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Electromyographic evaluation of a patient treated with extraoral traction: a case report

ABSTRACT

Background This work seeks to provide information on the utility of surface electromyography (SEMG) as an aid for diagnosing orthodontic conditions. Classic orthodontic monitoring by radiography, plaster models, cephalometry, and photography can be improved by using SEMG before and during treatment, to prevent clinical worsening and relapses.

Case report This paper presents the SEMG results for a 10-year-old female patient, orthodontically treated by extraoral traction (EOT). Significant muscular variations in the patient's EMG were observed as she changed different postures and as headgear device was used.

Conclusion SEMG should be performed prior to the orthodontic treatment to assess the neuromuscular patient's pattern, in order to prevent strain induced by extraoral forces. EMG can be a valid aid for evaluating the patient's neuromuscular condition before, during, and after orthodontic treatment.

Keywords Electromyography; Extraoral traction; Headgear; Kinesiology; Orthodontics.

Introduction

The primary aim of orthodontic treatment is alignment of the teeth according to an aesthetical and functional ideal relationship [Mahony, 2005]. To gather objective information about the improvements achieved with

the treatment, the orthodontist should evaluate the facial morphology and the occlusal relationship through photographs, radiographs, and plaster models. Surface Electromyography (SEMG), bite force measurements, and kinesiology (KG) can provide important information about the mandibular movements [Di Palma et al., 2009; Harada et al., 2000]. Surface EMG and computerised KG are primarily used to diagnose and treat temporomandibular joint (TMJ) disorders, to assess the extent of stomatognathic system dysfunctions in subjects with malocclusion, and to monitor orthodontic treatments [Wozniak et al., 2013]. It is very difficult to determine the exact relationships between facial morphology and stomatognathic function because of the many aetiological factors of malocclusions, the large inter-individual variability, and the plurality of predictors that characterise dentoalveolar and morphological disorders. In clinical orthodontics, SEMG has been used to evaluate the influence of occlusal conditions on the neuromuscular balance of the stomatognathic system [Ferrario et al., 2006; Castrolfiorio et al., 2008] and to evaluate, from a functional perspective, the efficacy of orthodontic treatments [De Rossi et al., 2009].

The objective of this paper was to evaluate the SEMG results of a Caucasian 10-year-old girl who underwent orthodontic treatment through headgear [Sadovsky, 1992; Halicioglu et al., 2012].

Case report

A 10-year-old Caucasian girl came to the Dental Clinic of the University of L'Aquila, Italy, for EMG and KG evaluations. The patient's medical history did not reveal any systemic pathologies, craniofacial syndromes, nor congenital pathologies. She was born by cesarean section without complications. The mother was not administered uterine myorelaxants during pregnancy.

At the age of 6 years, the patient underwent adenoidectomy and tonsillectomy. Disinclusion of the upper canines was being treated by cervical extraoral traction (EOT), with bands positioned on the upper first molars. Previous treatment with a rapid palatal expander had been interrupted because of lack of improvements, perhaps due to the patient's difficulty to adapt to this type of device. Pre-treatment orthopantomography (Fig. 1) showed a lack of space for the eruption of teeth 13 and 23 in the arch. After EOT, the post-treatment orthopantomography showed distalisation of the posterior sections and creation of the space needed for eruption of the upper canines (Fig. 2). The extraoral examination showed a slight lateral deviation of the mandible toward the left side, and a flat profile with no evident asymmetry in the facial third (Fig. 3). The intraoral examination showed narrow arches and left deviation of the midline (Fig. 3). The patient reported general discomfort, nausea and vomiting that started at the moment of insertion of the extraoral

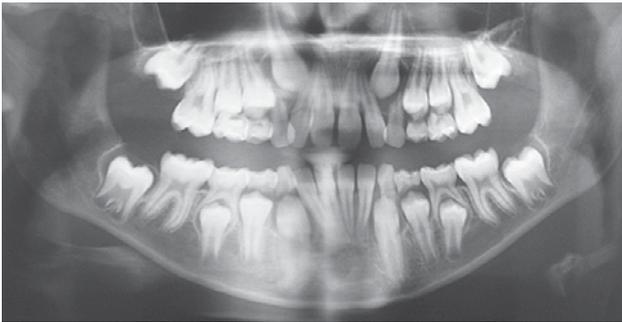


FIG. 1 Pre-treatment orthopantomography.



FIG. 2 Post-treatment orthopantomography.

FIG. 3 Intraoral photos.



FIG. 4 Photographs of the patient. Extraoral condition of the patient and with the device in place.

device, accompanied by strong vertigo and dizziness in the supine position. The patient had been referred to an otorhinolaryngologist, who excluded any pathological involvement. Because of this condition and the presence of vertigo, a neurological evaluation was requested; however, no neurological disorder was revealed.

Many authors, including Green and others, recommend extreme caution with EOT treatment to avoid damage to the TMJ and other side effects. When pathological symptoms appear, it is very important to modify or stop any ongoing orthodontic treatment, at least until the cause of the problem has been detected [Sadovsky, 1992; Muhl et al., 1987]. Keeling and McGorray, in a study on orthodontically treated subjects, suggested that patients be monitored for a longer period of time and with more precision compared to untreated patients to prevent dysfunction. Subjects treated with EOT, functional orthodontics appliances, and facial masks were found to be at the greatest risk of adverse events [Muhl et al., 1987; Halicioglu et al., 2012].

The EOT is a special device composed of two arcs. The internal archwire is inserted in the larger tubes of the upper molar bands. The external archwire is connected to the neck (cervical EOT) or head (high-pull EOT) through an elastic band with holes. Cervical EOT (headgear) permits extrusion and distalisation of the molars, straightening of the back palatal plate, growth inhibition of the upper

maxilla, it is effective in correcting overbite, back rotation of the mandible, and improvement of the molar anchorage. In contrast, high-pull EOT permits molar intrusion (with almost no distalising action), modification of the orientation in the upper molar growth, and improvement of the upper molar anchorage. EOT creates a constant tension, perceived by the patient, and it should be worn at least 15 hours a day (during the night and afternoon hours) [Kumar and Pentapati, 2013; Burhan, 2013; Lima et al., 2013]. Given these considerations, SEMG is the most specific aid for orthodontists before, during and after orthodontic treatment. This analysis can be used to evaluate and detect muscle tension in the stomatognathic system that might lead to relapses or worsening of the clinical condition if not resolved [Sadowsky and Polson, 1984].

After both parents provided their consent to the treatment, the patient underwent SEMG analysis.

Electromyography

EMG activity was recorded with an eight-channel K7 system (Myotronic Inc., Seattle, WA) using pre-gelled adhesive surface bipolar electrodes with an inter-electrode distance of 20 mm. The skin surface where the electrodes were applied was cleaned before electrode placement. Electrodes were positioned on the left and right masseter

muscles (LMM, RMM) and the left and right anterior temporal muscles (LTA, RTA), as described by Castroflorio et al. [2005a; 2005b] on the left and right anterior digastric muscles (RDA, LDA) [Castro et al., 1999] and the left and right sternocleidomastoid muscles (LSC, RSC) bilaterally parallel to the muscular fibers and over the lower portion of the muscle, according to Falla et al. [2002], to avoid the innervation point. A template was used to enable repositioning of the electrodes in the same position when the measurements were repeated at different times or if an electrode had to be removed due to malfunction.

Electrical signals were amplified, recorded, and digitised with a clinical software package (K7, Myotronics Inc., Seattle, WA). The root mean square (RMS) values (in μV) were used as indices of the signal amplitude [Masci et al. 2013; Monaco et al., 2012].

Results

The SEMG exam started with an evaluation of the muscular activity while at rest (SCAN 9). When the patient was seated with her eyes closed/open (Fig. 5), in standing position with her eyes closed/open (Fig. 6) and in the supine position with her eyes closed/open (Fig. 7), the recording

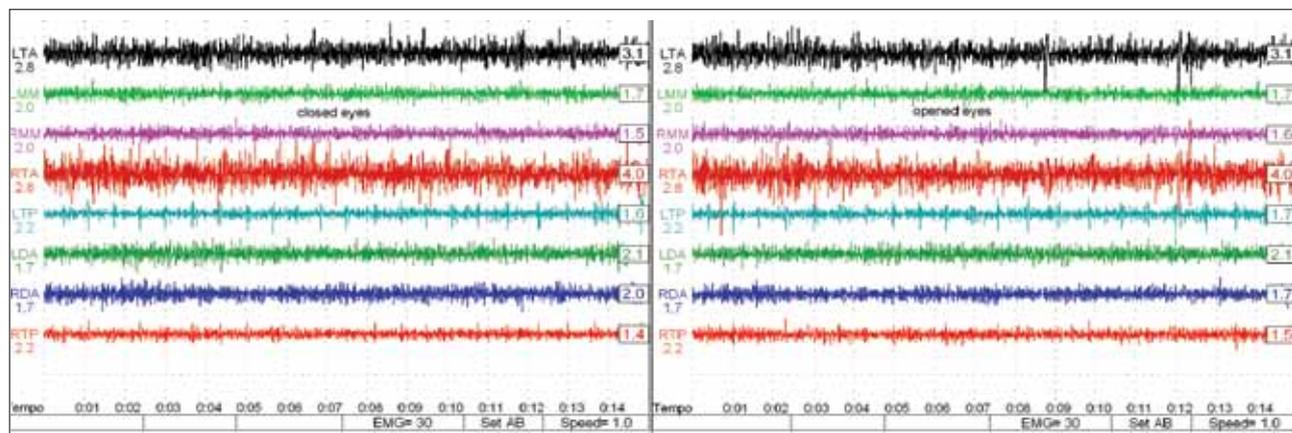


FIG. 5 SCAN 9. Muscular activity at rest, with the patient seated with closed and open eyes.

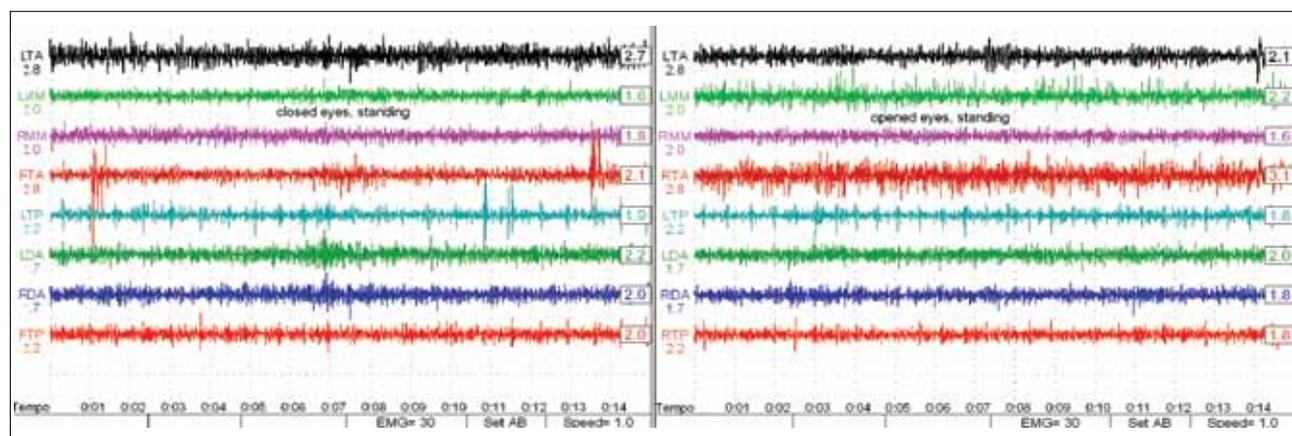


FIG. 6 SCAN 9. Muscular activity at rest, with the patient on standing position with closed and open eyes.

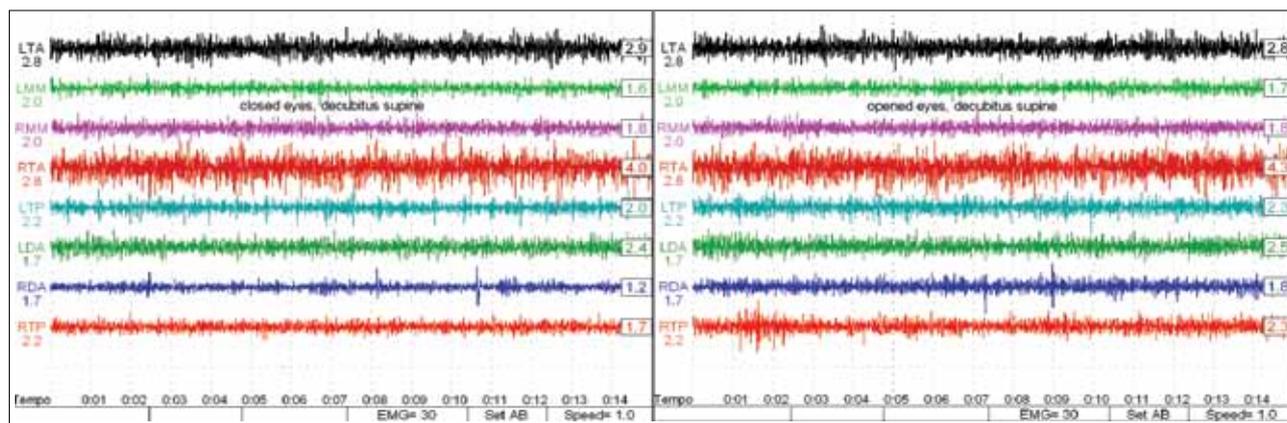


FIG. 7 SCAN 9 Muscular activity at rest, with the patient in decubitus supine position with closed and open eyes.

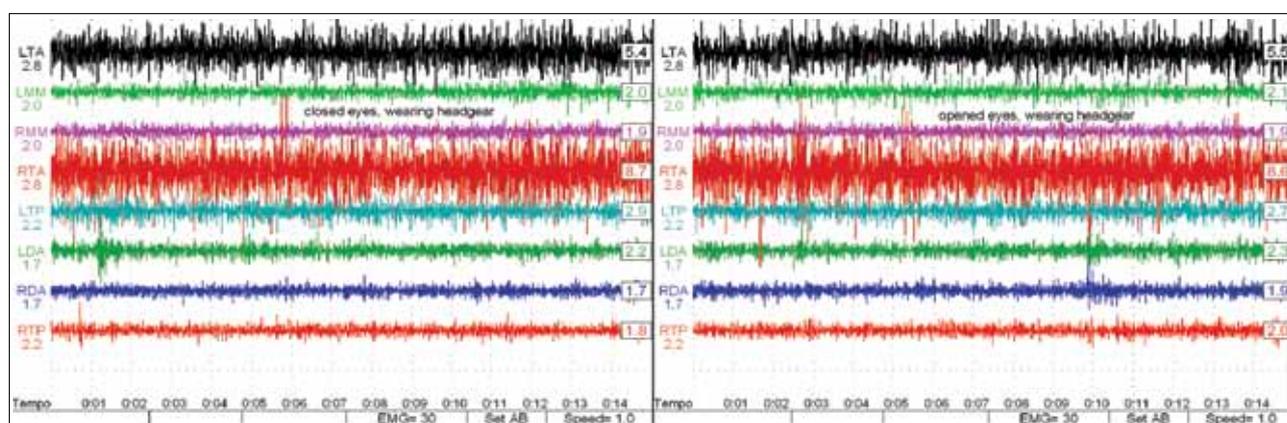


FIG. 8 SCAN 9. Muscular activity at rest, with the patient seated, wearing headgear, with closed and open eyes.

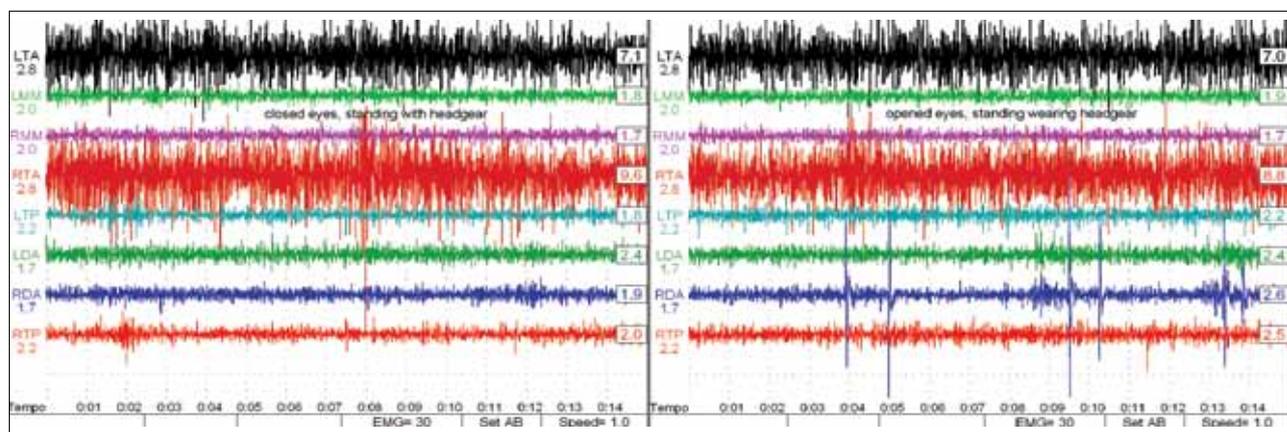


FIG. 9 SCAN 9. Muscular activity at rest, with the patient on standing position, wearing headgear, with closed and open eyes.

revealed an asymmetric pattern, with slight hypertonicity of both temporal muscles and both digastric muscles.

When the patient wore the headgear device, the muscular electric activity of the temporal and sternocleidomastoid muscles increased (Fig. 8). The same result on electrical neuromuscular activity was observed when the patient moved from the seated to the standing position with closed/open eyes (Fig. 9) and to the supine position with closed/open eyes (Fig. 10).

Discussion

Orthodontic treatment can cause tension that can elicit unwanted results. In classic orthodontics, the specialist aims at achieving certain aesthetic and morphological goals based on standard parameters. SEMG is used for evaluating the functional aspects of occlusion during orthodontic treatment. This case report documents the SEMG-muscular changes in a patient using an

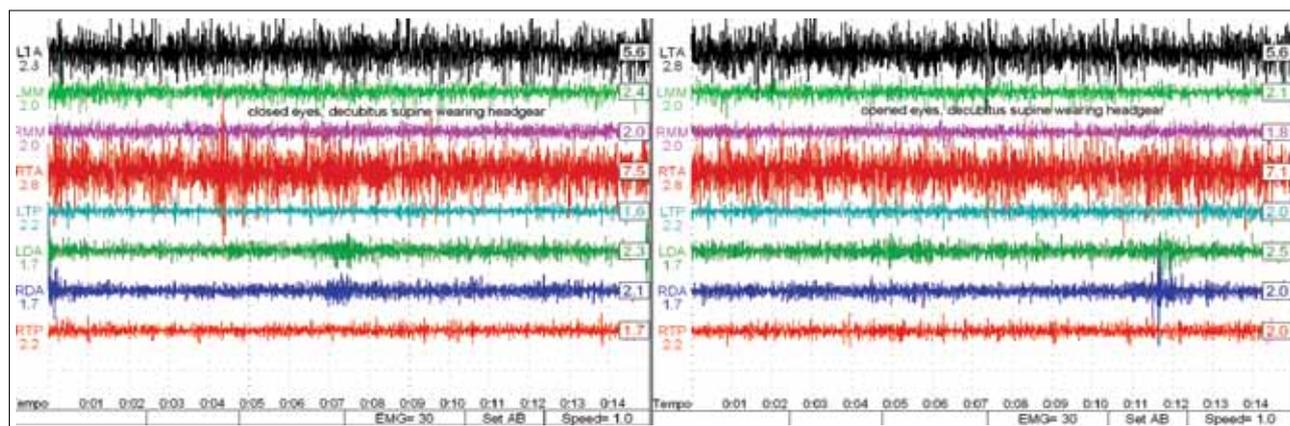


FIG. 10 SCAN 9 Muscular activity at rest, with the patient in decubitus supine position, wearing headgear, with closed and open eyes.

orthodontic device (cervical headgear). The SEMG values show to be sensitive to body posture and the presence of an orthodontic device.

The SEMG analysis showed that the orthodontic device increases the myoelectric activity at rest of the anterior temporalis and sternocleidomastoid muscles in several positions of the body.

Subjects treated with EOT, functional orthodontics appliances, and facial masks were found to be at greatest risk of adverse events [Muhl et al., 1987; Halicioglu et al., 2012].

EOT creates a constant tension, as perceived by the patient, and it should be worn at least 15 hours a day (during the night and afternoon hours) [Kumar and Pentapati, 2013; Burhan, 2013; Lima et al., 2013]. The results of SEMG evaluation suggest that the young girl of this case suffers from an increased muscle activity with the mandible at rest, regardless of the body posture. Possibly this SEMG data reflects the muscle tension needed in this patient to counterbalance the forces of EOT. The anterior temporalis and sternocleidomastoid muscles are involved in the maintenance of postural balance of mandible and body. It is very important to consider the relationship of the TMJ and craniomandibular muscles with the nervous system [Masci et al., 2013]. The stomatognathic system is strictly connected with the visual/extrinsic eye muscles system, and with the cranio-cervical system through shared pathways [Monaco et al., 2013b]. Several studies have evaluated the correlation between the stomatognathic and visual/extrinsic eye muscle systems and TMJ disorders [Monaco et al., 2013a; Monaco et al., 2013b; Monaco et al., 2003].

The muscular pattern of the patient's SEMG exhibited constant asymmetry. The asymmetrical activation of the mandibular and neck muscles may act as compensation to stabilise the mandibular and cervical systems during mastication. The SEMG values of this case could be interpreted as neuromuscular worsening when at rest, according to the recent literature [Ries et al., 2008]. Other authors have shown that the activation of these muscles is a common phenomenon in orthodontically treated

subjects compared to untreated subjects. The patient's experience of vertigo, nausea, vomiting, etc. at the time of device insertion seemed to confirm the nervous system involvement [Hasler, 2013; Babic and Browning, 2013].

A recent anatomical and physiological study demonstrated the direct and monosynaptic link between proprioceptive fibres coming from neck muscles (suboccipital, sternocleidomastoid, trapezius, longus capitis), the nucleus ambiguus and the hypoglossal nerve through the intermedius nucleus of the medulla, thus explaining the relationship between the cervical tension induced by TEO and autonomic symptoms [Edwards, 2014; Edwards et al., 2009].

Moreover, the asymmetric muscle activation could produce the effects, such as nausea and vomiting, showed by the patient through paths involving the oculocephalic and oculo-vestibular activity. The neck muscles, including the sternocleidomastoid muscle, are a peripheral part of a complex nervous set controlling the eye/head/neck/body mutual posture balance. The central nervous component of this set includes the vestibular nuclei, the cerebellum, the EOM nuclei and the trigeminal nuclei. The latter receives afferents from all others, commonly involved in autonomic symptoms when one of another part of the balance system is impaired and from the sternocleidomastoid, trapezius and suboccipitalis muscles [Dauvergne et al., 2004; Ndiaye et al., 2002; Diagne et al., 2006; Dauvergne et al., 2002; Hallman et al., 2011; Hallman and Lyskov, 2012]. On the other hand some animal data suggest the link among trigeminal and autonomous nuclei [Imbe et al., 1999; Ishii et al., 2005; Malick and Burstein, 1998].

All these literature data could partially justify the direct involvement of the trigeminal complex and the electrical hyperactivity of anterior temporalis muscle in the onset of the muscular and autonomic symptoms reported by the young patient of this case report.

The patient's SEMG results before orthodontic treatment were not available for this study. Therefore, the actual neuromuscular changes between the beginning of the treatment and the moment of the evaluation

could not be identified. As suggested by other authors, we recommend that a neuromuscular evaluation be performed before orthodontic treatment, especially in the case of particularly sensitive subjects, to avoid relapses and worsening of the clinical picture [Sadowsky and Polson, 1984].

Conclusion

The effects of orthodontic treatment on the stomatognathic system are not completely clear, but involvement of muscle and autonomic control centers sharing nervous path with trigeminal system could be hypothesised basing on recent anatomical and physiology studies. This case report shows that orthodontic treatment, which, in itself, causes strains on the stomatognathic system in sensitive subjects, can cause symptoms connected to the autonomic nervous system.

Only a few articles exist in the literature to document this hypothesis, and more studies are needed.

As suggested by this case report, surface electromyography is a valid aid for evaluating the patient's neuromuscular condition before, during and after orthodontic treatment, possibly to improve the control of orthodontic forces and monitor the effects on muscle activity.

Consent

Written informed consent was obtained from the patient's parent for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

Competing interests

The authors declare that they have no competing interests.

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