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Pain intensity measurements in patients with acute pain receiving afferent stimulation

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SUMMARY Six different pain rating scales, including a "pain relief scale", were compared in 80 patients suffering acute orofacial pain. Pain intensity measurements were made before and after a 30 min period of afferent stimulation (TENS/vibration and placebo). A good correlation was found between pain scores derived from the pain relief scale, visual analogue-, numerical- and graphic rating scales. The verbal rating scale did not perform well. The pain relief scale and the numerical rating scale are interesting alternatives to the established visual analogue scale.

Different techniques for pain assessment have been developed, some attempting to reflect several aspects of the complex pain experience, such as the McGill Pain Questionnaire (MPQ).[1 2] As discussed recently[3] it is important to define what dimensions of the pain experience are supposed to be rated by the patient, and later evaluated. The results may also be greatly influenced by the cause of the patients' pain as seen in studies on pain of different aetiologies using the MPQ.[4] In studies on measurement and assessment of chronic pain such a distinction concerning pain aetiology has not always been made. The MPQ has in fact been claimed to be a "useful clinical adjunct" in the diagnosis of dental pain.[5]

Most studies on pain measurement have concentrated on the sensory discriminative aspect, that is, the pain intensity, and several pain rating scales have been introduced. The visual analogue scale (VAS) is one of the most widely used and has been found to give valid and reliable data when used to measure experimental pain as well as acute and chronic pain in patients.[6] The advantages and disadvantages regarding the VAS and other similar scales have recently been extensively discussed.[3] A pain relief scale may, however, provide an interesting alternative to the VAS.[6 7] A relative scale provides all the patients with the same magnitude of potential response since they start from the same base-line. This is of special interest in studies of methods aimed at reducing pain in a population of patients. A relative scale designed as a continuous rating scale has not, to our knowledge, been evaluated in acute pain.

We have in the present paper focused our interest on the following questions concerning pain intensity in a group of patients suffering acute pain due to a similar aetiology, namely inflammatory lesions in the teeth, surrounding tissues and jaws;

(1) Is there any difference in the outcome between the VAS and other commonly used rating scales concerning (a) present pain intensity or (b) pain ratings following a pain relieving measure? The latter is important since in many studies a change in rating scores are central to demonstrate treatment effects.

(2) Is a relative pain relief scale comparable to other commonly used pain rating scales?

Material and methods

Patients: Eighty randomly assigned patients (36 males and 44 females aged 18–68 years; mean 30·7, median 28·0 years) were from an emergency clinic for dental and oral surgery. The patients had suffered from pain for 1–4 days. The causes for their pain were either pulpal inflammation, apical periodontitis, pericoronitis or post-operative pain following removal of a tooth. None of the patients had taken any analgesics within less than 4 hours before the examination. In order to be included in the study patients had to report a constant pain intensity for at least 2 hours before the examination.

The patients participating were told about their role in the experiments. They were informed that they could terminate the experiments at any time and that they would get conventional dental treatment following cessation of the experiments.

Rating scales: The five scales used before and after afferent stimulation are seen in fig 1.

The visual analogue scale (VAS) consists of a 10 cm hori-

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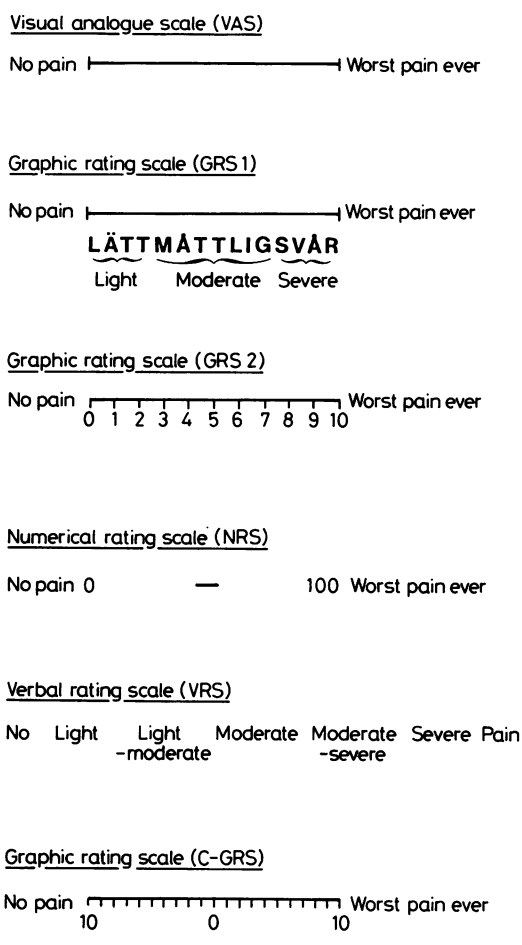

Fig 1 *The different pain rating scales used in the study. Swedish text in brackets at GRS1 scale.*

zontal line on a card with the words "no pain" and "worst pain ever" placed at the left and right hand extremes of the line, respectively. The patients were instructed to mark the line at a point representing their pain.

The graphic rating scales (GRS1 and 2) were constructed as a modified VAS with words or figures added to the line. The patients were instructed to mark the line at a point representing their pain.

A numerical rating scale (NRS) was also used. The patients were asked to choose a figure between 0–100 corresponding to their pain intensity. 0 represented "no pain" and 100 "worst pain ever".

The verbal rating scale (VRS) was composed of six words; no pain, light, light-moderate, moderate, moderate-severe or severe pain. The patients were instructed to choose the word describing their pain intensity.

During afferent stimulation the patients continuously rated their pain intensity using a modified graphic rating scale (C-GRS), fig 1. The C-GRS consisted of a lever attached to a potentiometer. The latter controlled the position of a pen on a chart recorder out of sight of the patient. The patients were instructed to move the lever from 0 position (indicating pain intensity before the start of stimulation) to one side if pain was reduced (endpoint = 10, meaning "no pain" or complete pain relief) and in the opposite direction if pain increased (endpoint = 10, meaning "worst pain ever" or increased pain).

Procedures: The patients willing to participate were asked to rate their pain intensity using the five different scales. The scales were presented separately in random order by one of the authors. The patients were instructed to rate only their present pain intensity. Ratings were made during supervision by one of the authors, that is, the patients could ask how to use the scales. No patient had earlier seen or used any type of pain rating scale.

Following pain ratings the patients received one of the following types of afferent stimulation for 30 minutes; transcutaneous electrical nerve stimulation (TENS) at 2 Hz or 100 Hz (n = 14), mechanical vibratory stimulation at 10, 100 or 200 Hz (n = 46). Twenty patients received placebo-TENS or placebo-vibration. For a further technical description on afferent stimulation see refs 8 and 9. The patients were randomly selected from those being investigated for the influence of different types of peripheral afferent stimulation on acute oro-facial pain. This explains the unequal number of patients in the different groups. Following the 30 min stimulation period the patients once more received the different rating scales, as above, to rate their pain intensity. During stimulation the patients rated their pain intensity continuously using the modified graphic rating scale (C-GRS). This procedure enabled us to compare the five scales pre- and post-stimulatory as well as post-stimulatory with the C-GRS.

Results

The recordings obtained before and after stimulation were evenly distributed using the different scales except for the VRS. The latter scale had a significant skewness when used after stimulation, table 1.

The correlation (Pearson product-moment correlation coefficient) between the VAS and the other scales (VRS excluded, see below) was very good and significant, table 2. This relationship was not changed by afferent stimulation (table 2). Using linear regression, the slope of the different lines varied between 0·91 and 1·00. The relationship between the VAS and NRS is shown in more detail in fig 2. If the pre- and post-stimulatory values for each patient were recalculated and expressed as percentage change of pain intensity after stimulation (as compared with pre-values) the correlation was still good and significant, table 2. A one-way analysis of variance (ANOVA) did not indicate any significant differences. Before afferent stimulation the correlation between the VRS and the other scales was equal and significant with a coefficient of 0·81–0·88 ($p < 0·001$; $n = 80$). The values obtained with the VRS were not

Table 1 *Mean pain intensity in all patients (n = 80) recorded with 5 different rating scales before and after afferent stimulation*

	Scale	*Means (mm) (SD)*	*Range*	*Skewness*	*p*
Before	VAS	52·0 (20·60)	8–99	0·106	NS
	GRS (1)	54·0 (20·44)	10–99	0·104	NS
	GRS (2)	55·0 (19·72)	13–99	−0·021	NS
	NRS	56·0 (20·48)	5–99	−0·269	NS
	VRS	3·2 (0·97)	1–5	−0·251	NS
After	VAS	40·0 (24·97)	0–95	0·345	NS
	GRS (1)	40·0 (25·97)	0–98	0·384	NS
	GRS (2)	42·0 (23·74)	0–94	0·343	NS
	NRS	43·0 (24·15)	0–98	0·145	NS
	VRS	2·8 (1·55)	0–5	2·898	<0·01

A skewness-value between −1 and 1 indicate a normal distribution of recorded values with each scale. SD = standard deviation.

normally distributed following stimulation, table 1. If logarithmically transformed the correlation between the VRS and the other scales was r = 0·61 − 0·75 (p < 0·001).

A matter of interest is the reliability. This was estimated in those patients (n = 30) who after stimulation verbally reported that their pain intensity was unchanged. From table 3 it can be seen that the mean difference in ratings on the different scales before as compared with after stimulation only varied between 1–3 mm, or expressed in percentage, 1–6%. The reliability estimated using a calculated 95% confidence interval did not show any significant differences between the scales, table 3.

The change in pain intensity following afferent stimulation, measured with the "pain relief scale" (C-GRS) was compared with the pre- and post-stimulatory values (expressed as % pain reduction) obtained with the other scales (except the VRS). A significant correlation was found (table 4A) without any difference in outcome concerning pain reduction, either expressed in % change (table 4B) or in number of patients experiencing a certain degree of pain reduction using a non-parametric test (table 5).

The distribution of values obtained with the VRS as compared with the other scales was plotted, as exemplified by the relationship between the VAS and the VRS in fig 3.

Data from all patients are shown in table 6. From

Table 2 *Correlation (r) between VAS and GRS1, GRS2 and NRS before and after afferent stimulation*

Scale VAS vs	*GRS1*	*GRS2*	*NRS*
Before	0·92	0·95	0·94
After (A)	0·98	0·98	0·98
After (B)	0·89	0·89	0·90

Before and After (A) = measurements in mm. After (B) = change in pain intensity (before vs after afferent stimulation expressed in % change). N = 80. All values were significant at p < 0·001.

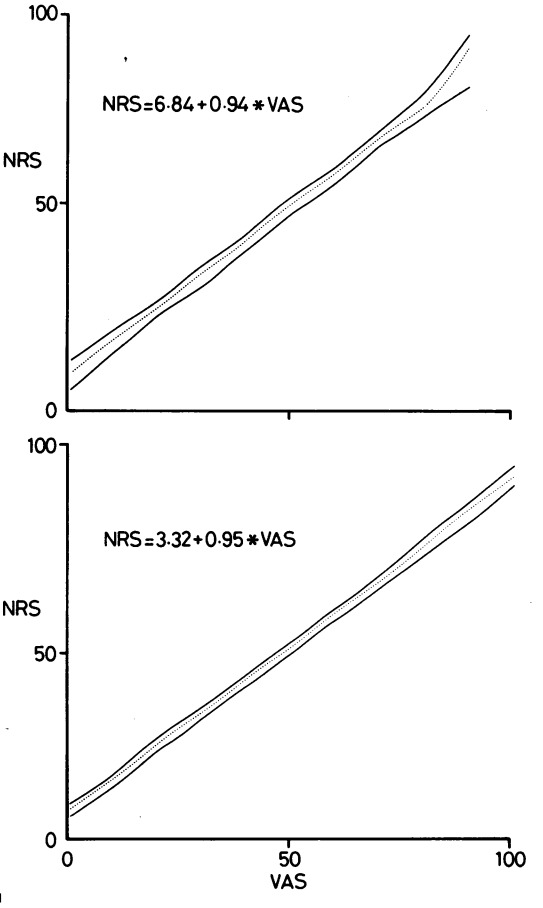

Fig 2 *Relationship between VAS and NRS before (A) and after (B) afferent stimulation. Hatched line show linear regression with 95% confidence interval indicated by solid lines. The equation for the linear regression is given above the line.*

Table 3 *Difference in pain intensity between measurements before and after afferent stimulation in those 30 patients who reported constant pain throughout the test period. (B) = before and (A) = after stimulation*

Scale	*Mean diff*	*SD*	*95% Conf. int*
I:			
VAS (B)–VAS (A)	1·0 mm	10·27	−2·9–4·8 mm
GRS1 (B)–GRS1 (A)	3·4	9·54	−0·2–7·0
GRS2 (B)–GRS2 (A)	1·9	7·29	−0·8–4·6
NRS (B)–NRS (A)	1·9	6·81	−0·7–4·4
II:			
VAS (B)–VAS (A)	1·1%	17·23	−5·4–7·5%
GRS1 (B)–GRS1 (A)	6·0	14·99	0·2–11·7
GRS2 (B)–GRS2 (A)	3·0	11·38	−1·3–7·2
NRS (B)–NRS (A)	3·0	10·27	−1·0–6·9

I: recordings in mm. II: recalculated values in % change.
SD = standard deviation.

these data it was found that the 6-graded VRS behaved as a 4-graded scale. This finding was consistent for the other scales (GRS 1 and 2, NRS and C-GRS) when compared with the VRS.

The change in pain intensity following stimulation as recorded with the VRS was compared with the % change calculated from the other scales (VAS, GRS 1 and 2, NRS, C-GRS) as described above. (Note that the 16 patients who reported increased pain following afferent stimulation are not included. This was done to permit a comparison of % change in pain intensity regarding the clinically most interesting interval, that is, pain reduction). No patient reported a post-stimulatory change exceeding 2 steps (words or categories), table 7. Interestingly the stepwise change in pain intensity with the VRS did not correspond to equally large changes on for example the VAS or some of the other scales (table 7) for each step taken.

Discussion

We have in the present study concentrated on measuring present pain intensity in acute pain. The patients participating in the study were randomly selected during a series of investigations on the pain reducing effect of afferent stimulation. This is the reason for the unequal size of the different groups receiving various forms of stimulation (methods) and explains the overall low pain reduction using TENS or vibration in the present study as compared with earlier findings.[8 9] However, the aims of the present study were not to analyse the efficacy of various stimulation techniques and therefore this will not be further commented on.

Table 4 *A. Correlation (r) regarding change in pain intensity following stimulation using the C-GRS vs the VAS, GRS1, GRS2 and NRS. All values were significant at p < 0·001. B. Mean difference in pain reduction (% change) after stimulation as recorded with the different scales. N = 64; 16 patients who recorded increased pain after stimulation are excluded*

A.

Scale C-GRS vs	VAS	GRS1	GRS2	NRS
Correlation (r)	0·83	0·80	0·86	0·85

B.

Scale	*Mean diff.*	*SD*	*t value*	*P*
C-GRS-VAS	0·8%	16·54	0·39	NS
-GRS1	−2·2	18·91	−0·94	NS
-GRS2	2·6	15·30	1·41	NS
-NRS	−0·5	15·20	−0·29	NS

Table 5 *Number of patients experiencing < 50% or ⩾ 50% reduction in pain intensity following stimulation*

Scale	*Change in pain intensity (%)*	
	< 50%	*⩾ 50%*
VAS	66	14
GRS1	62	18
GRS2	67	13
NRS	65	15
C-GRS	61	19

N = 80. No significant difference among groups; chi-square test, significance level p < 0·05.

A good and significant correlation among the different scales used was seen both before and after (except the VRS, see below) afferent stimulation. The NRS in the present study and in recent papers,[10–12] has proved to be an alternative to the established VAS. This is of special interest since the numerical scale (NRS) is well suited to be combined with the new technique of portable and computerized pain recording devices.[13 14] The corresponding results between the NRS and the VAS/GRS suggest similarities in the patients' strategy to use the different scales to record their present pain intensity. The good correlation between the VAS and the GRS might of course also be due to the similarities in design, facilitating a carry-over effect (halo phenomena).[10] It should be stressed, however, that no patient had been presented to any pain rating scale before participating in the experiments.

A second scale of interest is the "pain relief scale" (C-GRS). It turned out that the results obtained with this scale were in agreement with those recorded with

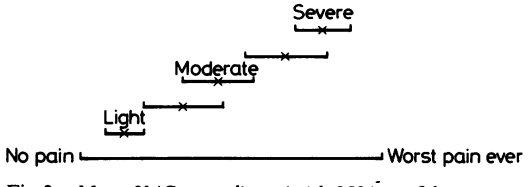

Fig 3 *Mean VAS-recordings (with 95% confidence interval) for those who reported light (n = 4), light-moderate (n = 15), moderate (n = 30), moderate-severe (n = 26) and severe (n = 5) pain before afferent stimulation. Total n = 80.*

Table 6 *Mean and SD values (mm) obtained with the different rating scales compared with category words chosen on VRS. Range of values given in brackets*

Scale					
VRS	*vs*	*VAS*	*GRS1*	*GRS2*	*NRS*
Light		14·5 (5·9) (8–20)	20·8 (7·2) (10–26)	21·8 (7·1) (14–30)	15·0 (8·1) (5–25)
Light-Moderate		34·2 (13·5) (14–72)	33·1 (12·2) (13–56)	35·0 (12·0) (13–70)	37·1 (13·1) (10–70)
Moderate		46·1 (11·2) (27–72)	47·8 (7·1) (34–61)	49·2 (10·6) (30–70)	50·9 (10.6) (30–70)
Moderate-Severe		68·4 (13·3) (48–99)	71·3 (11·1) (51–99)	71·9 (9·8) (55–99)	73·3 (10.3) (60–99)
Severe		80·6 (8·7) (68–91)	86·8 (8·5) (78–98)	82·8 (6·7) (75–92)	82·0 (5·7) (75–90)

the VAS/GRS/NRS. In a study on chronic pain patients[15] a modified "comparative" VAS was tested against an ordinary "absolute" VAS. The results were however less convincing than our present data. The "comparative" VAS in that study lacked absolute anchor words at the two extremes of the line, respectively, in contrast to the "absolute" VAS. The C-GRS in the present study was designed with absolute anchor words at the extremes. This might be one reason for the higher correlation presently found (r = 0·80–0·86) between the C-GRS and the other scales, as compared with the study by Carlsson[15] (r = 0·60). Another reason might be the fact that we studied acute pain. It has thus been found that the memory for acute pain may be reliable over a period of days[16] in contrast to the marked influence of time on measurement in chronic pain patients.[15 17] A good pain memory is a prerequisite when using a scale based on comparisons with an initial pain intensity at the start of stimulation. Furthermore we studied a larger and more homogenous population (regarding pain aetiology) than did Carlsson[15] which also may have influenced the results in a positive way.

Since the C-GRS used in this study was constructed as a relative scale it has to be complemented, at least initially, with an "absolute" scale such as the VAS or NRS. It is important to know the patients' pain intensity from the start, since the effect of a pain relieving treatment, including placebo,[18] might be dependent on the initial pain severity. The need to use two scales might be a limitation for some.

Table 7 *Reduction in pain intensity (in %) after stimulation calculated from the different scales in those who reported 0, 1 or 2 steps reduction in pain intensity using the VRS. N = 64; those 16 patients who reported increased pain are excluded*

Scale	*Change in pain intensity mean (%) SD*		
	0	*1*	*2*
VAS	9·7 (20·50)	34·9 (19·48)	55·4 (17·88)
GRS1	12·1 (22·77)	36·1 (20·71)	56·5 (26·90)
GRS2	8·4 (11·53)	34·5 (15·15)	52·5 (18·47)
NRS	11·6 (19·17)	37·6 (20·22)	51·4 (17·57)
C-GRS	10·1 (17·47)	38·8 (23·18)	61·4 (20·34)
	(n = 31)	(n = 26)	(n = 7)

The C-GRS in the present study was also constructed to permit continuous recording throughout the period of afferent stimulation. This enabled us to record and measure for example induction time for pain reduction during afferent stimulation in an easy and precise way as compared to the use of a set of VAS on separate paper sheets. The technique has been used in earlier studies on healthy subjects and patients receiving afferent stimulation both in experimental and clinical situations.[19 20] An ordinary VAS/GRS or a scale such as the NRS can of course easily be adopted to this technique using a simple pen-recorder or a computer.[13]

Since 30 patients verbally reported an unchanged pain intensity following afferent stimulation it was possible to estimate the reliability/reproducibility for the different scales. No scale was superior and the results indicate a fairly good reliability (cf table 3).

Our results indicate that an interval of ± 5 mm or $\pm 10\%$ change in pain intensity could be regarded non-significant. This ability to define an interval of a non-significant change in pain intensity for a certain scale is of great value and may increase the relevance of obtained data in studies on pain relieving treatments.

A problem with rating scales, using category judgements (for example the VRS in the present study), is that the relative rank or strength between the different words is often unknown. Furthermore, the limit(s) between different categories is also often unknown with a presumption of equal intervals between the various used words. This is reflected in a simple assignment of numbers to rank the categories in ascending or descending strength, as seen in the statistical analyses in various reports. This may be hazardous especially when using parametric methods. Interestingly, the boundaries of the various categories were not equally spaced and the 6-graded VRS turned out to behave like a 4-graded scale when comparing it

with the VAS/GRS/NRS. This might be a reason for the low correlation between the VRS and the other scales as found presently and by others (range 0·40–0·64).[11 21 22] We also analysed the data from the different scales measuring the reduction of pain following afferent stimulation. We found that the change in pain intensity using the VRS was not proportional for a change between 0, 1 or 2 category words when comparing it with the other scales. This is interesting since category scales most often have been used based on the assumption that the change between category words represent an equal change in pain intensity. This assumption might not be valid as shown by others[10 23] and supported by our findings. The VRS might be a less sensitive scale[24 25] but the sensitivity of the VRS might of course be improved if the relative strength of each category word is known.[23] It therefore seems important to use a VRS in parallel with a validated scale of well known behaviour to unravel the relative and absolute ranks of the different categories used. A technique for the validation of different rating scales in general, using cross-modality matching, has been presented[26] and later specifically tested with the VAS.[27]

A reason for the discrepancy between the VRS and the other scales might be due to a difference in patient preference for a certain scale. This seems less probable, however, since it was found in a previous study[11] that an adjectival scale was in fact preferred (compared with a VAS and a NRS) but this did not influence measurements.

The results of the present study show that pain rating scales, such as the VAS, GRS and NRS, yield similar results measuring present pain intensity in patients suffering acute oro-facial pain, either before or after a period of afferent stimulation using TENS/vibration or placebo. The NRS and C-GRS, in contrast to the VRS, are interesting and comparable alternatives to the generally used VAS.

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References

1 Melzack R, Torgerson WS. On the language of pain. *Anesthesiology* 1971;**34**:50–9.

2 Melzack R. The McGill Pain Questionnaire: Major properties and scoring methods. *Pain* 1975;**1**:277–99.

3 Chapman CR, Casey KL, Dubner R, Foley KM, Gracely RH, Reading AE. Pain measurement: an overview. *Pain* 1985; **22**:1–31.

4 Dubuisson D, Melzack R. Classification of clinical pain descriptions by multiple group discriminant analysis. *Exp Neurol* 1976;**51**:480–7.

5 Grushka M, Sessle BJ. Applicability of the McGill Pain Questionnaire to the differentiation of "toothache" pain. *Pain* 1984;**19**:49–57.

6 Huskisson EC. Visual analogue scales. In: R Melzack, ed. *Pain Measurement and Assessment*. Raven Press, New York, 1983:33–37.

7 Scott J, Huskisson EC. Graphic representation of pain. *Pain* 1976;**2**:175–84.

8 Hansson P, Ekblom A. Transcutaneous electrical nerve stimulation (TENS) as compared to placebo TENS for the relief of acute oro-facial pain. *Pain* 1983;**15**:157–65.

9 Hansson P, Ekblom A. Influence of stimulus frequency and probe size on vibration-induced alleviation of acute orofacial pain. *Appl Neurophysiol* 1986;**49**:155–65.

10 Downie WW, Leatham PA, Rhind VM, Wright V, Branco JA, Andersson JA. Studies with pain rating scales. *Ann Rheum Dis* 1978;**37**:378–81.

11 Kremer E, Hampton Atkinson J, Ignelzi RJ. Measurement of pain: patient preference does not confound pain measurement. *Pain* 1981;**10**:241–8.

12 Jensen MP, Karoly P, Braver S. The measurement of clinical pain intensity: a comparison of six methods. *Pain* 1986;**27**:117–26.

13 Posner JA. A modified submaximal effort torniquet test for evaluation of analgesics in healthy volunteers. *Pain* 1984; **19**:143–51.

14 Gustavsson S, Nyren O, Hedin B. Pain recording with a portable data logger in peptic ulcer. *Gastroenterology* 1985;**88**:1520.

15 Carlsson AM. Assessment of chronic pain. I. Aspects of the reliability and validity of the visual analogue scale. *Pain* 1983;**16**:87–101.

16 Hunter M, Philips C, Rachman S. Memory for pain. *Pain* 1979;**6**:35–46.

17 Linton SJ, Melin L. The accuracy of remembering chronic pain. *Pain* 1983;**13**:281–5.

18 Beecher HK. *Measurement of Subjective Responses*. New York: Oxford University Press, 1959.

19 Ottoson D, Ekblom A, Hansson P. Vibratory stimulation for the relief of pain of dental origin. *Pain* 1981;**10**:37–45.

20 Ekblom A, Fjellner B, Hansson P. The influence of mechanical vibratory stimulation and transcutaneous electrical nerve stimulation on experimental pruritus induced by histamine. *Acta Physiol Scand* 1984;**122**:361–7.

21 Reading AE. A comparison of pain rating scales. *J Psychosom Res* 1980;**24**:119–24.

22 Ahles TA, Ruckdeschel JC, Blomchard EB. Cancer-related pain—II. Assessment with visual analogue scales. *J Psychosom Res* 1984;**28**:121–4.

23 Heft MW, Parker SR. An experimental basis for revising the graphic rating scale for pain. *Pain* 1984;**19**:153–61.

24 Joyce RB, Zutski DW, Hrubes V, Mason RM. Comparison of fixed interval and visual analogue scales for rating chronic pain. *Eur J Clin Pharmacol* 1975;**8**:415–20.

25 Sriwatanakul K, Kelvie W, Lasagna L, Calimlim JF, Weiss OF, Mehta GI. Studies with different types of visual analog scales for measurement of pain. *Clin Pharmacol Ther* 1983;**34**:234–9.

26 Gracely RH, McGrath P, Dubner R. Ratio scales of sensory and affective verbal pain descriptors. *Pain* 1978;**5**:5–18.

27 Price DD, McGrath P, Rafii A, Buckingham B. The validation of visual analogue scales as ratio scale measures for chronic and experimental pain. *Pain* 1983;**17**:45–56.