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Review

The use of laser Doppler flowmetry to evaluate oral soft tissue blood flow in humans: A review

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ABSTRACT

The objective of this work is to define the conditions for improving the use of laser Doppler flowmetry (LDF) and to determine the limits for the use of this technique.

This article systematically reviews the literature on the evaluation of oral soft tissue blood microcirculation by LDF. We analysed the available literature through October 2016 using the database resources Medline/PubMed, the Cochrane Oral Health Group Specialist Trials Register and the ISI Web of Knowledge.

Several points emerged from this literature review

The use of LDF involves specific constraints; however, the influence of different factors (temperature, tobacco, pressure etc.) must be adequately controlled when using LDF. LDF measurements of soft tissue within the oral cavity vary depending on the anatomical site. In dentistry, LDF can be used to track healing progress in periodontal surgery and to diagnose vascular flow changes in the connective tissue of mucosae covered by a removable prosthesis at an early stage prior to the onset of clinical inflammation signs.

1. Introduction

LDF allows the measurement of microcirculation in tissues of humans and animals. This approach was first used in the 1980s and continues to be used because it is not invasive and is an easy technique to use after a training period. The principle of LDF is based on light-tissue interactions, i.e., the principle of the Doppler effect as applied to laser radiation (Doppler, 1842) (Fig. 1). The main disadvantage of LDF is that it does not accurately measure blood flow, so it cannot be used to calculate absolute blood flow (e.g., in units of ml/min/100 g tissue). LDF produces a relative value of blood flow (Vongsavan & Matthews, 1993). This technique has been used for various tissues such as skin (Svalestad, Hellem, Vaagbø, Irgens, & Thorsen, 2010), retina (Riva, Geiser, & Petrig, 2010), intestine (Hoff, Gregersen, & Hatlebakk, 2009), kidney (Babos, Járai, & Nemcsik, 2013) and bone (Hellem, Jacobsson, Nilsson, & Lewis, 1983). In addition, in the orofacial area (Retzepi, Tonetti, & Donos, 2007a; Verdonck et al., 2009), this tool has been used to highlight the microcirculation of the tongue (Singh, Stansby, & Harrison, 2008), the buccal mucosa (Hirai, 2005), periodontal tissue (Cho, Yu, Lee, Lee, & Kim, 2013), the masseter muscle (Curtis, Gansky, & Plesh, 2012), human dental pulp (Gazelius, Olgart, Edwall, & Edwall, 1986; Chen & Abbott, 2009) and luxated teeth (Gazelius, Olgart, & Edwall, 1988).

However, issues involving the use of this technique must be strictly respected, such as the method of standardization adopted for the Periflux, the effects of ambient light and the artefacts caused by probe movement during measurements (Vongsavan & Matthews, 1993). Therefore, in dentistry (Orekhova & Barmasheva, 2013), the study of blood microcirculation in various soft tissues is used to evaluate the following:

- The mucosal variation of microcirculation due to pathological conditions in the oral cavity (gingivitis, periodontitis, white and red lesions)
- The healing of gingival, palatal and connective grafts
- Tissue modification in mucosa recovery due to dentures

This article systematically reviews the literature on the use of LDF

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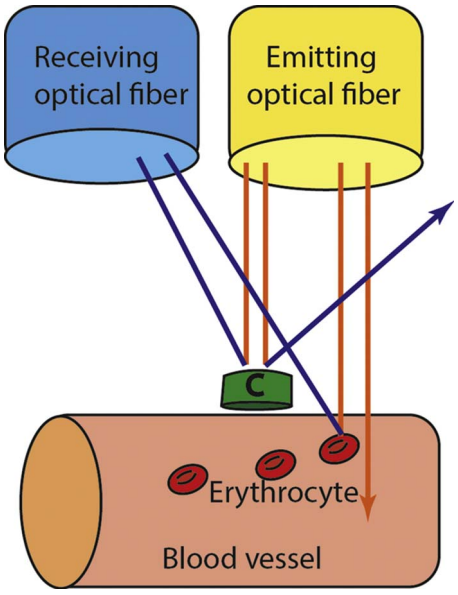

Fig. 1. Effect of Doppler applied to laser radiation; c: immobile cell.

for studying oral mucosa blood microcirculation.

2. Materials & methods

A literature search for articles published through October 31, 2016 was performed using the following keywords: “oral mucosa,” “palatal mucosa,” “alveolar mucosa,” “mucosa gingival,” “laser Doppler flowmetry” and “laser Doppler”. Combinations of the keywords were also used. A total of 295 articles were extracted from PubMed/MEDLINE; the Cochrane Oral Health Group (COHG) Specialist Trials Register and ISI Web of Knowledge. Article titles and abstracts were examined to exclude irrelevant articles and articles that had already been manually identified. Then; the abstracts of the selected articles were read to identify studies that met the inclusion criteria. Finally; additional articles were obtained by reviewing the references of the selected articles.

2.1. Inclusion criteria

Original articles written in English were included in the review if they met one of the following criteria:

- Articles on blood microcirculation in the human oral cavity mucosa measured using laser Doppler
- Articles on the measurement of microcirculation in the human oral cavity mucosa using laser Doppler
- Articles on the variability of blood microcirculation in the oral cavity mucosa measured using laser Doppler

2.2. Exclusion criteria

- Articles were excluded from this review if they met one of the following criteria:
- Articles on blood microcirculation in the oral cavity of animals measured using laser Doppler
- Articles on blood microcirculation in the oral mucosa of animals measured using laser Doppler
- Articles on blood microcirculation in dental organs measured using laser Doppler (indirect measurement)
- Clinical case reports (due to the high variability of the results)
- Articles written in a language other than English.

The articles were divided into five themes to provide a precise clinical perspective in this review. The following themes were analysed:

1. Recording techniques used with LDF
2. Stimuli that can modify blood flow
3. Oral cavity soft tissues that are studied with LDF
4. LDF applications in surgical treatments
5. The influence of mucosal recovery on a removable prosthesis

3. Results

The electronic and manual literature searches resulted in 295 articles. After evaluating the titles and abstracts, the references from the selected articles, and the exclusion and inclusion criteria, 30 articles were chosen and read entirely (Fig. 2).

To summarize our results, the papers were grouped according to five themes as follows:

1. Recording techniques used with LDF (Table 1) (Hoke, Burkes, White, Duffy, & Klitzman, 1994; Hinrichs, LaBelle, & Aeppli, 1995; Matsuki, Xu, and Nagasawa, 2001; Singh et al., 2008)

2. Stimuli that can modify blood flow (Table 2) (Baab, Oberg, & Holloway, 1986; Herlofson, Brodin, & Aars, 1996; Ahn & Pogrel, 1998; Ketabi & Hirsch, 1997; Perry, McDowell, & Goodis, 1997; Heckmann et al., 2000; Kemppainen, Avellan, Handwerker, & Forster, 2003; Patino-Marin et al., 2005; Sakr et al., 2010; Kawaai et al., 2013); (Reuther, Hale, Matharu, Blythe, & Brennan, 2016)

3. Oral cavity soft tissues that are studied with LDF (Table 3) (Baab, Oberg, & Lundström, 1990; Matheny, Johnson, & Roth, 1993; Matheny,

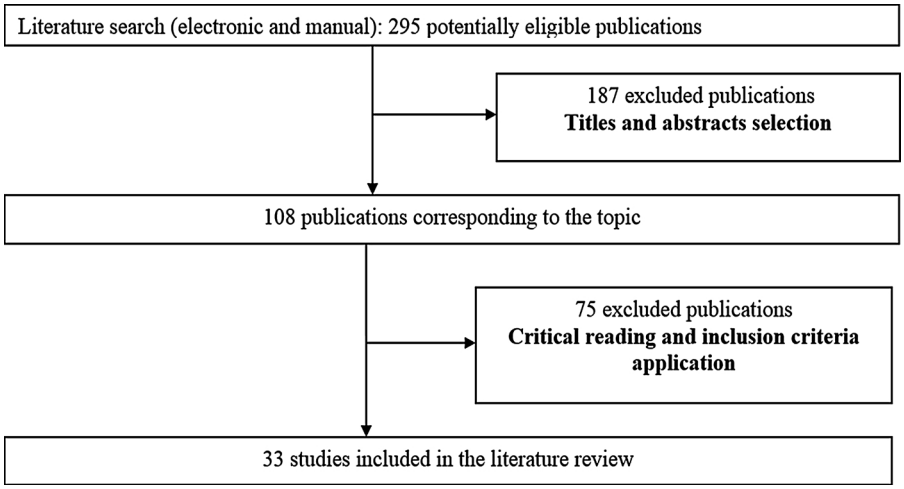

Fig. 2. Selection procedure of articles included in the literature review.