

# **REDUCING MUSCULOSKELETAL STRAIN WITH THE USE OF MOBILE GEL-PADDED ELBOW-RESTS IN A DENTAL CLINIC**

**ROSE-ANGE PROTEAU**

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## **SUMMARY**

The work of dental hygienists imposes prolonged static muscle load on the upper limbs. To date, few solutions have been studied to reduce this load. Our study was designed to see if the use of new mobile gel-padded elbow-rests reduced static stress on the shoulders under usual working conditions. Ten volunteer hygienists in the Montreal area took part in the study. The muscular activity of eight muscles was measured by surface electromyography (EMG) before and after one month's use of the new elbow-rests. The results showed a significant reduction in upper trapezius muscle load. The hygienists were all right-handed and the reduction was more significant on the left side. Most of the hygienists observed succeeded in changing their position with respect to the patient's head, to reduce the frequency and range of arm abduction. Use of the elbow-rests did not lead to an increase in muscle load on the wrists.

*Part of this presentation is in the Proceedings of the SELF-ACE 2001 Conference-Ergonomics for changing work, in October 2001, in Montreal*

*( SELF=Société d'ergonomie de langue française and ACE = Association of canadian ergonomy)*

## **INTRODUCTION**

Over the past four years (1997-2001), a number of dental hygienists consulted the *Association pour la santé et la sécurité du travail secteur affaires sociales* (ASSTSAS) about various physical problems they had developed in their shoulders, elbows, wrists, hands and fingers. These problems had forced them to stop working for an extended period of time. Some hygienists had found it difficult to return to work, while others had had to change careers.

The work of dental hygienists imposes tremendous static load on the muscles responsible for mobilizing the shoulder girdle, shoulder and elbow (Oberg, 1993). This load is mainly associated with positioning and stabilizing the joints responsible for the precise hand and finger movements used when performing operations related to cleaning teeth (scaling, ultrasound, etc.). In dental clinics, hygienists in particular must frequently keep their arms in a position of extreme abduction (arms held away from the body). The right arm is placed in a position of abduction above the patient's chest, while the left arm is in abduction above the patient's head (photos 1, 2 and 3). These positions are more common when the hygienist is seated beside the patient's head (clock positions 8:00, 9:00 and 10:00) and are less common when she is seated behind the patient (11:00 and 12:00).



**Photo 1.** Left arm in abduction over the patient's chest .



**Photo 2.** Right arm in abduction over the patient's head



**Photo 3.** Both arms in abduction at the same time.

An earlier study (Proteau, 1997) showed that the introduction of telescopic pivoting arm rests (designed for office workers) and weekly monitoring of working positions for two months had helped hygienists reduce the amount of time spent in abduction for both arms. During this same period, the time spent working behind the patient's head increased.

The muscular activity of specific muscles can be measured with EMG. The values obtained are then compared to those achieved by the person during the maximum voluntary contraction (MVC) specific to each of the muscles studied. By dividing the two values (measurement during activity/maximum measurement), we obtain the mean maximum voluntary contraction (MVC) for each muscle. The safe MVC value for static muscle load required to maintain a position is 5% or less as suggested by Bjöksten and Jonsson (1977). MVCs exceeding 10% are considered high-risk because they hinder blood circulation in the muscle.

In 1998, EMG measurements in one hygienist who had been using these arm rests for more than a year revealed a significant reduction in MVC in the upper trapezius muscles, dropping from more than 10% to less than 5% (Marchand, 1999). This study showed a slight increase in forearm muscle contractions when using vibrating tools (ultrasound and polishing).

Recently, ASSTSAS was involved in developing a new mobile gel-padded elbow rest. The purpose of this project was to increase the comfort and function of the elbow rest and to reduce the effect of vibrations produced by certain tools (polishing and ultrasound). The equipment had to support the hygienist's elbows while maintaining freedom of horizontal movement. Since the elbow is somewhat moulded into the gel, the elbow rest follows the arm movement more easily than a rigid support system.

The purpose of this study was to evaluate the physical impact of using these new mobile gel-padded elbow-rests and their potential for fostering the adoption of safer working positions and methods. More specifically, it also aimed to see if the elbow-rests helped reduce static muscle load under actual working conditions, with monitoring and basic training on ergonomic concepts, in order to prevent musculoskeletal disorders.

## 1- METHODOLOGY

In 2000, ten dental hygienists volunteered to participate in this study at six dental clinics in the Greater Montreal area. Their work experience ranged from 1 to 22 years. The project had at its disposal four stools with gel elbow-rests (photos 4-6). Tests in the field were scheduled over a period of four months. Assessment of physical workload was performed on two occasions about one month apart, for a total of 20 days.

On the first measurement day, the hygienists used their usual stool and working methods. Over the next few days, an ASSTSAS ergonomic counsellor met with each hygienist during the workday to

observe her working methods and to give her advice about working techniques that would reduce musculoskeletal strain. A prevention handbook for dental hygienists was distributed at the end of the meeting (Proteau, 1999).

The hygienists were instructed to use both elbow-rests as often as possible, but to avoid leaning on either one if this caused flexion or extension of the wrist on that side. The main recommendations in terms of methods involved:

- Increasing the amount of time spent working behind patient's head instead of beside the patient.
- Placing the patient in a more horizontal position (raising the patient's chair and lowering the chair back).
- Moving the patient's head more often.

The hygienists were then given one month to familiarize themselves with the new gel elbow-rests (photos 4-6) and to implement the advice they had been given. After this period of adaptation, muscle load was reassessed.

The urethane gel elbow-rests are round and flat. They are attached to a rod with a ball joint that allows them to move on a horizontal axis. They can therefore follow the movement of the hygienist's arms, but stay in place when the hygienist raises her arms. They are attached to the underside of the seat of the stool and their height is adjustable.



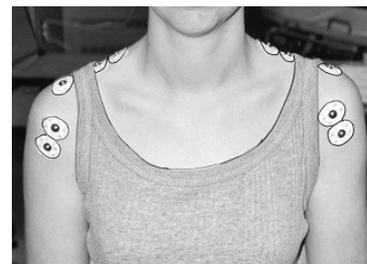
**Photos 4, 5 and 6.** Stool with back support and mobile gel-padded elbow-rests used in the study.

On each of the two evaluation days, data was collected on an average of four clients who had come in for a cleaning (total of 72 procedures: 37 with and 35 without support). Muscle workload was measured by surface EMG (ME3000P8) with a sampling frequency of 1000 Hz, averaged and recorded every 0.1 seconds.

Electrodes were affixed to the eight muscles being evaluated: bilateral upper trapezius and bilateral anterior deltoids (photo 7), first right radial, right anterior cubital and bilateral spinal erectors. On each evaluation day, for each muscle being studied, the hygienists exerted maximum isometric\* effort against resistance (photo 8). The EMG (uV) results for each muscle were then converted into a percentage of maximum voluntary contractions (MVC), using the highest maximum value achieved on both days.

For each of the muscles, mean MVC was calculated as follows:

$$\text{MVC} = \frac{\text{mean EMG values measured} \times 100}{\text{EMG maximum contraction value}}$$



**Photo 7.** Position of the electrodes for the upper trapezius and anterior deltoid muscles.



**Photo 8.** Maximum isometric effort by the upper trapezius against resistance using a rope attached to a ring on a wooden platform.



**Photo 9.** Simultaneous video monitoring on three planes (front, side and overhead) and synchronization.

The use of three miniature cameras made it possible to view the hygienist's work on three planes (photo 9) and to classify the tasks being performed. The EMG measurements were then synchronized with the video using a temporal marker. These measurements were then compiled to compare the muscle load associated with each step of the procedure, with and without the elbow-rests.

### Initial equipment and work situations

For the majority of the hygienists, changing the type of dental stool was very important. Seven of the ten hygienists had been working with a dental assistant's stool (photos 10-12). This stool is designed so that the assistant can support her chest and arms on it while assisting the dentist. The three other hygienists had clinical stools with back support.

The dental assistant 's stool is equipped with a rounded support. The hygienists do not rest their arms on it because it hinders their movements and keeps them too far from the patient. They cannot rest their back on it because it is too far away and is not the right shape to provide adequate lumbar support.



**Photos 10, 11 and 12.** Examples of stools used by 7 of the 10 hygienists.

To use this stool with the mobile gel-padded elbow-rests, and to be able to work behind the patient's head (12:00 position), the hygienists have to be able to move easily between the back of the patient's chair and the counter or back wall of the room. This space was therefore increased from 9 to 12

inches by moving the patient's chair away from the counter for two of the hygienists, and away from the wall for one of them.

For three of the hygienists, access to the instruments was provided at the back only (Cox system). This system was designed for a dentist working with an assistant (four hands), while hygienists generally work alone.

## 2- RESULTS

### 2. Muscle analysis

#### 2.1 Impact on the stabilizer muscles of the shoulders and neck : the upper trapezius muscles

For the hygienists' principal work activities, i.e. scaling, ultrasound and polishing, the results of the variance analyses (ANOVA) show that using the elbow-rests causes a significant reduction ( $p < 0.05$ )\*\* in the use of the muscles responsible for stabilizing the arms, i.e. the upper trapezius. The trapezius has three end sections. The upper one lifts the shoulder and is responsible for the extension of the head. The lower one moves the shoulder down (Calais-Germain, 1991).

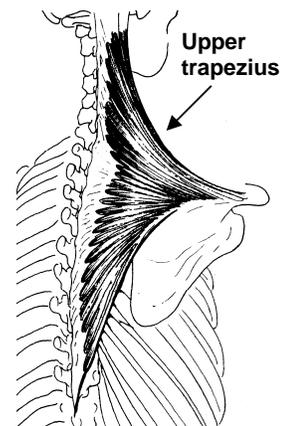
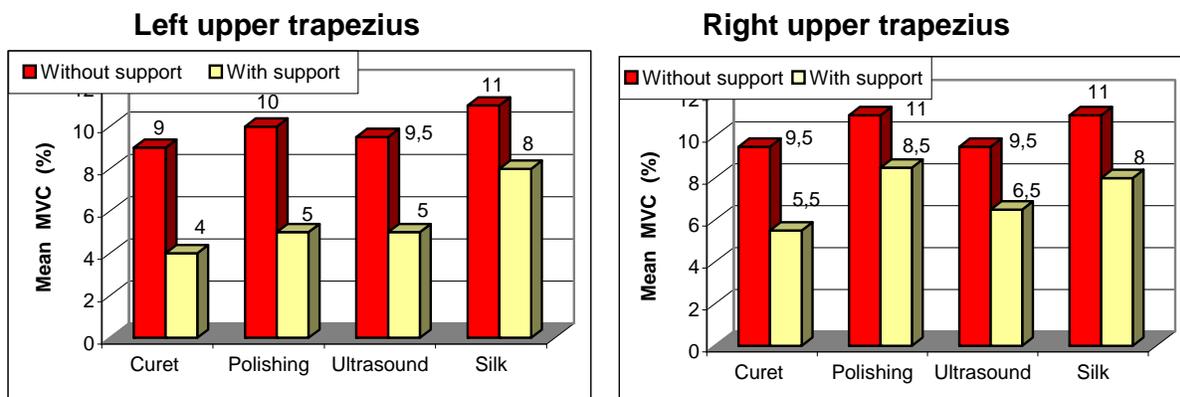


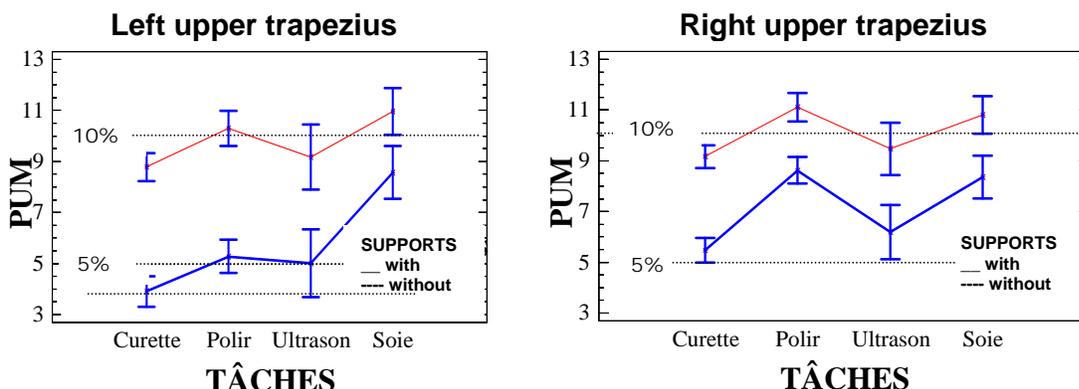
Figure 1 shows the decrease recorded in the use of the upper right and left trapezius muscles. For the left trapezius, use of the elbow-rests led to an average reduction of 38% to 50% and made it possible to approach a safer level of static load of 5% or less (Bjöksten & Jonsson, 1977). For the right trapezius, there was less reduction, i.e. an average of 8% to 23%, but the elbow-rests also made it possible to approach safe levels when using curet and ultrasound. When using dental floss, it seems that the majority of the hygienists made little use of the elbow-rests, but a statistically significant effect was observed nevertheless.



**Figure 1.** Mean maximum voluntary contraction (MVC), with and without mobile gel-padded elbow-rests, for the upper trapezius muscles when performing four tasks of cleaning (total of 72 procedures by 10 hygienists : 37 with and 35 without elbow-rests).

### 2.1.1 Statistically significant data

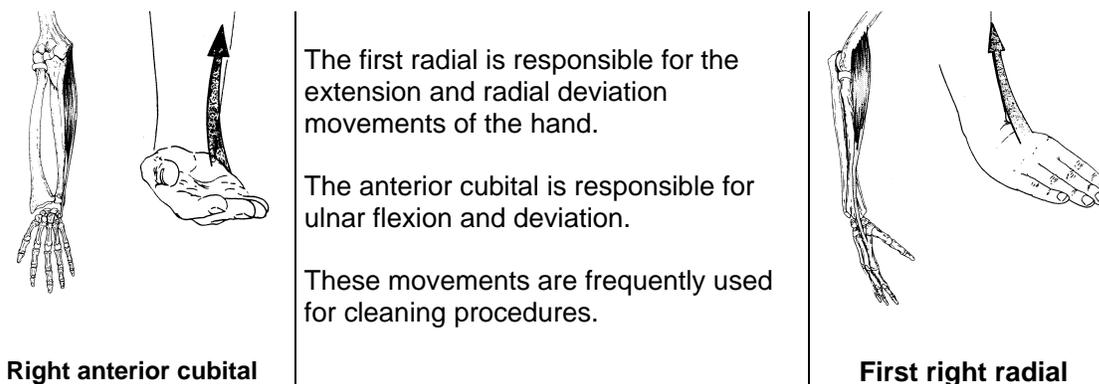
The following figures present the same statistical data as in figure 1, showing that these are statistically significant.

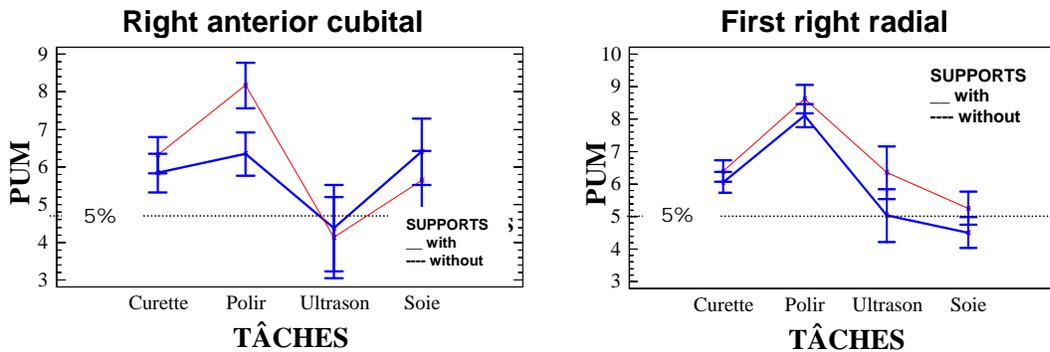


**Figure 2.** Mean maximum voluntary contraction (MVC) (*Pourcentage d'utilisation musculaire (PUM)*) with and without mobile gel-padded elbow-rests (“*supports*”), for the upper trapezius muscles when performing four tasks of cleaning. (Total of 72 procedures: 37 with and 35 without elbow-rests). (Upper and lower values of horizontal bars on each side of the mean represents confidence intervals at 95%\*\*\*).

### 2.2 Impact on the muscles responsible for right hand mobilization

Despite a predictable reduction in the load on the shoulder girdle and shoulder muscles, the study aimed to show that use of the elbow-rests did not result in overloading the muscles responsible for mobilizing the hands. As indicated in figure 2, the use of the mobile gel-padded elbow-rests did not result in an increase in the load on the first right radial and the right anterior cubital. The mobility of the elbow-rests and the changes in working methods probably contributed to this result.





**Figure 3.** Mean maximum voluntary contraction (MVC) (*Pourcentage d'utilisation musculaire (PUM)*) with and without mobile gel-padded elbow-rests, for the first right radial and the right anterior cubital when performing four tasks.

### 2.3 Impact on the anterior deltoid muscles

The mean MVCs for the left and right deltoid muscles were all under 5%, which was already a relatively safe level. These levels dropped to about 3% on the right and 2% on the left. This reduction is statistically significant on the left side when using curets and ultrasound, and on the right side when using curets ( $p < 0.05$ ).

### 2.4 Impact on the spinal erector muscles

The mean MVCs for the right and left spinal erector muscles were less than 5%. They dropped to about 4%, but were not statistically significant ( $p > 0.05$ ) with the exception of polishing for the right erector.

### 2.5. Impact when using vibrating tools

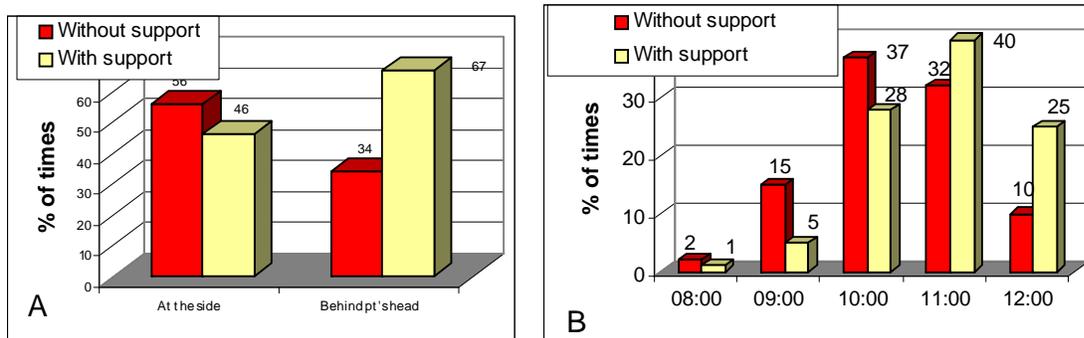
Polishing and ultrasound are procedures performed with tools that produce high-frequency vibrations. The study also aimed to determine the effect of the elbow-rests when used with vibrating tools. Figures 3 indicate a significant reduction in MVC ( $p < 0.05$ ) in the muscles studied during polishing and ultrasound. Figure 7 indicates the same for polishing.

## 3. Impact on working postures in relation to the patient's head

The elbow-rests and training are designed to reduce the use of postures with the arms maintained in a position of abduction above the client's chest and head. These postures, frequently observed when the hygienist is working beside the patient's head (8:00, 9:00 and 10:00 positions) are less common when she is positioned behind the patient's head (11:00 and 12:00 positions). An analysis of the percentage of time spent beside and behind the patient's head gives an indication of the impact of using the elbow-rests and education about working methods.

It is difficult to change habits and movements, because when a person's attention focuses on the task at hand rather than on posture, the efforts made to control movement patterns are generally of short duration (Kolber, 1998). Several of the hygienists mentioned that when using the elbow-rests, they realized sooner that they had their arms up in the air and therefore corrected their posture.

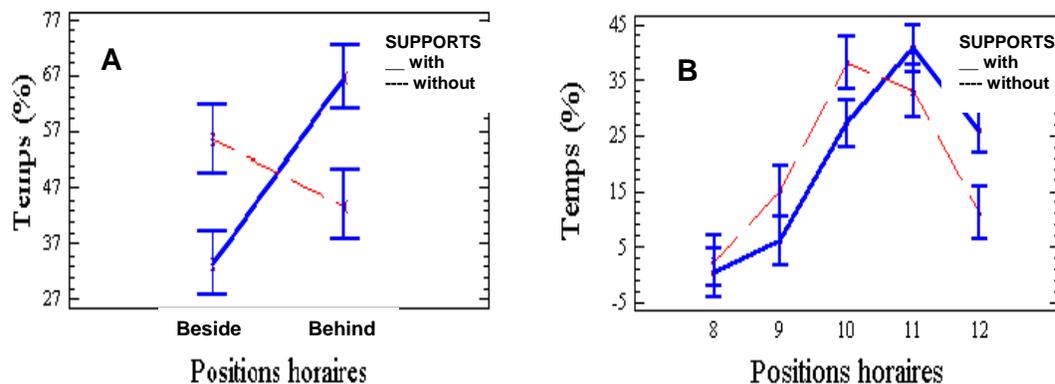
The posture analyses revealed that the percentage of time spent working behind the patient's head increased to 32% by the time of the second evaluation ( $p < 0.05$ ). In addition to providing arm support, the use of the mobile gel-padded elbow-rests seems to facilitate the adoption of safer working methods by dental hygienists.



**Figure 4.** Percentage of time spent beside and behind the patient's head (A) and in different clock positions (B), with and without support (mobile gel-padded elbow-rests).

### 3.1 Statistically significant data

The following figures present the same statistical data as in figure 4, showing that these are statistically significant.

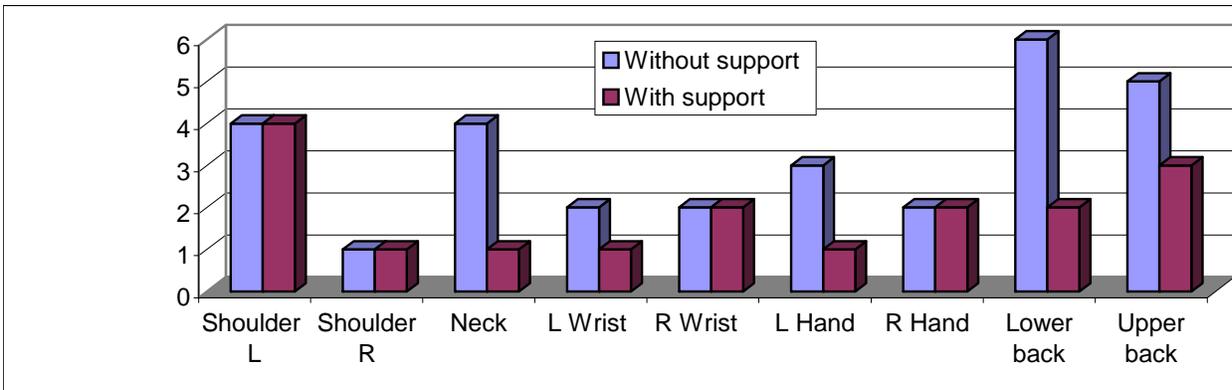


**Figure 5.** Percentage of time spent beside and behind the patient's head (A) and in different clock positions (B), with and without mobile gel-padded elbow-rests. (Upper and lower values of horizontal bars on each side of the mean represents confidence intervals at 95%\*\*\*).

## 4. Impact of the elbow-rests on musculoskeletal symptoms

When we first met with the hygienists, they filled out a questionnaire on musculoskeletal injuries, known as the Nordic questionnaire (Kuorinka, 1995). As a condition for participating in the study, hygienists were required not to have had any absences in the past six months and also had to be able to perform a maximum contraction (maximum effort) for the different muscles being evaluated.

Most of the hygienists had at least one area where they had experienced pain in the 12 months prior to the study. With the elbow-rests, some of the hygienists reported decreased pain in the lower back (4), neck (3), lower back and left hand (2) and left wrist (1) as illustrated in figure 4. However, one of the four hygienists in the first group, who had already experienced sensitivity in several areas and had a history of therapy, experienced an increase in her symptoms (both frequency and seriousness).



**Figure 6.** Number of hygienists who reported discomfort or pain in nine areas (*L* = left, *R*= right) with and without mobile gel-padded elbow-rests (“support”).

#### 4.1 Impact of adjusting the height of the elbow-rests

At the beginning of the study, the majority of the hygienists were working with their arms held out at some distance from their body (abduction). When the height of the elbow-rests was being adjusted, they asked that the elbow-rests be set quite high so they could use them. This resulted in their arms being held in a position of abduction with angles ranging from 30° to 40° (photo 10).

After one of the hygienists in the first group experienced an increase in her symptoms, we insisted that the elbow-rests be set lower for the six other subjects, so that they could work with their arms held closer to their body (photo 11). Five of the six hygienists who were successful at using the lower elbow-rests showed considerably less static muscle contraction in the upper trapezius muscles. None of the hygienists in this group experienced a significant increase in their symptoms.



**Photo 10.** Subject 3 uses high elbow-rests: arms in abduction at about 35°.

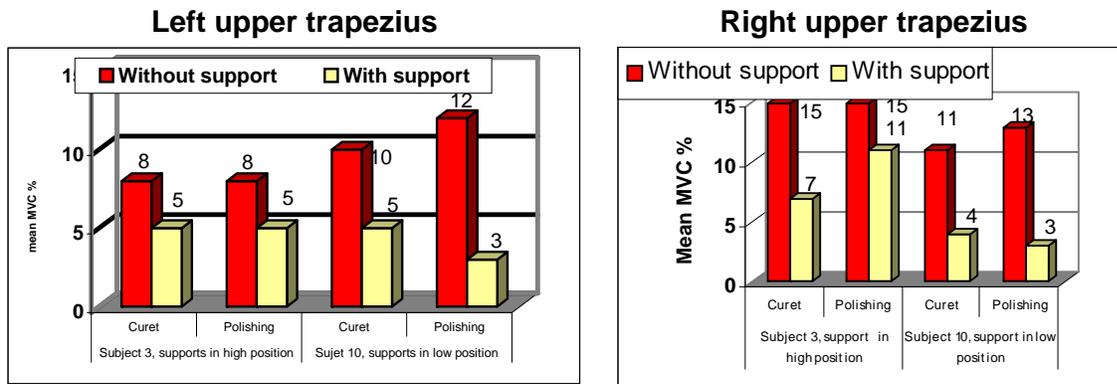


**Photo 11.** Subject 10 uses the elbow-rests set at a lower level!: arms held near her body (no abduction).



**Photo 12.** Subject 10. When the patient's head is higher, there is less flexion of the hygienist's neck.

For two hygienists, working with high and low elbow-rests, the EMG results for the left and right upper trapezius muscles showed a reduction in MVC in both situations, but the reduction was greater when the elbow-rests were set low (figure 7). During polishing procedures, the reduction was about 80%.



**Figure 7.** Mean maximum voluntary contraction (MVC) with and without mobile gel-padded elbow-rests (support), for the upper trapezius muscles for two hygienists (each performing 4 procedures with and 4 procedures without elbow-rests). Use of the elbow-rests reduced MVC in subjects 3 and 10. It was further reduced in subject 10, whose elbow-rests were set lower.

In these photographs, it is evident that the hygienist's neck is more bent when the patient's head is lower (photos 10 and 11) and that her neck is straighter when the patient's head is higher and in a horizontal position (photo 12). When the hygienist's neck is straight, this contributes to reducing the static load on the upper trapezius muscles.

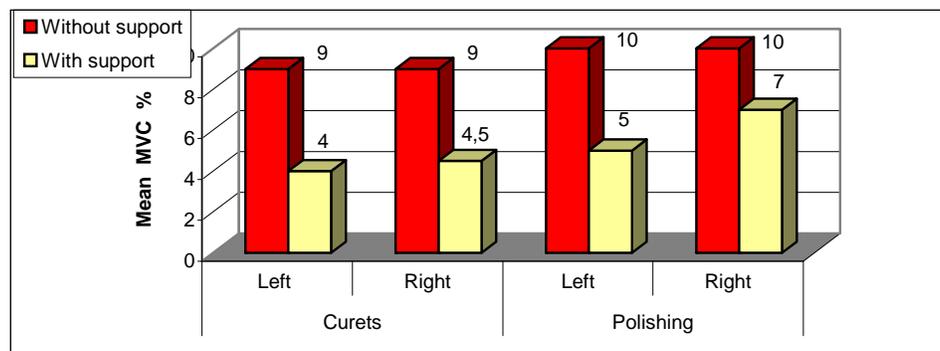
## 5. Evaluation of satisfaction level

In a satisfaction questionnaire, eight hygienists indicated that they were satisfied or very satisfied with the back support and with the comfort of the gel elbow-rests on the stool tested during the experiment. They also mentioned that they would buy it if they could.

## 6. Is the reduction in MVC the result of using the elbow-rests or changing working methods and postures?

Given that there were changes in the clock positions (figure 3) and possibly other changes in working methods after instruction, the data was compiled for a single position, i.e. working behind the patient's head (12:00), in order to determine the actual effect of the elbow-rests. It is in this position that hygienists most often have their arms closest to their body.

### 6.1 Impact of the elbow-rests in the 12:00 position on the upper trapezius

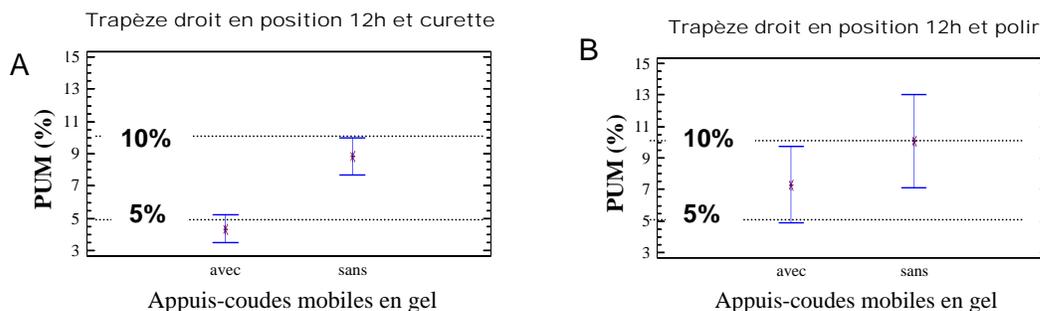


**Figure 6.** Mean maximum voluntary contraction (MVC) with and without mobile gel-padded elbow-rests of the left and right upper trapezius muscle, working behind the patient's head (12:00), when using cures and polishing.

## 6.1 Impact of the elbow-rests in the 12:00 position on the right upper trapezius

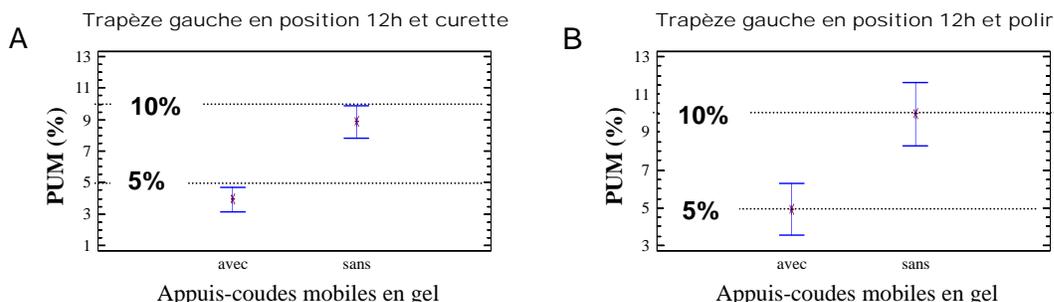
### 2.1.1 Statistically significant data

The following figures present the same statistical data as in figure 6, showing that these are statistically significant effect ( $p < 0.05$ ) when using curets, for the right and left upper trapezius muscles (figure 9 and 10) and for the left upper trapezius muscle when polishing (figure 10). The principal effect of reducing MVC for the upper trapezius muscles is therefore related to the use of the mobile gel-padded elbow-rests for these activities.



**Figure 9.** Mean maximum voluntary contraction (MVC) (*Pourcentage d'utilisation musculaire (PUM)*) with ("avec") and without ("sans") mobile gel-padded elbow-rests ("appuis-coudes mobiles en gel") of the right upper trapezius muscle, working behind the patient's head (12:00) when using curets (A) and polishing (B). The effect is significant when using curets.

## 6.2 Impact of the elbow-rests in the 12:00 position on the left upper trapezius



**Figure 10.** Mean maximum voluntary contraction (MVC) (*Pourcentage d'utilisation musculaire (PUM)*) with ("avec") and without ("sans") mobile gel-padded elbow-rests ("appuis-coudes mobiles en gel") of the left upper trapezius muscle, working behind the patient's head (position at 12:00) when using curets (A) and polishing (B). The effect is significant for both activities.

## CONCLUSION

According to the results of the study, the use of mobile gel-padded elbow-rests seems to be an interesting solution for reducing discomfort related to maintaining certain static postures. These elbow-rests lead to a significant reduction in MVC when performing three demanding tasks (curet, polishing and ultrasound), two of which are performed with vibrating tools. A more significant reduction was observed in the muscles that stabilize the left shoulder (the side that holds the mirror and suction). Without support, this activity is most often performed with the arm in pronounced abduction.

According to observations, this reduction in static workload is associated with the combined effect of using the mobile gel-padded elbow-rests and changes in working methods. The hygienists observed changed their working positions with respect to the patient's head, positioning themselves behind the patient's head more frequently. The elbow-rests probably helped them make this change.

## ACKNOWLEDGEMENTS

The authors would like to thank the ten hygienists and six dental clinics that took part in this research. They would also like to thank Annik Chapados and Christian Pinsonnault (masters students in the UQAM anthropokinetics department) for taking the measurements and processing the data, Lyne Noiseux (industrial designer at Posiflex Design) who designed the new elbow-rests and Marie-Josée Chagnon (director of the dental hygienist training program at CEGEP Maisonneuve in Montréal), for validating the prototypes. This research was funded by the *Institut de recherche Robert Sauvé en santé et en sécurité du travail du Québec* (IRSST) and by ASSTSAS.

\* *Isometric contraction = contraction without changing the length of the muscle.*

\*\* ( $p < 0.05$ ) = 95% probability of rejecting the null hypothesis, which in this study would be that the elbow-rests have no effect.

\*\*\*Confidence interval at 95%: vertical bars with horizontal lines on each side of the mean. They indicate that the data is statistically significant when they do not overlap.

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\*The **ASSTSAS** (*Association pour la santé et la sécurité du travail, secteur affaires sociales*, or the Occupational Health and Safety Association, Social Affairs Sector) is a non-profit joint association. Twelve of its 20 counsellors have training in ergonomics.

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