Visualising and measuring facial expressions in patients with a Cleft Lip using 3D surface data obtained from 3D sensors

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Summary

According to the UK's Equality Act 2010, disfigurement (visible facial difference) is included as a disability. In particular, cleft lip and palate is one of the most common birth-related causes of visible facial difference with an incidence of 1 in 700. Whilst a cleft lip can be surgically repaired, measuring the outcomes following cleft lip repair involves a lot of human intervention, which is time-consuming and often non-standardised. The main goal of this project is to visualise and measure the changes in facial expressions and anatomy of children with a cleft lip before and after cleft lip surgery. With the advancement of depth-sensing technology, 3D surface information can be captured using portable and affordable devices. We intend to develop new software algorithms for cleft surgeons to acquire 3D facial information from patients to *measure the outcomes of operations using such devices in a simple clinical setup*. We will aim to visualise the face in 3D and measure properties such as facial symmetry and smoothness of transition between expressions by capturing 3D information over time. These properties cannot be measured using the static and sparsely captured 2D/3D images that are currently used in clinical practice.

Purpose

Currently there is no validated tool which provides dynamic assessment of facial aesthetics following cleft lip repair. This project aims to replace the existing 3D imaging practices, which acquire 3D static images of patients face, with an efficient and affordable 3D sensing framework. The framework will assist cleft surgeons in assessing and decision making tasks aligning with the concept of personalised medicine (NHS England). By using affordable and portable devices, we are aiming at deploying the system in a wider range of clinics with simple clinical setup. The 3D data will be captured over time (as temporal sequences) to provide the cleft surgeons with the facial movement for further analysis.

One of the controversies in cleft care is whether children with cleft lip have impaired maxillary (mid-facial) growth because of having a cleft (intrinsic developmental deficiency) or whether this is due to surgery (iatrogenic scar tissue caused by surgical closure of a cleft interferes with maxillary growth). Un-operated cleft lip and palate patients show better antero-posterior maxillary growth and likely have normal growth potential. Minimizing iatrogenic mid-facial growth interference is therefore an important goal within cleft surgery. Consensus regarding the optimal surgical and orthodontic treatment protocol is however lacking. The great heterogeneity in treatment protocols and the small patient groups of previously published cohorts make it hard to differentiate between the effects of each treatment factor on mid-facial growth. Furthermore, any deficiency in maxillary growth has traditionally only been detectable around growth maturity (i.e. mid to late teenage years). It is clinically important to see whether any maxillary growth deficiency can be detected earlier or indeed before any surgery. This would help determine whether certain surgical techniques for cleft lip and palate repair are deleterious for mid-facial growth. Antonarakis et al. used pre-operative measurement with callipers (ie physical measurement of the cleft anatomy). They felt that a deficiency of the soft tissue on the side of the cleft was associated with maxillary growth deficiency later. In this project, we will improve this - with dynamic 3D imaging - to provide a more accurate measurement for assessment.

Design

The study will be divided into two arms. The first arm will be aimed at collecting a variety of types of images (standard 2D, standard static 3D and dynamic 3D imaging) of patients with and without Cleft lips to help develop computer recognition of specific landmarks on patients with a cleft lip. The second arm will be a longitudinal study looking at pre-operative and post-operative images of patients undergoing a cleft lip repair.

The images from CCUK will be used in the first arm of the study. The images will be annotated by hand by the surgical team and analysed by the computer science department at Northumbria to help develop a computer programme which can recognise the specific landmarks on patients with a cleft lip.

The second arm of the study aims to capture a longitudinal series of dynamic 3D imaging of patients undergoing cleft lip repair pre-operatively and post-operatively in a clinical setting. These images will then by analysed by the collaborative research team at the Northumbria University Computer Science Department. The research project will run initially over 18 months identifying all patients diagnosed with a cleft lip in the Newcastle Cleft Lip and Palate Service. This time period was chosen based on the average number of new referrals per year and the aim to enrol 20-30 patients.

At the RVI, we have around 60-70 new babies referred to our service each year with cleft lip and palate. We would expect roughly half of these babies would have a cleft lip (with or without a cleft palate). We have a good track record in terms of recruiting patients to studies as evidenced by over 90% recruitment rate to the TOPS study and Cleft Collective. We would estimate that we could enrol 20 babies per year. Identification of patients will be co-ordinated by the help of the Cleft lip and Palate Specialist Nurses who are the first point of contact for such patients.

All patients undergoing a cleft lip repair within the time frame will be invited to take part (please see section below on recruitment). For those that agree to take part in the study images will be captured at multiple time points along the patient journey for example pre-operatively, immediately post-operatively, 6 weeks post-operatively and at 1 year follow up. Due to COVID situation the timing and location of these appointments is likely to vary significantly. The pre-operative, immediately post-operatively and 6 week images correspond to appointments the patients would otherwise have within routine NHS care for a cleft lip repair prior to COVID. The 1 year appointment will have been an additional appointment with the families. The 6 week and 1 year follow up appointment may be adjusted in time and location to fit with clinical need/evolving COVID situation. The patients will be consented to include their standard 2D and static 3D images which are taken for routine clinical purposes. Additional dynamic 3D images will be taken. Each image capturing session should not take more than 10 minutes. Images will be captured during the outpatient clinic by the surgical team or at on a home visit by the cleft specialist nurses. This would be mean that the patients/parents would not undergo any additional procedures and minimise burden of care.

As mentioned, patients undergoing cleft lip repair would routinely have 2D and static 3D photography done. Therefore, the 3D images required to be taken in this project could be seen as an extension of this and the patients/family experience would not be vastly different for those agreeing to take part in the study.

The devices used to capture the 3D imaging use infra-red technology with is non-invasive and not harmful to patients.

The research team met with members of North-East Regional Cleft Lip and Palate Association (CLAPA) and patient and parent support group on 19/08/2017. They were fully supportive of the research proposal and felt that it was likely to help improve outcomes for individuals with a cleft lip and/or palate. They were happy that the project would add no extra burden of care to patients and had an acceptable methodology.

The project has been REC approved and has full HRA approval. IRAS ID: 240451.

Key words: 3D imaging, cleft lip, outcomes