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TECHNIQUE

Surface electromyography and mandibular motion recording input in prosthetic rehabilitation of segmental mandibulectomy: The MAC2 protocol

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ABSTRACT

Lateral segmental mandibulectomy can be associated with sequelae, such as mouth opening limitation and mandibular deviation, that lead to altered oral functions (chewing, swallowing, speech) and complex prosthetic management. The authors present a new protocol for surface electromyography (sEMG) and mandibular motion recording to help clinicians with decision making and dental prosthetic treatment planning for segmental mandibulectomy. The clinical case of a patient with a reconstructed titanium endoprosthesis is presented. The MAC2 protocol is used and consists of chronologically performing various recordings by using a device for sEMG and mandibular tracking. During the orofacial reeducation and dental prosthetic reconstruction, three therapeutic steps can benefit from the MAC2 protocol: to analyze the initial muscular imbalance, to provide guidance in the choice of maxillomandibular relationship and to quantify the functional improvement. sEMG of masticatory muscles is a useful diagnostic tool in a context of mandibular kinematic disorders and the MAC2 protocol adds some guidance for dental prosthetic rehabilitation in the context of segmental mandibulectomy. (*Int J Maxillofac Prosthetics 2021;4:47-54*)

KEYWORDS

Segmental mandibulectomy, maxillofacial prosthetics, surface electromyography, jaw movement tracking, masticatory muscles.

INTRODUCTION

Lateral segmental mandibulectomy represents the treatment for various acquired pathologies such as tumor, trauma, infection or necrosis.[1] Surgical reconstruction is performed when possible and is associated with preventive and curative treatments (physiotherapy and orthotics) to limit the extent of sequelae. However, classical functional consequences are mouth opening limitation, mandibular deviation, kinematic disorders and alteration of masticatory cycles.[2] The effectiveness of dental prosthetic treatments is poorly characterized, usually assessed by qualitative parameters, such as quality of life, or specific quantitative variables, such as eating/ mixing ability or tongue movements.[3] In this context, studying muscle activity and mandibular movements may provide some complementary and critical information to determine the optimal dental occlusion and to characterize the prosthetic rehabilitation effectiveness.[4,5]

Surface electromyography (sEMG) is an accessible technique that quantifies muscle activity, masticatory force, and muscle tone.[6] There are different electromyographic devices adapted to the oro-facial sphere: K7 (Myotronics®, Seattle USA) and Biopack (Bioresearch®, Milwaukee USA). The K7 system is an integrated computerized system designed specifically to visualize mandibular movements in the three dimensions of space and time, to measure mandibular velocity during opening and closing, and obtain electromyographic data from four muscle groups (using surface electrodes).[7,8]

Here we provide a protocol for neuromuscular examination and analysis of mandibular kinematics

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in patients with maxillofacial defects (Muscular ACtivity and MAndibular Cinematics; MAC2).[9] This protocol includes six diagnostic steps, with three muscle recordings and three mandibular kinematics recordings. It can be completed, in case of prosthetic reconstruction, a complementary registration allowing to record the therapeutic mandibular position: the search for a myocentric occlusion is particularly interesting in the absence of dental and joint landmark (lack of centered relationship) as it is often encountered in the presence of condylectomy and mandibulectomy.

TECHNIQUE

A 70-year-old woman presented to the maxillofacial prosthetics consultation of the Toulouse's Teaching Hospital (France) as part of the rehabilitation of a segmental mandibulectomy in sector 3 with no teeth from 32 to 37. She received radiotherapy sessions at the rate of 20 sessions (60Gy) which resulted in a limitation of oral opening. A scarring strap was visible on the face and the chin was deflected to the loss of substance side. The patient had unilateral mandibular posterior edentment and the maxillary arch had worn anterior teeth and posterior prosthetic restorations (Figs.1,2). About mandibular cinematics, mandibular laterodeviation completes oral opening limitation. The radiological examination showed many restorations, a correct periodontal state and a reconstruction by a titanium endoprothesis (Fig.3).

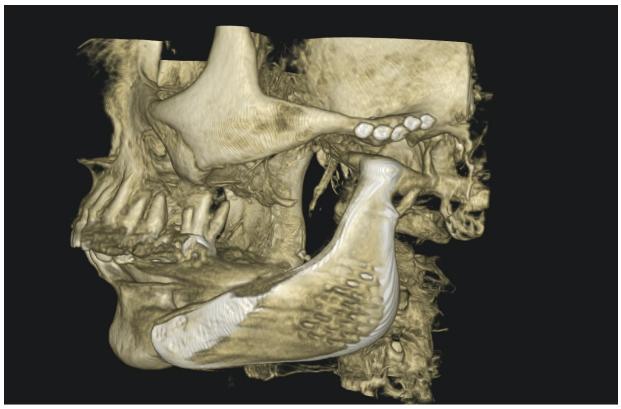


Fig 3. CBCT: lateral segmental mandibulectomy and endoprosthetic reconstruction requiring prosthetic dental rehabilitation.

After mandibular reconstruction with a titanium endoprosthesis, the patient had followed active mechanotherapy sessions with a maxillofacial and self-passive physiotherapist.[10] Worn for several months, an occlusal ramp placed at the palate allowed the patient to be re-educated to close by refocusing the mandible with a resin strip (Fig.4). At the beginning of the treatment, no prosthesis was placed due to an unstable mandibular position deflected in the transverse direction. Three months after the start of mechanotherapy and the placement of the occlusal guidance device, an electromyography and a recording of the mandibular cinetics were performed and compared with the initial records (K7 Evaluation System, Myotronics, Kent, WA, USA).[4] A 6-step exam protocol was then performed (MAC Protocol, Fig.5).[9]



Fig 1. Intraoral examination (frontal and lateral views).



Fig 2. Intraoral examination (occlusal views).

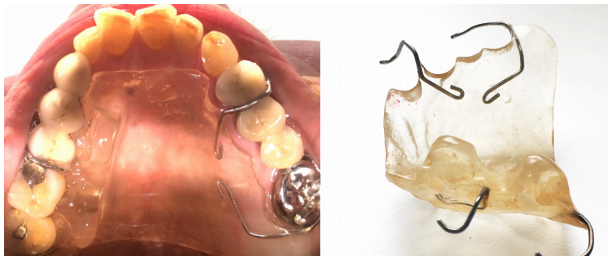


Fig 4. Occlusal ramp.

1. Muscle tone assessment (Muscular ACtivity 1a; MAC1a)

To record the mandibular activity of each muscle at rest, the patient needed to be relaxed, with the mandible in physiological resting position. Rest electrical activity is recorded for each of the following muscles: temporal, masseter, anterior digastric muscles and sternocleidomastoid (Fig.6). The initial recording revealed a postural muscle-tonic hyperactivity of the temporal muscles: an oro-facial rehabilitation with physiotherapy was then indicated. After rehabilitation, the postural activity of the temporal muscles returned to normal.

2. Contraction synchronicity assessment (Muscular ACtivity 1b; MAC1b)

To record the reaction time of masseter and temporal muscle activity, the patient was asked to gradually tighten the teeth from mandibular resting position to maximal tightening contraction (resulting in isotonic contractions, followed by isometric contractions) (Fig.7). The recording before rehabilitation shows an asynchronous contraction at the beginning of the isometric contraction corresponding to the first dental contact which stop the ascending mandibular movement: occlusal stabilization, using the restoration of the posterior sectors and the search for a myocentric occlusion position, allowed to restore the muscle contraction synchronism.

3. Contraction efficiency assessment (Muscular ACtivity 1c; MAC1c)

To record masseter and temporal muscle contraction, the patient was asked to clench teeth and release several times on demand (Fig.8). The contraction of the masseter and temporal muscles before treatment is not sufficient for an effective masticatory capacity; it is increased thanks to prosthetic restoration. The activity of the masseter muscle remains reduced due to its partial resection (hemi-mandibulectomy).

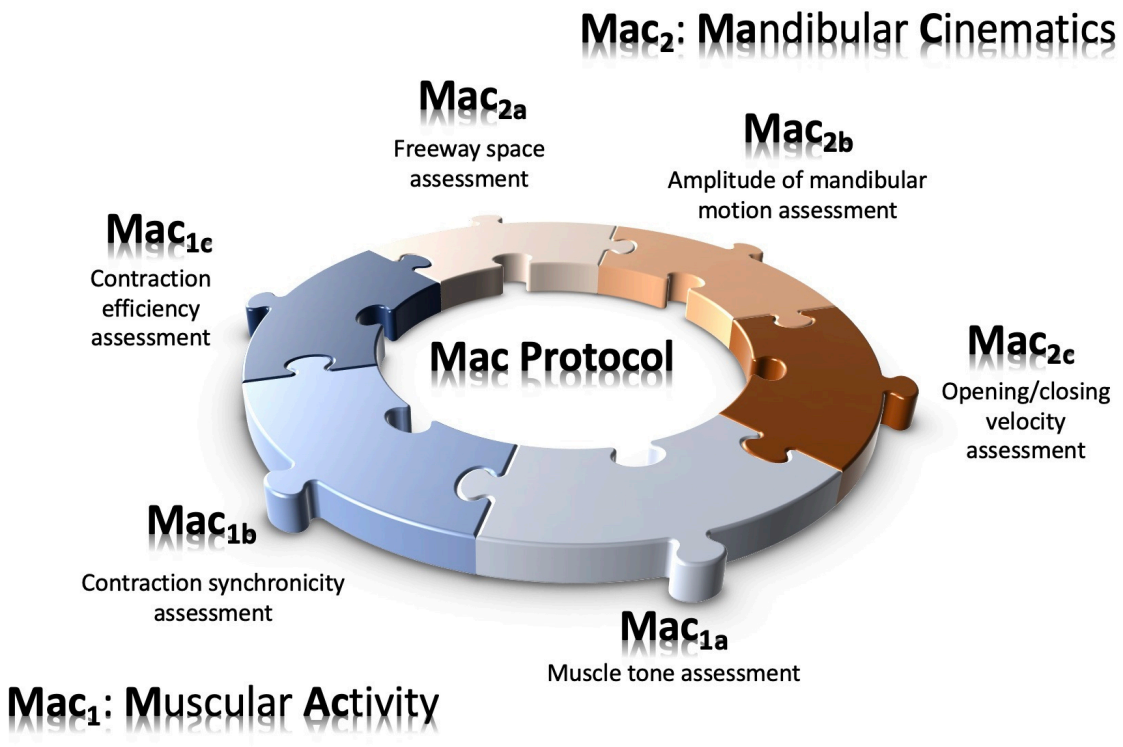


Fig 5. MAC protocol chronology.

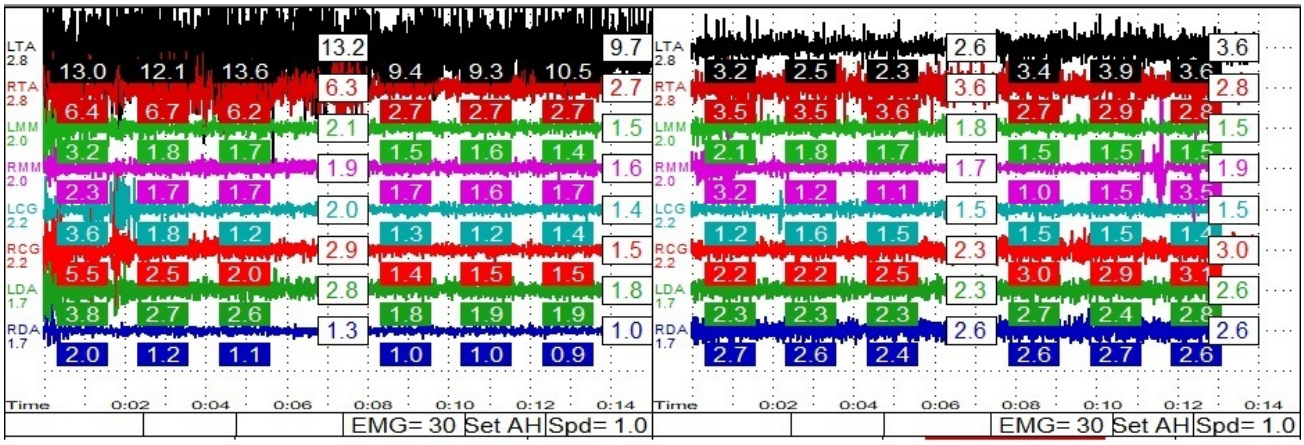


Fig 6. Muscle tone recordings (Muscular ACtivity 1a; MAC1a) of a patient with lateral segmental mandibulectomy and endoprosthetic reconstruction before and after prosthetic treatment (in µV). Hyperactive temporal muscles were normalized after orofacial reeducation. Left and right anterior temporal (LTA, RTA), masseter (LMM, RMM), sternocleidomastoid (LCG, RCG), and anterior digastric (LDA, RDA) muscles.

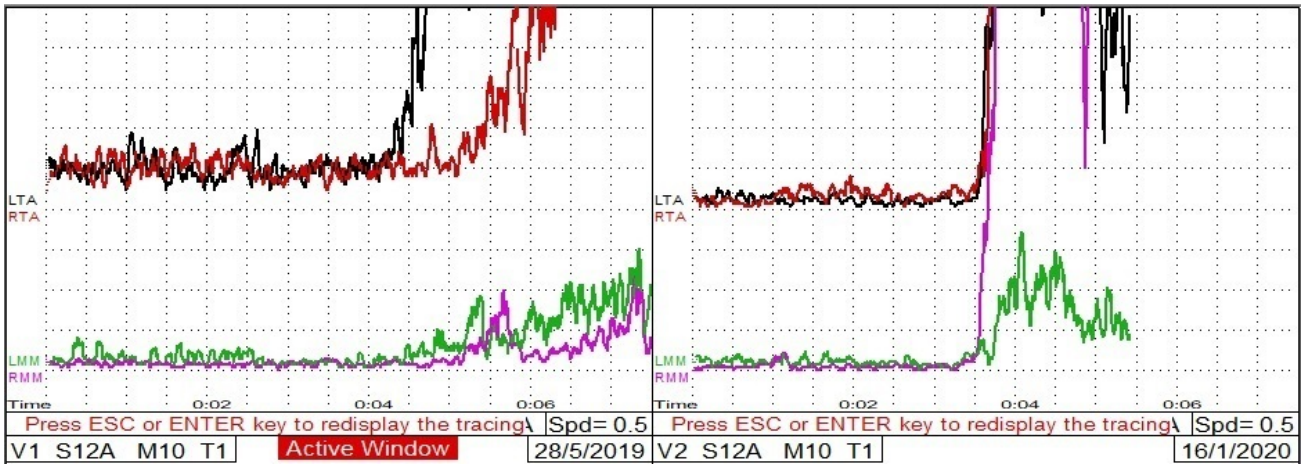


Fig 7. Contraction synchronicity recordings (Muscular ACtivity 1b; MAC1b) of a patient with lateral segmental mandibulectomy and endoprosthetic reconstruction before and after orofacial reeducation (in µV). Pathological muscle activities were synchronized after prosthetic reconstructions. Left and right anterior temporal (LTA, RTA), masseter (LMM, RMM) muscles.

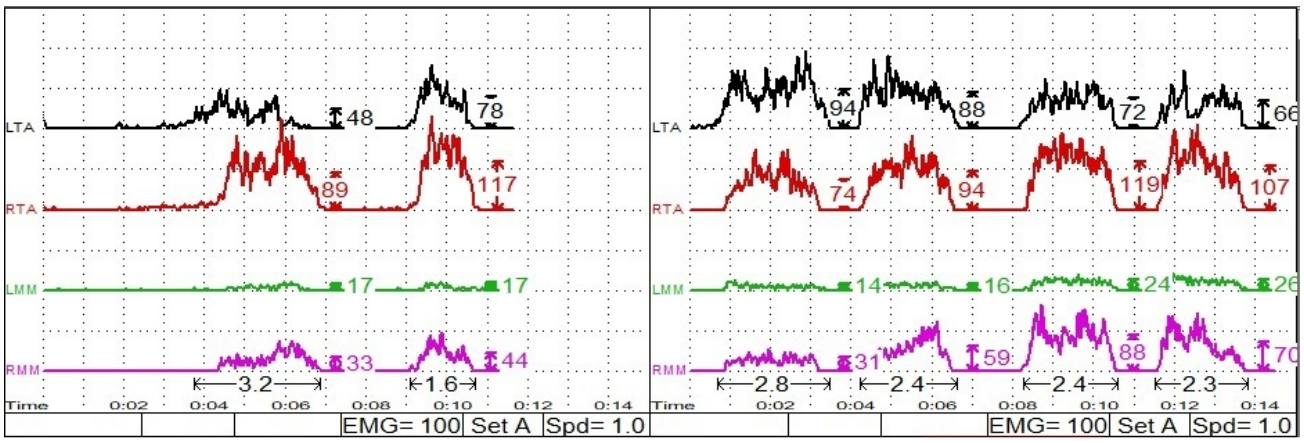


Fig 8. Contraction efficiency recordings (Muscular ACtivity 1c; MAC1c). Muscle efficiency was improved after prosthetic reconstructions. Left and right anterior temporal (LTA, RTA), masseter (LMM, RMM) muscles.

4. Freeway space assessment (MAndibular Cinematics 2a; MAC2a)

This 3D examination evaluated the trajectory between rest position and to intercuspal position (Fig.9). This record is supplemented by a swallowing analysis.[11] Note that the registration of the unobstructed space is directly related to the determination of the vertical dimension of therapeutic occlusion with an accuracy of 0.2 mm.

5. Amplitude of mandibular motion assessment (MAndibular Cinematics 2b; MAC2b)

The patient was asked to perform extreme mandibular movements and so, to open wide and close as fast as he could, which are visualized on 3D graphic representation (Fig.10). These plots allow a better understanding of the kinematics of the patient particularly useful in this patient with a hemi-mandibulectomy (causing a latero-deviation) and who has benefited from oral-facial radiotherapy (causing oral opening limitation).

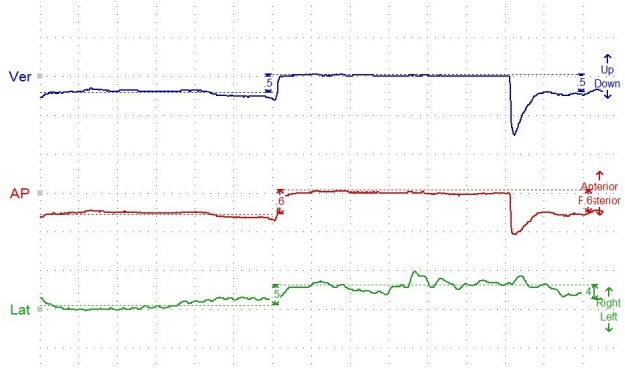


Fig 9. Freeway space assessment (MAndibular Cinematics 2a; MAC2a).

6. Opening/closing velocity assessment (MAndibular Cinematics 2c, MAC2c)

The patient was asked to perform quick opening/closing movements by opening the mouth in the maximum position and closing until teeth contact (Fig.11). A reduction in closing speed may suggest occlusal instability that will need to be corrected during prosthetic treatment.[12]

In summary, the recording of resting muscle activity showed a decreased activity of the temporal muscles and masseters, but especially of the left temporal after orofacial reeducation. The scan of the recording of mandibular opening and closing movements showed an increase in the opening from 38 mm to 45 mm. A refocusing on the starting and finishing points during the opening/closing movement were visible. There had also been an improvement in the speed and accuracy of this movement after oral-facial rehabilitation and prosthetic reconstruction.

Occlusal restoration was then undertaken with the realization of a mandibular removable prosthesis (Fig.12) and a fixed maxillary restoration at the level of the anterior block (Fig.13), taking into account an aesthetic demand expressed by the patient (Fig.14). After the orofacial rehabilitation and prosthetic reconstruction, the patient presented a stable and comfortable therapeutic mandibular position, with an improvement in muscle activity and mandibular kinematics, validated by EMGs and mandibular tracking.

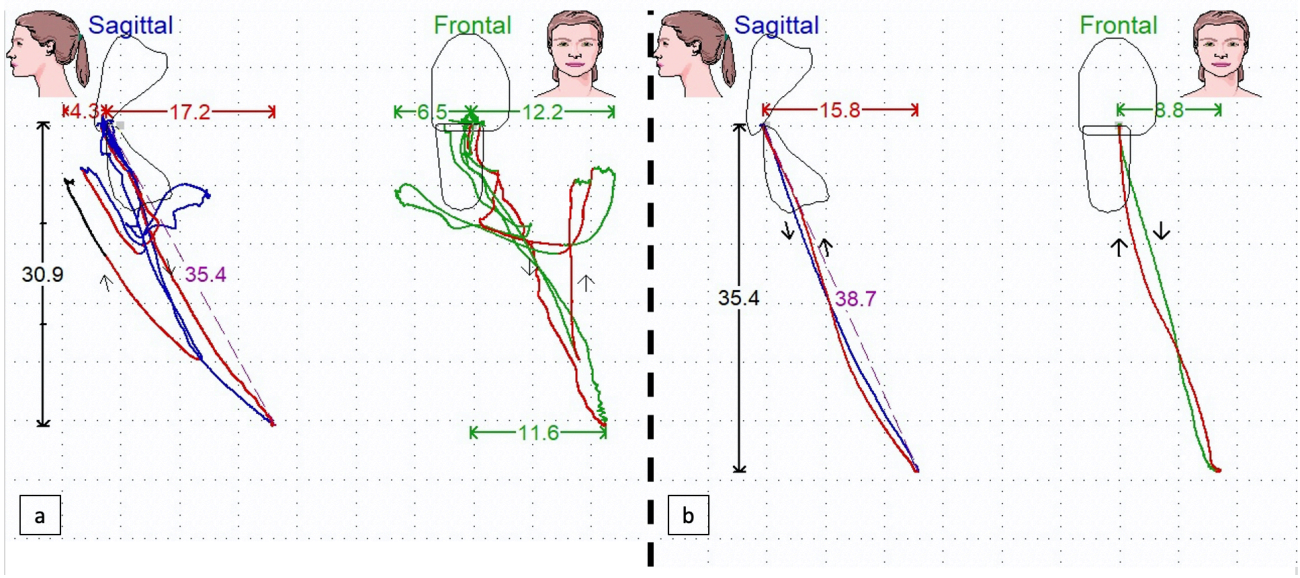


Fig 10. Amplitude of mandibular motion assessment and Farrar's diagram before (a) and after prosthetic restauration (b) (MAndibular Cinematics 2b; MAC2b): the amplitude of the mouth opening is increased and the laterodeviation has decreased.

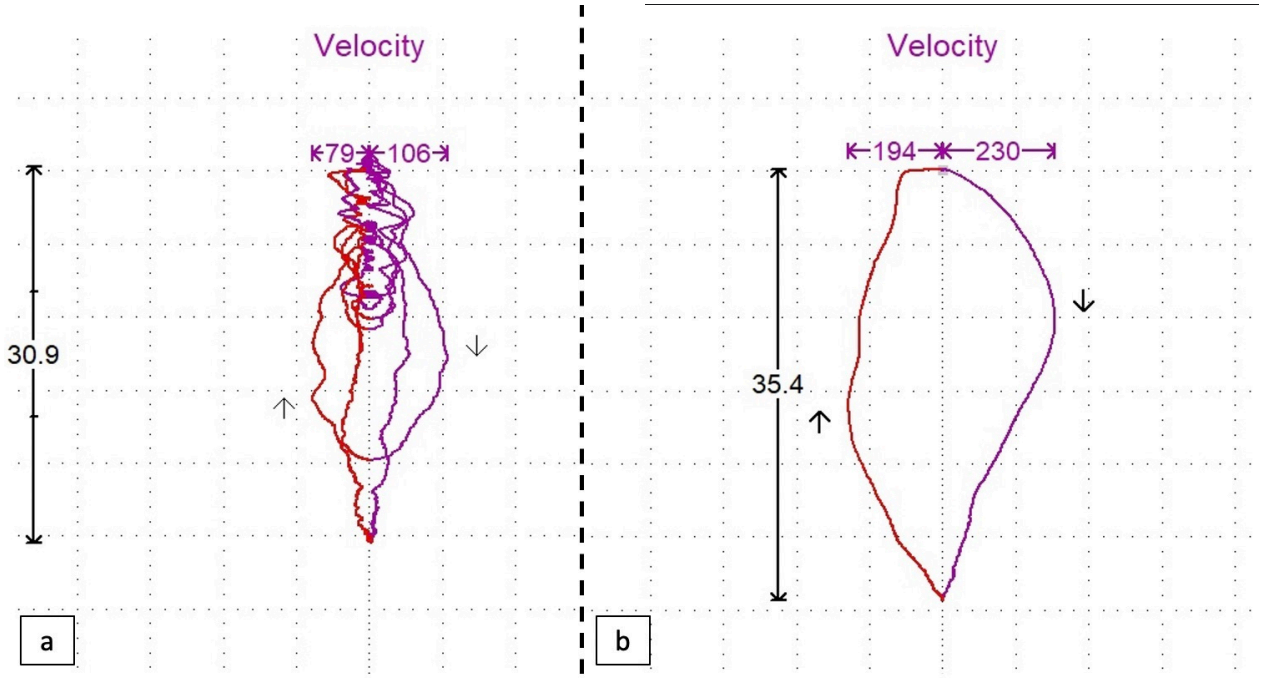


Fig 11. Opening/closing velocity (MAndibular Cinematics 2c, MAC2c) recordings of a patient with lateral segmental mandibulectomy and endoprosthetic reconstruction before (a) and after prosthetic restauration (b) (in mm and mm/s): velocity improvement.



Fig 12. Rehabilitation of mandible removable dental prosthesis (lateral view).



Fig 13. Final rehabilitation with maxillary fixed prosthetics.



Fig 14. Final prosthetic rehabilitation and satisfaction patient (esthetic and function).

DISCUSSION

There are many advantages to using the EMGs. This is a non-invasive, safe and easy-to-use method using a rigorous protocol like the MAC protocol. This technique makes it possible to record muscle activity at rest but also continuously during the whole movement which is a complement to muscle palpation, muscle testing or visual observation. The practitioner compares the data collected during the clinical examination with the data recorded with the EMGs. EMG activity provide clinicians and researchers with data on the mechanism of muscle contraction, whether pathological or not. For this, it is important to use instruments that allow the simultaneous recording of EMG activity of the same muscle on the right and left sides. It is also essential to simultaneously record several pairs of muscles. The comparison of the data obtained on studied muscles, informs the practitioner on the asymmetries both quantitatively and on the chronology of the contraction. A comparison of the data collected for the same patient, before and after treatment, shows whether or not the effectiveness of treatment.

During the maxillofacial rehabilitation, this particular protocol will benefit the practicing clinician because three therapeutic steps can benefit from the MAC2 protocol:

1. Before orofacial reeducation: to analyze the initial muscular imbalance. A neuromuscular occlusal assessment completed the preprosthetic occlusal examination (clinical examination of occlusion and examination of monting models on the articulator). It also allowed to verify the existence of dysocclusion and to assess the importance of muscle deficiency (lack of force and/or asynchronism of contractions at the closure).

2. After orofacial reeducation and before dental prosthetic reconstruction: to quantify the functional improvement due to orofacial reeducation (guidance device and/or physiotherapy sessions), and to provide guidance in the choice of maxillomandibular relationship, assistance during its recording, and validation during prosthetic try-in. Indeed, because the centric relation is not of interest in these clinical circumstances, a myocentric relationship is sought. Myocentric requires a TENS stimulated mandibular movement originating from rest position.[13]

3. After dental prosthetic rehabilitation: to quantify the final functional improvement. Moreover, by providing quantitative data, the MAC protocol (EMG and tracking) allows to modify prosthetic parameters until improving muscle activity and mandibular kinematics. The clinical key point is the improvement of the follow-up of the patient (before, during and after the rehabilitation). For example, during the initial electromyography, tonic postural over activity may indicate a postural problem and/or a deficiency of the occlusal sensor. During closure and mandibular anchorage, asynchrony and/or deficiency of the masseter and temporal muscles are signs of dysocclusion, which can be corrected by occlusal reconstruction (prosthesis). The recording of the free space of inocclusion allows to evaluate the vertical dimension of occlusion and to modify it if necessary. The study of the velocity makes it possible to reveal the existence of prematureness and/or joint disorders.

Finally, these recordings can also be a means of communication between different practitioners (physiotherapists, maxillofacial practitioners) and the patient, especially during the rehabilitation phase. EMG records would complement the questionnaires and provide a more objective view of the functional improvement of the chewing device and of the patient's quality of life. Nevertheless, the MAC2 protocol has some limitations: only the study of superficial muscles is possible. Lateral pterygoid muscle is also not accessible. Another difficulty is that the signal is sometimes disturbed by artifacts. The placement of the electrodes along the muscle fibers also requires knowledge of the anatomy of the muscle concerned. For maximum efficiency and to limit bias, it is therefore essential to use a standardized method.

CONCLUSION

The MAC2 protocol adds some guidance for prosthetic rehabilitation in the context of segmental mandibulectomy. This is a rigorous protocol, which makes it possible to highlight certain dysfunctional criteria that are to be corrected by oro-facial reducation and/or occlusal reconstruction. This is an essential exam that complements clinical occlusal analysis and analysis of joint study models. A specific but accessible equipment is needed to record muscular activity and mandibular cinematics. In conclusion, this protocol is helpful before, during and after rehabilitation and particularly when establishing an intermaxillary relation in a myocentric relationship. This protocol especially guides the practitioner in maxillofacial prosthesis, in the case of prosthetic reconstructions after mandibulectomies.

CONFLICT OF INTEREST

The authors declare no conflict of interest regarding the publication of this article.

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