restorations were finished and polished and the occlusion checked. After some minor adjustments, the rehabilitation phase was completed. Three months after the end of the treatment, final intraoral (Fig 11) and extraoral (Fig 12) photographic documentation and radiographic control (Fig 13) were performed. Finally, an optical impression was taken, according to the previously mentioned European consensus management guidelines for severe tooth wear, and the patient was given a protective night guard. Due to the high caries risk that had been assessed, the patient was instructed and motivated in correct dental hygiene procedures (brushing and flossing).
Fig 11  (a to e)
Posttreatment intraoral photographs.
Fig 12  (a to f) Posttreatment extraoral photographs.
He also entered a 6-month recall program with a dental hygienist for regular cleaning and interproximal and palatal/lingual fluoride (Duraphat; Colgate) varnish application. A last jaw-tracking examination was performed (Figs 15 and 16), which was then compared with other registrations. The result obtained was stable from a functional and an esthetic point of view.

Since the patient did not stop smoking, some staining appeared in time, but this was easily removed during standard professional cleaning. Figure 14 shows the 15-month postoperative control.

Fig 13  Posttreatment radiographs.
Fig 14  (a to e)
15-month postoperative control.
Discussion

This clinical case of a full-mouth rehabilitation was performed by applying minimally invasive concepts and using no-prep adhesive restorations that allowed for the preservation of the natural dental hard tissue.

The choice of the most appropriate restorative material in rehabilitations of severe tooth wear cases is still an open discussion in the literature. A recent systematic review concluded that there is no strong evidence to suggest that any one material is superior in cases of severe tooth wear. In these cases, the choice is made according to the clinical context and the financial affordability of the rehabilitation for the patient. The available clinical studies and case reports indicate that modern composite resins perform well in patients affected by severe tooth wear When compared with other CAD/CAM resin blocks, Lava Ultimate showed the highest mechanical properties in terms of tooth wear and flexural strength. Moreover, Wendler et al recently reported unexpected data about this material: even though its mechanical properties evaluated in a static test were lower than the ceramic equivalents, its stress tolerance to dynamic loading was surprisingly high and at the
same level as that of a disilicate-reinforced ceramic. This mechanical aspect is particularly interesting for treating a parafunctional patient with severe tooth wear in view of the high level of cyclic stress that occurs due to repeated episodes of parafunction. Another advantage of this material resides in its reparability: parafunctional cases may require interventional maintenance care, eg, the repair of chipping in the esthetic area. Such interventions are easily realizable with a composite resin material.26

The main problem with CAD/CAM blocks, whether composite or ceramic, is the unnatural esthetic appearance that results from their intrinsic monochromaticity. Even though the level of translucency is high in the material chosen for the present restoration, that alone might not have been enough to achieve a natural tooth appearance in the anterior region.27 This problem was overcome by manually stratifying composite resins of different shades and translucencies on the labial area of the anterior restorations, thus improving the esthetics without affecting the mechanical resistance of the incisal area of the restorations.

To date there is no clear evidence supporting a possible pathological consequence of VDO augmentation, even if some...
authors have expressed concerns about this procedure. A recent review by Abduo showed that an increase in VDO of up to 4 mm is predictable and safe. In cases of severe tooth wear, VDO augmentation creates space, allowing the clinician to adopt a noninvasive approach to save as much natural dental hard tissue as possible.

To avoid any doubts in the present case, the new jaw position was tested for 1 month with a snap-on, which turned out to be a useful device to test this type of additive rehabilitation. A snap-on is prepared for both jaws, maxilla and mandible, and is held in place by the natural undercuts of the tooth anatomy. This simple retention is possible thanks to the elastic properties of the selected material. Given its higher flexibility, it is less susceptible to fracture and more resistant to flexural stress. Also, it can be milled following a very thin design. The main benefit of a snap-on is its ability to meet esthetic and functional expectations, both in terms of practicability for the clinician and comfort for the patient. Snap-ons, which are modifiable with simple adjustments and adhesive procedures, allow for corrections to be made to shade, shape, and tooth position. In the present case, the snap-on allowed for the testing of the new VDO for a period of time, which achieved a high level of predictability for the permanent rehabilitation.

Despite severe tooth wear, the patient presented in good health from a functional point of view:

1. He did not complain of any masticatory problem; despite not being able to bite with his anterior teeth due to the lack of contacts, his jaw movements were free with large extensions.
2. He neither showed nor complained of any kind of symptom, orofacial pain, headache or neck muscle pain.
3. No clicking was noticed during auscultation of the TMJ, nor was any anatomical anomaly noticed.
4. No pain was evoked during maneuvers of palpation of any masticatory or neck muscles.

The functional analysis of the rehabilitation was supported by kinesiography before the treatment, during the planning phase, and at the end of the restorative phase (Figs 15 and 16). Kinesiography is a 3D tracking and reconstruction analysis of jaw movement that is both qualitative and quantifiable and which expresses the muscular coordination during mastication. Modification of the VDO automatically results in a variation of dental guidance, which consequently changes the patterns of protrusive and lateral movements. However, on the basis of the pretreatment functional considerations, and following the principles of minimally invasive dentistry, the kinesiography was intended to maintain the mandibular motoric scheme as closely as possible to the initial situation.

Maximum open/close movements did not undergo radical modifications, but a late right deviation present in the initial situation disappeared after the end of the treatment. A minor reduction of the maximum extent of the movement of 0.5 cm was considered to be related to the space occupied by the thickness of the restorations. Thanks to the restored length of the anterior teeth, the protrusive movement found a new anterior guidance that had been lost for many years. The marked deviation on the left side that was present before the treatment completely disappeared at the end of the treatment, most probably thanks to the augmented proprioceptive sensibility that resulted from the new anterior guidance. In laterotrusion, the dental guidance angle (visible on the frontal plane of the kinesiography) looked almost flat from the frontal plane before the treatment and presented a symmetrical pattern between the right and left sides. As the snap-on reproduces the
occlusal contours of the digital wax-up, it reflects not only the newly defined bite but also the newly designed dynamic occlusion, allowing for an interactive functional examination. Slight modifications were performed on the lateral guidance of the snap-on to obtain a flatter angle that was closer to the initial situation. The canine guidance became a group guidance function (the situation before the treatment), and the esthetic outcome of the canines was slightly sacrificed by reducing their length. Interestingly, an immediate modification of the pattern of movement in the horizontal plane (ie, not only in the frontal plane) was noticed: lateral movements were more anteriorized, with flatter lateral guidance compared with deeper angled guidance. There is scarce information in the literature on the clinical interpretation of kinesiographic analyses. However, observations in the present case concur with the results of a study by Papini et al,13 where an increased inclination on the frontal plane of the lateral guidance corresponded to an augmented restorative component during the first third of the lateral’s excursions. The clinical feedback from the patient was that he found the flatter lateral guidance configuration more comfortable.

Conclusions

The available literature on the restorative management of severe tooth wear lacks a robust body of high-level evidence. This case report shows that a complex clinical situation of severely worn dentition can be managed with a fully digital workflow, which simplifies the clinical procedure and allows for good, predictable functional and esthetic results. Further clinical studies and monitoring should be conducted to determine both the long-term prognosis of this kind of treatment and the clinical relevance of the kinesiographic analysis. Deeper investigation in this regard should provide information that would allow this type of analysis to be better interpreted and understood.

References