

# A new way of looking at the face?

Facial articulation – and the ability to produce facial expressions – is a key component of human interaction and non-verbal communication. Facial function can be disrupted by a number of medical conditions. Emerging imaging technology has the potential to accurately record the deformation of rapidly changing surfaces, such as that of the human face during animation.

Three-dimensional scanners are devices which capture object shapes, with optical scanning systems being one of the most widely used. Optical scanning facilitates digitization of surfaces with high resolution and accuracy. Traditional three-dimensional optical scanners have been unable to rapidly acquire sequential three-dimensional surface data sets. Dynamic three-dimensional optical scanning (also known as four-dimensional scanning) is an emerging medical imaging technol-

ogy able to acquire time sequences of three-dimensional surface data at up to 60 times per second (snapshot images shown in *Figure 1*). This opens new research avenues to investigate clinically viable quantitative assessment methods for measurement of facial dysfunction. By applying mathematical deformable surface modelling to such dynamically-acquired three-dimensional surface data, even small changes in facial articulation can be detected and potentially correlated with specific types of dysfunction. This should facilitate the detection of even minor facial changes, with a range of potential clinical applications.

## Common neurological disorders and facial function

Several common neurological conditions alter facial function. For example, facial weakness may accompany stroke, or be

the result of Bell's palsy, and in both these situations there can be unilateral weakness, causing 'drooping' of the face. Impaired facial expression or 'masking' occurs in Parkinson's disease. Assessment of these impairments is usually based solely on clinical examination. Grading systems in use generally rely on the assessment of resting symmetry (Finsterer, 2008). Arguably, the effects for the patient of facial dysfunction may be relatively overlooked in routine neurological practice, but it should be noted that these impairments are associated with considerable morbidity. Various anatomical and psychological consequences can accompany facial weakness. Long-term sequelae of facial nerve (including Bell's) palsy can include persisting weakness, contractures, facial spasms, synkinesis, decreased tearing, crocodile tears or psychosocial effects (Peitersen, 2002).

**Figure 1.** Sample dynamic three-dimensional optical scanning images (a) depicting articulation involving eyebrows (top row) and mouth (bottom row) in control subjects and (b) in a patient with left facial paresis as a result of subcortical cerebral infarction.



Facial masking in Parkinson's disease may impair social interaction (Hemmesch et al, 2009) or impede recognition of depression (Poewe and Luginger, 1999). Recently, orofacial therapy was found to have a significant effect on facial movement and mental status in patients with central facial paresis as a result of stroke, when assessed using functional scales and two-dimensional facial video analysis (Konecny et al, 2011). Whether objective assessment and monitoring of facial dysfunction can contribute to the management of neurological conditions certainly seems worthy of further investigation. Quantitative assessment using dynamic three-dimensional optical scanning may be a valuable approach.

## Head and neck cancer

Dynamic three-dimensional optical scanning may also benefit people suffering with head or neck cancer. Facial disfigurement and disruption of physical function induced by head and neck cancer treatment pose formidable obstacles to the psychosocial adaptation of cancer patients. Extensive research has been undertaken to assess some of these outcomes. The areas or side effects studied include xerostomia (dry mouth) resulting from the effect of radiation on parotid and other minor salivary glands (Nutting et al, 2011). Another current study is aiming to investigate the effect of radiation on the cochlea.

The effects on the temporomandibular joint are another area of concern following radiotherapy to the head and neck region. The effects of surgical resection on organs such as the tongue, oral cavity and larynx have a significant impact on the patient's ability to speak, swallow and eat, and patients often require extensive rehabilitation measures following their treatment. These effects are possibly exacerbated by postoperative radiotherapy which is sometimes required to reduce the likelihood of tumour recurrence.

While facial disfigurement is a very distressing aspect of head and neck cancer and its treatment, there has been very little in the way of a systematic assessment of this complication (Katz et al, 2000). No studies to date have examined disfigurement using a valid and reliable observer-rated measure (Katz et al, 2000). There have been no prospective studies into the effects of radiation

therapy on functional impairments resulting from irradiation of facial musculature and temporomandibular joint. It may be possible to document such effects more objectively with the use of three-dimensional dynamic scanning.

## Conclusions

While the clinical application of dynamic three-dimensional optical scanning of facial articulation is highly speculative, if quantitative measures can be robustly established, then a range of clinical applications might be possible. The authors' team are exploring the feasibility of using the technique to quantitatively assess facial dysfunction as a result of neurological disorders including stroke. They will also aim to investigate the potential of this technique to detect the onset of facial dysfunction as an acute effect of radiotherapy among head and neck cancer patients. **BJHM**

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- Finsterer J (2008) Management of peripheral facial nerve palsy. *Eur Arch Otorhinolaryngol* **265**(7): 743–52
- Hemmesch AR, Tickle-Degnen L, Zebrowitz LA (2009) The influence of facial masking and sex on older adults' impressions of individuals with Parkinson's disease. *Psychol Aging* **24**(3): 542–9
- Katz MR, Irish JC, Devins GM, Rodin GM, Gullane PJ (2000) Reliability and validity of an observer-rated disfigurement scale for head and neck cancer patients. *Head Neck* **22**(2): 132–41
- Konecny P, Elfmak M, Urbank K (2011) Facial paresis after stroke and its impact on patients' facial movement and mental status. *J Rehabil Med* **43**(1): 73–5
- Nutting CM, Morden JP, Harrington KJ et al (2011) PARSPORT trial management group (2011) Parotid-sparing intensity modulated versus conventional radiotherapy in head and neck cancer (PARSPORT): a phase 3 multicentre randomised controlled trial. *Lancet Oncol* **12**(2): 127–36
- Peitersen E (2002) Bell's palsy: the spontaneous course of 2,500 peripheral facial nerve palsies of different etiologies. *Acta Otolaryngol Suppl* (549): 4–30
- Poewe W, Luginger E (1999) Depression in Parkinson's disease: impediments to recognition and treatment options. *Neurology* **52**(7 Suppl 3): S2–6

## KEY POINTS

- Facial articulation is a key component of human interaction but can be disrupted by a number of medical conditions
- Dynamic three-dimensional optical scanning is an emerging technology which can facilitate modelling of dynamically-acquired three-dimensional surface data, including facial articulation.
- Facial function is altered by a number of common neurological conditions, including stroke and Bell's palsy. Head and neck cancer and its treatment can also significantly affect facial function.
- The impact of facial dysfunction upon the patient may be relatively overlooked but can be associated with significant morbidity.
- Quantitative assessment of facial dysfunction using dynamic three-dimensional optical scanning may have a range of potential clinical applications.