Abstract

Four occlusal marking media (Parkell film, articulating silk, articulating paper and T-Scan foil) were tested to assess whether they affected neuromuscular function during occlusal marking events. Muscle activity of the anterior temporalis (TA) and superficial masseter (MS) muscles were obtained from surface EMG measurements during a slow closure to occlusion followed immediately by a forceful bite and a maximum clench onto each of the various occlusal indicating media. Muscle activity during the whole period of activation and immediately following onset were investigated.

Do The Physical Properties of Occlusal-Indicating Media Affect Muscle Activity (EMG) During Use?

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Significant differences in neuromuscular function between the occlusal marking media were observed, particularly between the Parkell film and articulating silk as opposed to the articulating paper and the T-Scan foil. The Parkell film and articulating silk gave neuromuscular function very similar to that of natural dentition occlusal contact, while the articulating paper and T-Scan foil showed similarities to occluding onto cotton rolls as previously reported (1). These results suggest that both the thickness and plasticity of the indicating media affect neuromuscular function during occlusion.

Introduction

Occlusal marking media are important clinical tools used to locate interferences and refine occlusal contacts in the fitting of prosthetic devices (2). A wide range of occlusal indicator media exist from articulating film, inked silk and paper through to the T-Scan pressure measurement system. The media differ in their thickness, plastic deformation, tensile strength and marking ability of the registration strip or its transfer to the indicated area of the effected tooth surface.

The selection of an indicator is commonly based on cost and ease of application. However, there is controversy surrounding their efficacy and whether or not they interfere with the patient's normal path of closure and, therefore, distort the indicated occlusal contact pattern. This has been the subject of a number of previous studies. These studies have largely focussed on the sensitivity, reliability, validity and practical utility (benefit versus cost) of each from a marking perspective (2, 3). Even though it has previously been recognised that excessive thickness can induce a proprioceptive response that, in turn, can cause the jaw to be deflected (4), no previous study has investigated whether occlusal marking media affect the function of the muscles involved in occlusion. If indicating media do affect muscle function, this may compromise the validity of their use. This study was designed to determine whether, and how, occlusal marking media affect the neuromuscular function of occlusion based on four different indicators (Parkell film, articulating silk, articulating paper and T-Scan foil (Figure 1). This was achieved using surface electromyography (EMG) to record muscle activity of the temporalis anterior (TA) and superficial masseter (MS) activity during biting and clenching onto each occlusal indicator medium.

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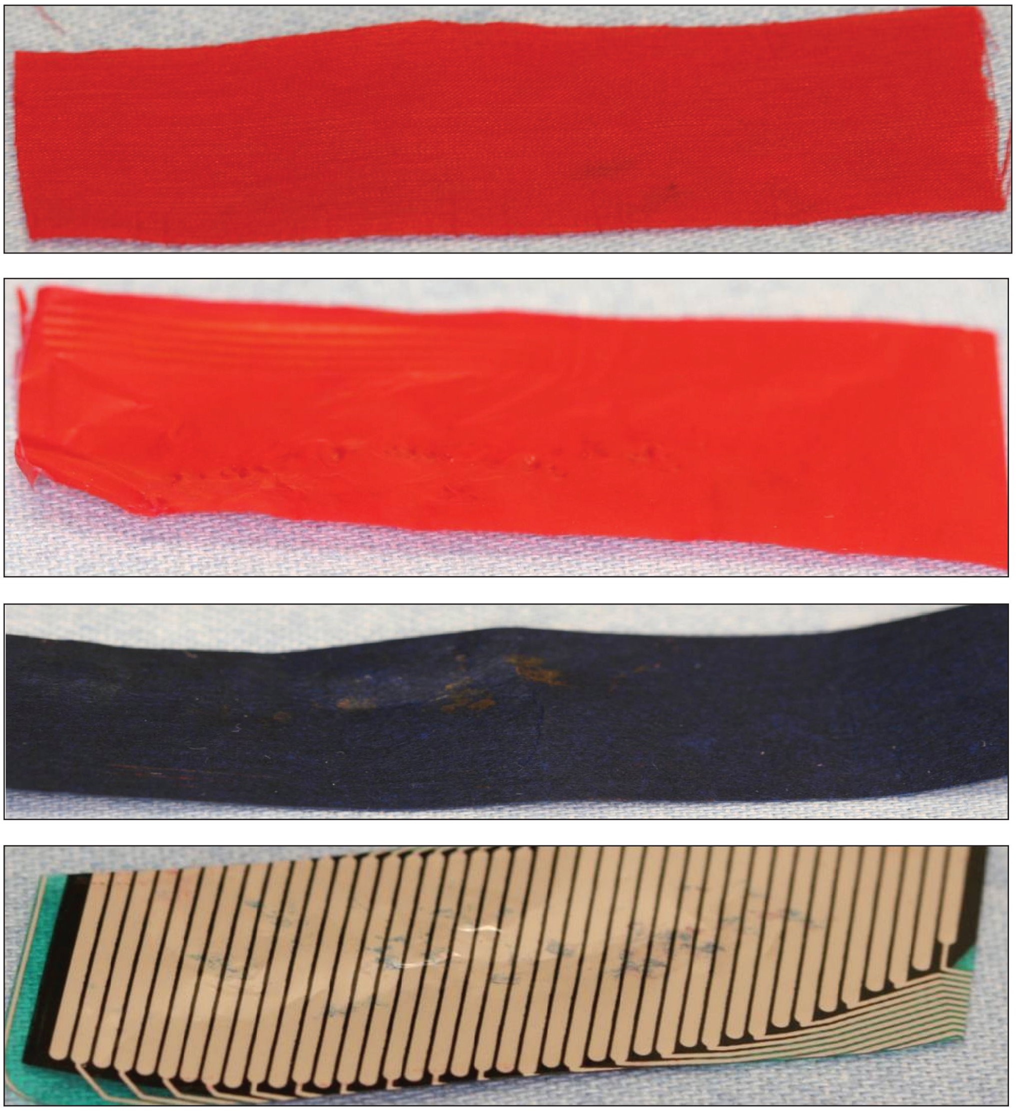
Methods

Eight healthy adult human subjects performed a series of trials which included a slow occlusion onto, then bite into and a maximum clench on four occlusal marking media commonly used in clinical situations (Table 1). Surface EMG was recorded bilaterally from the anterior temporalis (TA), superficial masseter (MS), sternocleidomastoid (SCM) and digastric (DA). Only results for the TA and MS are presented here, as activity in the SCM and DA were very low throughout testing. Muscle activity for the various marking media was compared based on the maximum and mean muscle activity and mean anterior-posterior coefficient (the ratio of total temporalis activity to total masseter activity (1, 5) over the duration of muscle activity and immediately following onset. The study was conducted under the auspices of the institutional review process of Loughborough University, Loughborough, UK.

Table 1. Summary of the four occlusal indicator media.

Indicator	Thickness (microns)	Material Source
Parkell (PK)	24	AccuFilm II Red, double sided
Articulating Silk (SK)	60	Hanel GmbH
T-Scan foil (TS)	96	Tekscan Inc., Boston, Mass.
Articulating Paper (PA)	202	Dentsply Thick Blue/Blue
Note: thicknesses were obtained through measurements on a Sylvac d100s plunger-type capacitive absolute measuring probe (www.sylvac.ch).		

Figure 1. Various occlusal media after completion of test. Note permanent deformation.



Medium 1 – Silk

Medium 2 – Parkell film

Medium 3 – Paper

Medium 4 – T-Scan Foil

Data collection

Data collection was conducted in a dental office setting and the surface EMG measurements were obtained as described previously (1). The experimental protocol is given in Table 2, with the order of occlusal marking media testing randomised between subjects and no information given to the subject on the nature of each of the media to be tested. A bite onto cotton rolls was performed between each indicator media trial to provide a common neuromuscular starting condition for each indicating media. The various indicator media were handled exclusively by the same certified dental assistant and all samples were prepared and handled in a similar manner, i.e., the T-Scan was cut to a similar shape and applied in the same manner as the other indicator media, rather than using the T-Scan handle. This approach was used for the T-Scan, since this study focused only on the effect of the occlusal indicator medium's material properties on neuromuscular function.

Table 2. Summary of the experimental protocol.

For the clenches subjects were asked to use maximum effort, for bites the subjects were asked to use strong effort. The bites and clenches were held for approximately 3 seconds.

Trial	Description	Code
1 - 3	Warm up bites / clenches	——
4	Maximum clench on natural dentition	iND
5	Maximum clench onto cotton rolls	iCR
6	Slow occlusion to contact the indicator + bite	S+B
7 - 8	Maximum clench onto the indicator	MC1 & MC2
9	Bite onto cotton rolls	CRb
10 - 13	Repeat trials 6 – 9 for second indicator	——
14 - 17	Repeat trials 6 – 9 for third indicator	——
18 - 21	Repeat trials 6 – 9 for fourth indicator	——
22	Maximum clench onto cotton rolls	fCR
23	Maximum clench on natural dentition	fND

Data processing

The initial stages in processing the EMG signals were the same as in previous studies (1). In brief:

- bandpass filter (10-600 Hz);
- RMS average (50 ms);
- globally normalise the RMS amplitude (AMPN); and
- determine the on and off times for each muscle.

Thereafter, two sets of parameters were evaluated.

A. Overall muscle activity:

- Maximum and mean activity of the TA and MS while the muscles were active. The right and left values were averaged to obtain single TA and MS values.
- Mean anterior-posterior coefficient (APC) while all muscles are active. This reflects the ratio of total temporalis activity to total masseter activity and can take values between -1 (MS dominant) to +1 (TA dominant).

B. Onset conditions:

To compare the characteristics of the ramp-up of muscle activity following onset, the following parameters were calculated:

- Mean activity of the TA and MS and mean APC for five time windows immediately following all muscles being active. For the slow occlusion + bite trials, the time window was 200 ms and for the maximum clenches, the time window was 50ms.

Single-factor (indicator) ANOVAs with Bonferroni post-hoc analysis were conducted on each of the variables described above, with the significance level set at p = 0.05. All statistical tests on maximum and mean activities were based on total TA and total MS activities, i.e., averaging right and left values.

Results and Discussion

A. Overall muscle activity

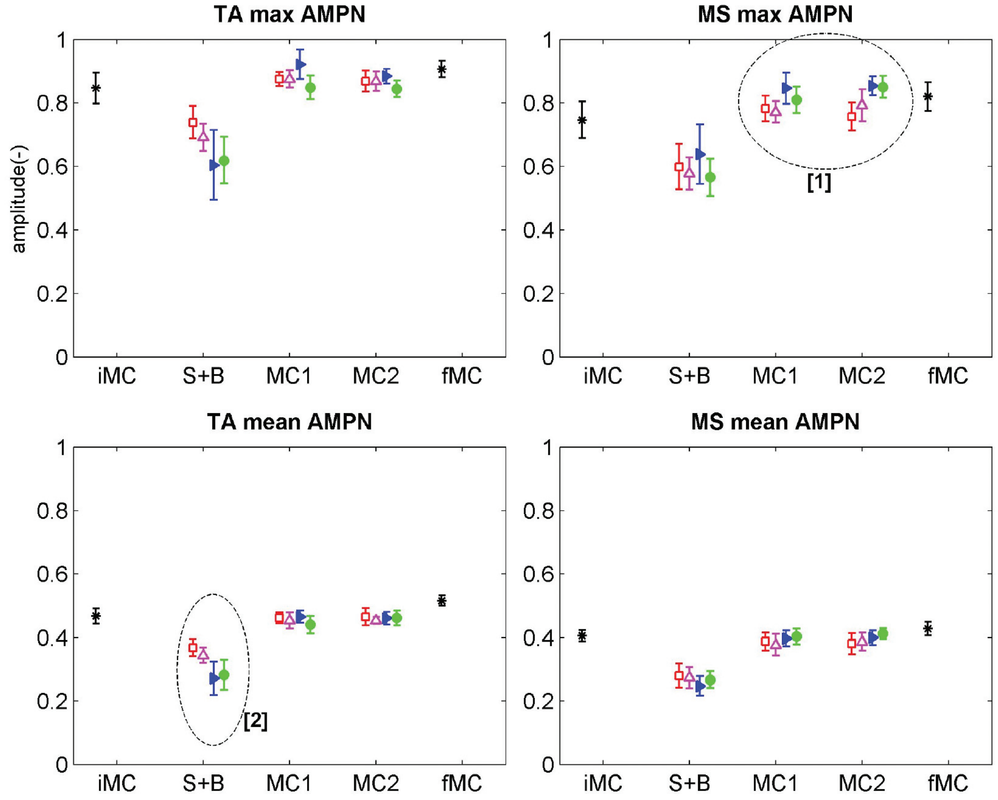
The overall activity parameters gave significant differences shown in Table 3 and Figure 2.

Table 3. Summary of statistically significant differences between indicators in the overall EMG activity parameters for maximum amplitude, mean amplitude and mean APC. (Shaded cells indicate no statistically significant difference).

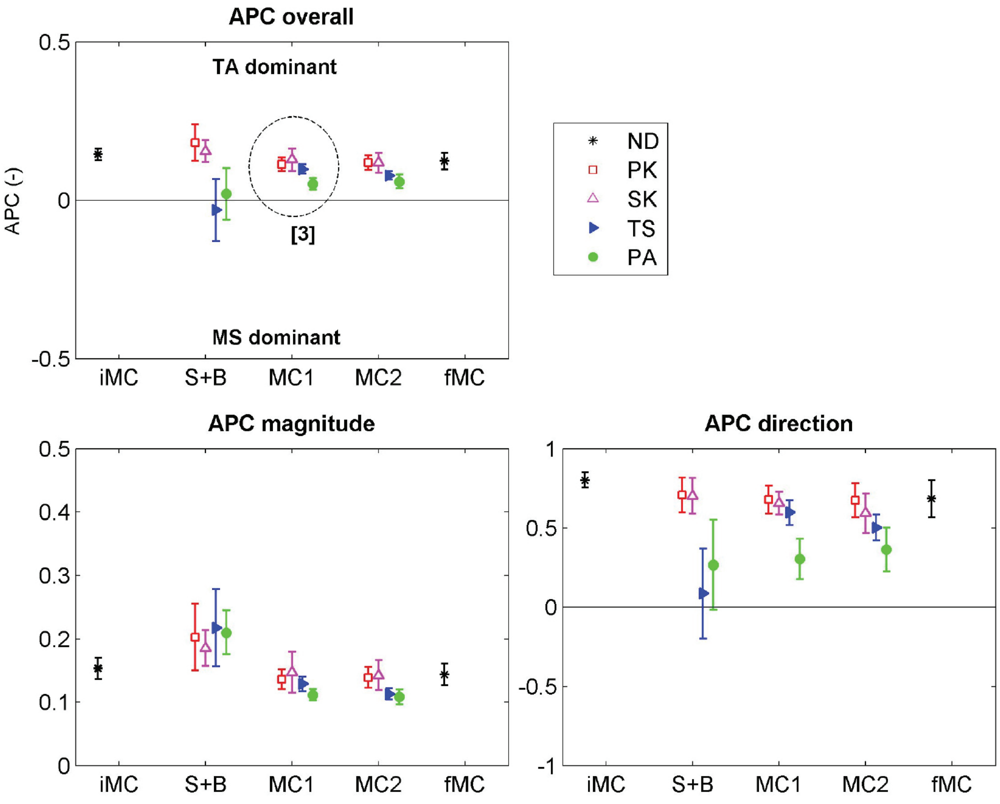
EMG Parameter	Maximum amplitude		Mean amplitude		Mean APC	
	Value	Ranking	Value	Ranking	Value	Ranking
MAXIMUM CLENCH, TA					PK,SK > PA 0.013)[3]	PK,SK > PA (0.000)
MAXIMUM CLENCH, MS	PK < TS (0.026)[1]	PK <TS,PA (0.024)				
SLOW OCCLUSION + BITE, TA			PK > TS,PA (0.031)[2]	PK > TS,PA (0.0025)		
SLOW OCCLUSION + BITE, MS						

[1] maximum activity of the MS in the maximum clench trials (Parkell less than T-Scan and articulating paper);
[2] mean activity of the TA in the slow bite trials (Parkell greater than T-Scan and articulating paper); and
[3] mean APC in the maximum clench trials (Parkell and articulating silk greater than articulating paper).

Figure 2. Results for overall muscle activity. Mean EMG ± SEM values averaged over all subjects.



(a) maximum & mean AMPN



(b) APC

For the maximum clenches, MS activity increased when the indicator was thicker or less flexible (T-Scan and articulating paper), and with little influence on TA activity this also led to a lower APC. The maximum clenches onto Parkell and articulating silk showed negligible difference to the maximum clenches on natural dentition. Relating these results to the first study suggests that the articulating paper, and to a lesser extent the T-scan, have a similar influence on neuromuscular activity, as was observed for occluding onto cotton rolls (4). Note that the maximum clenches onto cotton rolls in this study differed from those in the first study, since in this study the cotton rolls were applied in a different position and orientation, giving a smaller contact area and less stable occlusion. The difference in neuromuscular function between the articulating silk and T-Scan results suggest that the response is affected by both the thickness and plasticity of the indicator, as these two have similar thicknesses but very different plasticity.

The slow occlusion + bite results also conform to the earlier studies, with lower TA activity when using T-Scan and articulating paper compared to Parkell or articulating silk.

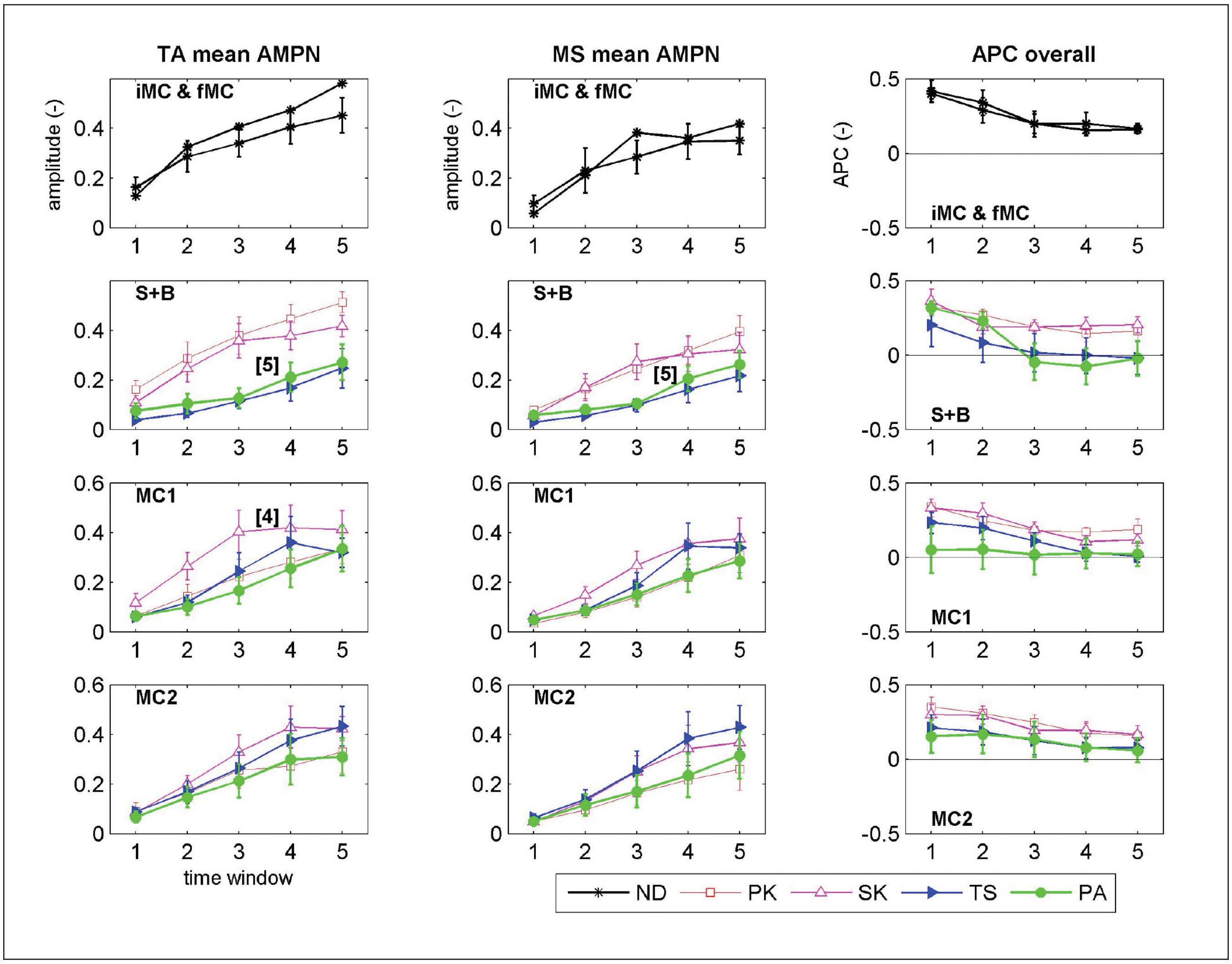
B. Onset conditions:
The onset parameters gave significant differences shown in Table 4 and Figure 3.

Table 4. Summary of statistically significant differences between indicators in the onset parameters (mean activity of the TA and MS and mean APC for 5 time windows immediately following onset; time window = 50 ms for maximum clenches and 200 ms for slow occlusion + bite) (Shaded cells indicate no statistically significant difference).

EMG Parameter	Mean activity in the 5 time windows following onset	Mean APC in the 5 time windows following onset
MAXIMUM CLENCH, TA	For middle time windows: SK > PK,TS,PA (0.012)[1]	
MAXIMUM CLENCH, MS		
SLOW OCCLUSION + BITE, TA	PK,SK > TS,PA (0.000)[2]	
SLOW OCCLUSION + BITE, MS	PK,SK > TS,PA (0.009)[2]	

[1] mean activity of the TA in the maximum clench trials over the middle 3 of the 5 50ms windows following onset (articulating silk greater than Parkell, T-Scan and articulating paper);
[2] mean activity of the TA and MS in the slow bite trials over all 5 of the 200ms windows following onset (Parkell and articulating silk greater than T-Scan and articulating paper).

Figure 3. Results for EMG activity onset parameters. Mean ± SEM values averaged over all subjects. Time windows for the slow occlusion and bite (S+B) were 200 ms, and for the maximum clenches 50 ms.



Investigating the neuromuscular parameters immediately following onset may be more useful for the slow occlusion + bite trials, as these would be expected to have a slower ramp up of activity giving greater opportunity to identify differences as well as representing a more realistic clinical situation compared to the maximum clenches. In the slow occlusion + bite trials, there was a significant difference between indicators, with the Parkell and articulating silk have greater muscle activity than the T-Scan and articulating paper throughout the initial 1-second ramp-up of muscle activity. Thus, the thicker/more rigid indicators resulted in a slower muscle activity ramp-up compared to the thinner/more flexible indicators.

Note that this method of comparing muscle activity following onset is the same as was used in the first study (1). It is recognised that an

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investigation into a more robust method of assessing and comparing the characteristics of this section of EMG signals (that is, less sensitive to the absolute onset time, which is difficult to measure accurately) is required.

Conclusions

In conclusion, there is some evidence of significant differences in neuromuscular function during occlusion between different occlusal marking media, although a larger study (with more subjects) is needed to confirm this observation. It is demonstrated clearly in comparison between the Parkell film and articulating silk versus the T-Scan and articulating paper. The Parkell and articulating silk gave occlusal values similar to those of natural dentition, while T-Scan and articulating paper show similarities to occluding onto cotton rolls (1). These results suggest that both the thickness and plasticity of the indicator affect neuromuscular function during occlusion. It is suggested that any further investigation should include a slow occlusion and bite on natural dentition, such that the occlusal marking media can be compared not only to each other, but also to the natural occluding dentition, since the validity of an occlusal marking media requires that it should not affect neuromuscular function during occlusion. Further measurements to consider include subjective feedback from subjects on each of the occlusal marking media.

References

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