

Differences in Dentists' Working Postures When Adopting Proprioceptive Derivation vs. Conventional Concept

Montakarn Chaikumarn

Department of Human Work Sciences, Luleå University of Technology, Luleå, Sweden

New technologies and changes in dental care, including the proprioceptive derivation (Pd) concept, aimed at providing dentists with greater comfort and better health, were introduced in Thailand. The aim of this study was to investigate the differences in dentists' working postures when adopting different work concepts: Pd and the conventional concept. The results showed differences in dentists' sitting posture, clock-related working positions, and Rapid Upper Limb Assessment (RULA) scores. This implied that Pd helped dentists to discover new ways of positioning themselves, and working comfortably and effectively, which made it possible for them to adopt better working posture and have lower RULA scores. In conclusion, the Pd concept had a positive effect on dentists' working posture.

proprioceptive derivation posture RULA dentist

1. INTRODUCTION

Musculoskeletal disorders (MSDs) are common among dental care workers as indicated in many studies [1, 2, 3, 4, 5]. Over a third of Finnish dentists have experienced at least one diagnosed musculoskeletal disease, which is above the average in the whole population [6]. A study in Sweden showed that both female and male dentists had higher prevalence of musculoskeletal symptoms during the past 12 months at the neck and shoulder region [4]. In Thailand, one of the most common occupational health problems (78%) among Thai dentists was musculoskeletal pain [7]. It has been suggested that work-related MSDs are associated with a number of ergonomic-related risk factors, such as vibration, repetitive movements, high static muscle and joint load, lack of pauses, forceful exertions, and non-neutral body postures [8, 9]. Working posture is the greatest risk factor for MSDs [10]. Many difficult working postures, including rotation and flexion of the cervical spine,

flexion of the elbow, and repetitive forceful hand grip are inherent in dental work [11], since dental work consists of precision tasks, involving a high degree of visual and manipulative elements, sometimes in combination with exertion of force [12]. Poor working postures generate high static loads (increased muscle tension), which create musculoskeletal discomfort or fatigue in the neck, shoulders, and upper back, and also work-related injury among professionals [13, 14, 15, 16, 17].

Not only do work-related MSDs cause suffering to dental professionals and their families, but they also add to the overall cost to society through lost productivity and increased use of medical and welfare services. The cost to society has been estimated at 2–14% of the gross national product in different studies in different countries [18, 19]. Therefore, the attention paid to and awareness of MSDs in the dental profession has increased noticeably in recent years. A great deal of ergonomics and new technology has been integrated into the modern dental office during the

past several decades. The concept of changes in dental practice by using technology in dentistry started many years ago. Considering that the new technologies and changes aim to give the dentist greater comfort and better health, many new technologies have been presented to the dentistry after sit-down dentistry, including four-handed dentistry [20] and the proprioceptive derivation (Pd) concept [21, 22].

The Pd concept was developed by Dr. Daryl R. Beach. At first, this concept was called performance logic [22, 23, 24]. A primary aim of the Pd concept is to provide dentists with a good posture and optimal control of dental tasks while minimizing musculoskeletal discomfort. The Pd concept has an Ideal Posture, which is simply described as the dentist sitting upright, both hands at the level of the heart, being able to easily reach necessary equipment and materials; the patient lying horizontally. The dentist is encouraged to maintain the optimum posture with maximum balance and comfort (Figure 1). In addition,

dentists are encouraged to determine their most balanced and comfortable working posture, and then integrate that posture into their clinical practice within the ideal posture. Once a dentist is sitting comfortably, the patient's oral cavity is positioned to support the dentist's derived balanced position, and fine adjustments are made during the appointment to allow the dentist to maintain balanced positioning and to be able to work more accurately, more efficiently, and with less physical and mental demand [25].

This ideal posture and position can be achieved through self-proprioceptived derivation and a complementary performance process [26]. In addition, the Pd concept fundamentally includes a system of reasoning that guides dentists in determining their most comfortable working posture and position, and increases their awareness of the work environment and preferred working position. This concept provides dentists with a number of strategies, such as five movements and the 10-step protocol, which help them to maintain

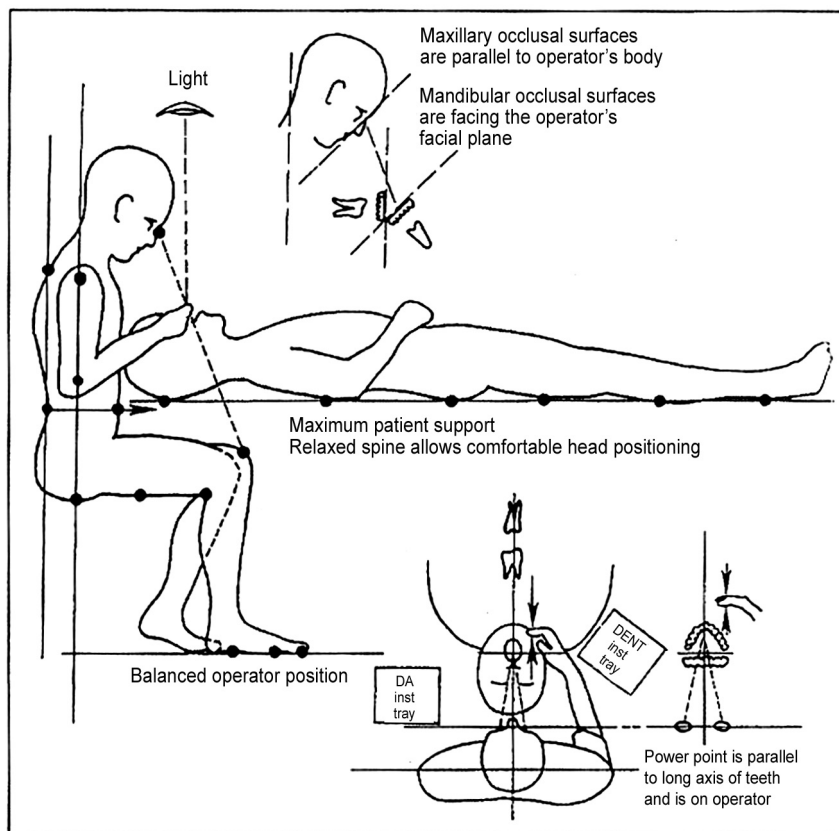


Figure 1. Dentist and patient posture according to the Pd concept [21, p. 288]. Notes. Pd—proprioceptive derivation, DENT—dentist's, DA—dentist's assistant's, inst—instrument.

their ideal posture with optimal control while working [21, 22, 27, 28].

No study had been done regarding the differences in working postures when dentists adopt different work concepts in Thailand. Therefore, the aim of this study was to investigate the differences in dentists' working posture when adopting different dental work concepts, namely, Pd and the conventional concept.

2. PARTICIPANTS AND METHODS

2.1. Participants

Two groups of dentists participated in this study. One group, the Pd one, consisted of 8 dentists who had been working with Pd. The other group, the conventional one, comprised 10 dentists who had been working with the conventional concept.

2.2. Methods

The observation study was conducted separately for each group by the same observer. Each observation took about 15–30 min for each dentist

in both groups. The observation was carried out while the dentists worked with patients. Each dentist's postures were coded on a data collection sheet according to the categorisation of sitting postures for dentists (clock-related sitting positions) [29]. Rapid Upper Limb Assessment (RULA) assessment [30] was used to give a quick and systematic assessment of the dentists' postures. Each dentist's most extreme, unstable, or awkward posture was selected and scored on a RULA worksheet. The final score (the RULA grand score) and the action level were also processed with free online RULA software [31]. The RULA grand score and the action level category are presented in Table 1. The mean RULA score of each group was calculated and compared with SPSS version 11.0 statistical analysis software.

3. RESULTS

3.1. Characteristic of the Dentists

Characteristic of the dentists in this study are shown in Table 2.

TABLE 1. The RULA Grand Score Can Be Categorised Into Four Action Levels of the RULA Grand Score [32]

Action Level	RULA Score	Description
1	1 or 2	Indicates that posture is acceptable if it is not maintained or repeated for long periods
2	3 or 4	Indicates that further investigation is needed and changes may be required
3	5 or 6	Indicates that investigation and changes are required soon
4	7	Indicates that investigation and changes are required immediately

Notes. RULA—Rapid Upper Limb Assessment.

TABLE 2. Characteristic of Two Groups of Dentists in the Study

Characteristics	Work Concept	
	Pd (<i>n</i> = 8)	Conventional (<i>n</i> = 10)
Age (<i>M</i> ± <i>SD</i>)	32.38 ± 7.76	44.60 ± 5.70
Gender		
Male	4	1
Female	4	9
Handiness		
Right	8	9
Both	0	1
Years in profession (<i>M</i> ± <i>SD</i>)	6.19 ± 6.29	18.83 ± 5.22
Working hours in clinic/week (<i>M</i> ± <i>SD</i>)	24.00 ± 8.73	39.9 ± 6.40

Notes. Pd—proprioceptive derivation.

3.2. Postural Analysis

3.2.1. Working posture

All dentists chose sitting as their main working posture. No dentists alternated their posture between sitting and standing. Further, dentists in the Pd group used dental chairs with lumbar support which were designed according to the Pd concept. Dentists in the conventional group used normal office chairs with backrests.

3.2.2. Categories of sitting posture





Dentists' sitting posture can be categorised into four postures [29]. The results showed that the

most frequent sitting posture among dentists working according to the Pd concept was posture 2 (90%) and posture 1 (10%). Dentists who worked conventionally adopted posture 1 (50%) and posture 3 (40%) while working.

3.2.3. The clock-related working positions

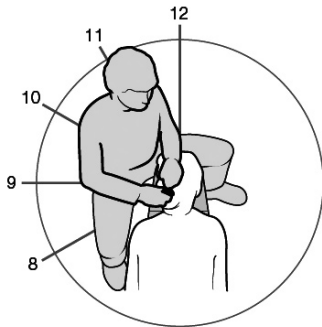
The most frequent clock-related working positions were assessed. Dentists in the Pd group sat at the 12 o'clock (87.5%) and 10 o'clock positions (12.5%). Dentists working conventionally worked in a sitting posture as well but most of them worked at the 10 o'clock position (80%), while a few of them worked at the 9 o'clock (10%), and 11 o'clock (10%) positions.

TABLE 3. Category of Sitting Posture and the Number of Dentists in Each Category

Sitting Posture Category	Work Concept	
	Pd (n = 8)	Conventional (n = 10)
 1. The whole back bent, the seat straight	1	5
 2. Straight low and upper back, the neck bent, the seat straight	7	—
 3. The whole back bent, the seat tilted forward	—	4
 4. Straight low and upper back, the neck bent, the seat tilted forward	—	1

Notes. Pd—proprioceptive derivation.

TABLE 4. The Main Clock-Related Working Positions of Dentists Working With Pd and Conventional Concepts

Position	Work Concept	
	Pd (n = 8)	Conventional (n = 10)
 12 o'clock	7	1
11 o'clock	—	1
10 o'clock	1	8

Notes. Pd—proprioceptive derivation.

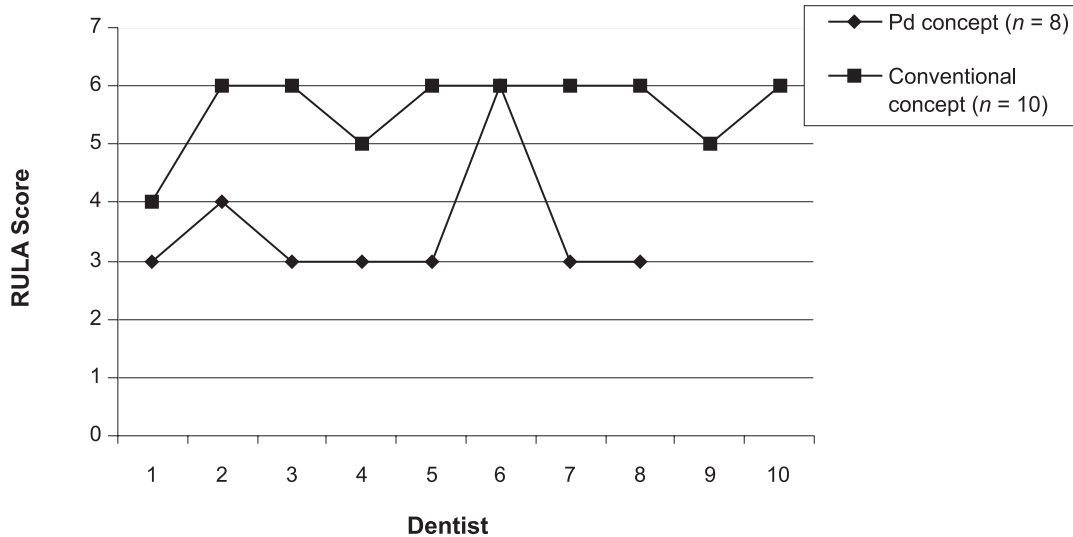


Figure 2. RULA score among the dentists in each group. *Notes.* RULA—Rapid Upper Limb Assessment.

3.3. RULA Score and Action Level

There was a significant difference in the average RULA score between the two groups of dentists ($p < .05$). The average RULA score for dentists in the Pd group was 3.5, which fell into action level 2. This indicates that further investigation is needed and changes may be required. The average RULA score of dentists in the conventional group was 5.6, which fell into action level 3, indicating that investigation and changes were required soon.

4. DISCUSSION

Dentists' working posture is a topic many researchers have paid most attention [2, 29, 33]. All dentists from both groups chose to work in a sitting posture 100% of the time. This finding is similar to a study by Rundcrantz et al. [33], which found that 95% of dentists worked in a sitting posture. Finsen et al.'s [2] study also found that 82% of dentists mainly sat while treating a patient. Very recently Marklin and Cherney [34] reported that dentists were seated 78% of the time. However, it was found that dentists who worked in the sitting posture had more severe low back pain than those who alternated between sitting and standing [35]. Therefore, it is important to recommend dentists in both groups to alternate their postures in order to prevent MSDs.

Dentists' sitting postures were put into four categories [29]. Based on these categories, the result showed that 7 of the dentists working with Pd mainly sat in posture 2: straight low and upper back, the neck bent, the seat straight. Only one dentist in this group adopted sitting posture 1: the whole back bent and the seat straight. Dentists working with the conventional concept most of the time adopted postures 1 and 3: the whole back bent, the seat tilted forward. Obviously, Pd provided horizontal seats for the dentists based on its philosophy and the ideal working posture as shown in Figure 1 [21, 22]. On the other hand, dentists working with conventional concept had the possibility to tilt their seats. A study by Bandix [36] reported that a 5° forward inclination and horizontal seats gave greater comfort than backward inclined seats. However, it is not definitely clear whether the horizontal seat or the forward inclined one is better. Another noticeable difference in the sitting posture is that dentists working with the Pd concept adopted more upright sitting. This observation implied that Pd gave dentists a better sitting posture than that in dentists working with the conventional concept.

In this study, dentists working with the conventional concept mostly (80%) worked at the 10 o'clock position, whilst a few of them worked at 9 (10%) and 11 (10%) o'clock positions (Table 3). Few studies have included clock-related

position. However, this result corresponds well with an investigation carried out in Denmark by Finsen et al. [2], which found that almost half of dentists used the 10 o'clock position as their most common position, while the second and third most common ones were 11 and 9 o'clock positions, respectively. Rundcrantz et al. [33] also found in her study that the most frequently adopted position was the 9 o'clock position when treating a patient. In contrast, all dentists working with the Pd concept most of the time worked at the 12 o'clock position. The possible reason for why most of the dentists in the Pd group chose to work at this position is related to the movement guideline provided by the concept [21]. Nevertheless, a further investigation on this issue will possibly further explain this. In addition, Pollack [37] reported that many factors influenced dentists' posture and position,

e.g., the type of dental treatment, patient's position (Figure 3).

The result of postural analysis using RULA showed that there was a significant difference in RULA grand scores between the two groups of dentists. Most dentists working with Pd had lower RULA grand scores, even though one of them had a RULA grand score equal to 6, like dentists in the conventional group. Moreover, significant differences in posture combinations were reflected in different grand RULA scores in the two groups. Figure 4 shows an example of a posture combination which gives grand RULA scores of 3 and 6 in this study. It is clear that the awkward postures of the neck, trunk, and upper limbs contributed to a high RULA score.

A few comments can be made on the relation between the optimal posture suggested by Pd

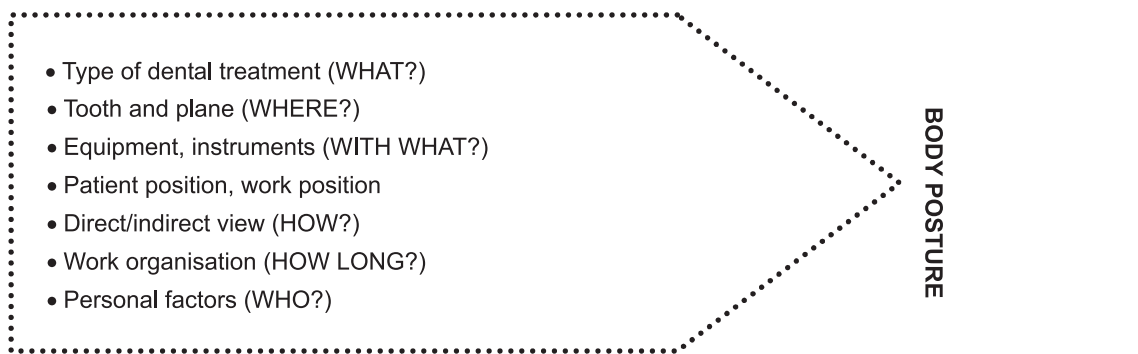


Figure 3. Factor influencing the working posture of dentist (modified from Rundcrantz et al. [33]).

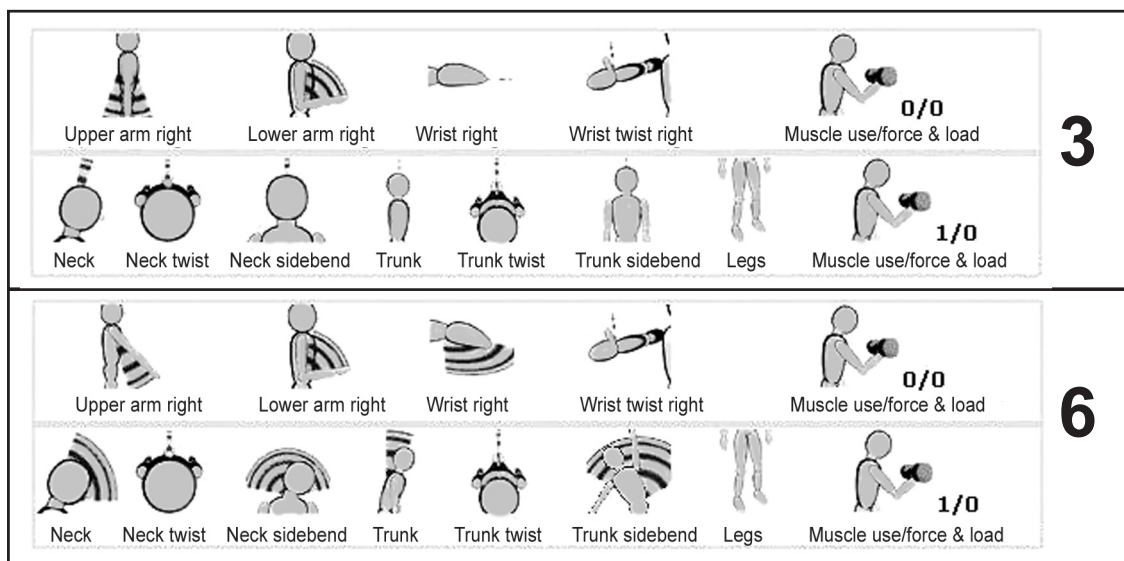


Figure 4. Differences in posture combination for RULA score 3 and 6 from this study. Notes. RULA—Rapid Upper Limb Assessment, Pd—proprioceptive derivation; RULA score = 3 from a dentist in the Pd group, and RULA score = 6 from a dentist in the conventional group.

and the one actually taken by dentists. Firstly, most dentists in the Pd group adopted an upright sitting posture with a straight low and upper back, the neck bent, the seat straight, which is similar to the suggested ideal posture. Further, they worked within the range of the suggested clock-related positions [22]. Moreover, one dentist in the Pd group had an extremely high RULA score compared to others within the group. After analysing the combination of postures taken by that dentist, it turned out that the actual posture of the trunk and upper limbs very much deviated from what the Pd concept suggested.

In this study, RULA was selected to use as a quick and systematic objective assessment of the posture, forces, and activities undertaken by dentists. RULA is a tool that assesses biomechanical and postural loading on the whole body with particular attention paid to the neck, trunk, and upper limbs and also a survey method developed for use in ergonomic investigations of workplaces where work-related upper limb disorders are reported [30]. Furthermore, RULA assessment requires little time to complete and the scoring generates an action level which indicates the level of intervention required to reduce the risks of injury due to physical loading on the dentist [32]. Additionally, RULA action levels can be used as an aid in efficient and effective control of any risks identified, and those actions lead to a further detailed investigation [32].

The reliability of postural analysis is crucial. Both tool and observation play an important role. Additionally, the reliability of RULA has been checked on video display unit (VDU) users and sewing machine operators [37]. Dental work can be considered sedentary work like VDU users' and sewing machine operators' work, because the dentist sits most of the time while treating patients. The experience of the observer also plays an important role in postural analysis. However, the observer in this study had long experience of using RULA and also had a rehearsal of the RULA procedure and technique before conducting each observation. In addition, Dismukes [38] had done a study on the accuracy of using RULA by people untrained in ergonomics. It was concluded that

they can provide accurate, rapid initial assessments of jobs that may result in upper limb disorders.

There were constraints in conducting this study, which affected the study design. Firstly, there were differences in working hours and, as a result of being the newest dental school in Thailand, the dentists who were working with the Pd concept had fewer years of profession practice compared with the dentists from the conventional group. Due to a shortage of lecturers in that new dental school, the dentists had to do more lecturing and spent shorter time in the clinic. The number of participants in this study was limited due to the fact that there was only one dental school in Thailand using Pd. Thus, it is difficult to draw a general conclusion from this study regarding the differences in dentists' postures between the two work concepts.

5. CONCLUSION

The results implied that the Pd concept helped dentists to discover new ways of positioning themselves, and working comfortably and effectively, which made it possible for dentists to adopt a more neutral, less awkward working posture and have a lower RULA score. However, dentists who work with the Pd concept still adopt awkward postures, such as twisted, abducted upper arm, trunk bent sideways. In conclusion, the Pd concept had a positive effect on dentists' working posture.

REFERENCES

1. Fish D, Morris-Allen D. Musculoskeletal disorders in dentists. *NY State Dent J* 1998; 64(4):44–8.
2. Finsen L, Christensen H, Bakke M. Musculoskeletal disorders among dentists and variation in dental work. *Appl Ergon* 1998; 29(2):119–25.
3. Åkesson I, Johnsson B, Rylander L, Moritz U, Skerfving S. Musculoskeletal disorders among female dental personnel: clinical examination and a 5-year follow-up study of symptoms. *Int Arch Occup Environ Health* 1999;72(6):395–403.

4. Åkesson, I, Schütz A, Horstmann V, Skerfving S, Moritz U. Musculoskeletal symptoms among dental personnel—lack of association with mercury and selenium status, overweight and smoking. *Swed Dent J* 2000;24(1–2):23–38.
5. Santos Filho SB, Barreto SM. Occupational activity and prevalence of osteomuscular pain among dentists in Belo Horizonte, Minas Gerais State, Brazil: a contribution to the debate on work-related musculoskeletal disorders. *Cad Saude Publica* 2001;17(1): 181–93.
6. Murtomaa H. Work-related complaints of dentists and dental assistants. *Int Arch Occup Environ Health* 1982;50(3):231–6.
7. Chohanadisai S, Kukiattrakoon B, Yapong B, Kedjarune U, Leggat PA. Occupational health problems of dentists in southern Thailand. *Int Dent J* 2000;50(1): 36–40.
8. Winkel J, Westgaard R. Occupational and individual risk factors for shoulder-neck complaints. Part II. The scientific basis (literature review) for the guide. *Int J Ind Erg* 1992;10:85–104.
9. Szymanska J. Disorders of the musculoskeletal system among dentists from the aspect of ergonomics and prophylaxis. *Ann Agric Environ Med* 2002;9:169–73.
10. Shugars DA, Williams D, Cline SJ, Fishburne C Jr. Musculoskeletal back pain among dentists. *Gen Dent* 1984;32(6): 481–5.
11. Wieslander G, Norbäck D. Dental work. In: Brune D, Gerhardson G, Crockford GW, D'Auria D, editors. *The workplace: volume 2*. Geneva, Switzerland: International Labour Office: Scandinavian Science Publishers 1997. p. 82–9.
12. Hagberg M, Hagberg C. Risks and prevention of musculoskeletal disorders among dentists. In: Brane D, Edling C, editors. *Occupational hazards in the health professions*. Boca Raton, FL, USA: CRC; 1989. p. 323–32.
13. Rundcrantz BL, Johnsson B, Moritz U. Cervical pain and discomfort among dentists: epidemiological, clinical and therapeutic aspects. *Swed Dent J* 1990;14(2):71–80.
14. Gerwadowski LJ, McFall DB, Stach DJ. Carpal tunnel syndrome: risk factors and preventive strategies for the dental hygienist. *Dent Health (London)* 1992;31(5):5–10.
15. Wolny K, Shaw L, Verougstraete S. Repetitive strain injuries in dentistry. *Ontario Dent* 1999;76(2):13–9.
16. Adam J, Yoser DC, Mito RS. Injury prevention for the practice of dentistry. *J Calif Dent Assoc* 2002;30(2):170–6.
17. Alexopoulos EC, Stathi IC, Charizani F. Prevalence of musculoskeletal disorders in dentists. *BMC Musculoskelet Disord* 2004;5(1):16.
18. Murray CJ, Lopez AD. Global mortality, disability, and the contribution of risk factors: Global Burden of Disease Study. *Lancet* 1997;349(9063):1436–42.
19. Leigh J, Macaskill P, Kuosma E, Mandryk J. Global burden of disease and injury due to occupational factors. *Epidemiology* 1999; 10(5):626–31.
20. Finkbeiner BL. Four-handed dentistry revisited. *J Contemp Dent Pract* 2000;1(4): 74–86.
21. Belenky MM. Human-centered ergonomics: proprioceptive pathway to occupational health and peak performance in dental practice. In: Murphy, DC, editor. *Ergonomics and the dental care worker*. Washington, DC, USA: American Public Health Association; 1998. p. 275–99.
22. Chaikumarn M. Working conditions and dentists' attitude towards proprioceptive derivation. *International Journal of Occupational Safety and Ergonomics (JOSE)* 2004;10(2):137–46.
23. Proprioceptive derivation [homepage of the Faculty of Dentistry, Thammasat University, Thailand]. Retrieved May 12, 2005, from: <http://www.tu.ac.th/org/dentist/teach4.html>. In Thai.
24. Beach D. Personal communication. December 15, 2001.
25. Dougherty M. Ergonomic principles are proprioceptive derived. Retrieved February 10, 2005, from: <http://www.designbyfeel.com>
26. Colangelo G, Belenky MMJ. Performance logic: a key to improving dental practice. *Dent Pract Adm* 1990;7(4):173–7.
27. Sunell S, Maschak L. Positioning for clinical dental hygiene care. Preventing back, neck

- and shoulder pain. *Probe* 1996;30(6): 216–9.
28. Rucker LM, Sunell S. Ergonomic risk factors associated with clinical dentistry. *J Calif Dent Assoc* 2002;30(2):139–48.
 29. Runderantz B, Johnsson B, Moritz L. Occupational cervico-brachial disorders among dentists: Analysis of ergonomics and locomotor functions. *Swed Dent J* 1991;15(5):105–115.
 30. McAtamney L, Nigel Corlett E. RULA: a survey method for the investigation of work-related upper limb disorders. *Appl Ergon* 1993;24(2):91–9.
 31. RULA—rapid upper limb assessment. Retrieved November 2, 2005, from <http://www.ergonomics.co.uk/Rula/Ergo/>
 32. McAtamney L, Nigel Corlett E. RULA—a rapid upper limb assessment tool. In: Robertson SA, editor. *Contemporary ergonomics*. London, UK: Taylor & Francis; 1994. p. 286–91.
 33. Runderantz BL, Johnsson B, Moritz U. Cervical pain and discomfort among dentists. Epidemiological, clinical and therapeutic aspects. Part 1: a survey of pain and discomfort. *Swed Dent J* 1990;14(2): 71–80.
 34. Marklin RW, Cherney K. Working postures of dentists and dental hygienists. *Calif Dent Assoc* 2005;33(2):133–6.
 35. Ratzon NZ, Yaros T, Mizlik A, Kanner T. Musculoskeletal symptoms among dentists in relation to work posture. *Work* 2000;15(3):153–8.
 36. Bendix T, Biering-Sorensen F. Posture of the trunk when sitting on forward inclining seats. *Scand J Rehabil Med* 1983;15(4): 197–203.
 37. Pollack-Simon R. Dental office ergonomics: how to reduce stress factors and increase efficiency. *J Can Dent Assoc* 1996; 62(6):508–10.
 38. Dismukes S. An ergonomic assessment method for non-ergonomists. In: *Proceedings of the Silicon Valley Ergonomics Conference and Exposition—ErgoCon '96*, Palo Alto, California, May 12–15, 1996. San Jose, California, USA: Silicon Valley Ergonomics Institute, San Jose State University; 1996. p. 106–17.