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Full thickness facial burns: Outcomes following orofacial rehabilitation

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ABSTRACT

Purpose: To document orofacial rehabilitation and outcomes after full thickness orofacial burn.

Methods: Participants included 12 consecutive patients presenting with full thickness orofacial burns. A group of 120 age-matched healthy participants was recruited for normative comparison. Non-surgical exercise was initiated within 48 h of admission and continued until wounds had healed, circumoral scar tissue had stabilised and functional goals were achieved to the best of the patient's ability. Outcomes were documented using vertical and horizontal mouth opening measures at start and end of treatment and therapy duration was recorded.

Results: At commencement of treatment, participants had significantly ($p < 0.001$) reduced vertical and horizontal mouth opening range compared to controls. Average duration of orofacial contracture management was 550 days, with half requiring >2 years rehabilitation. By end of treatment, significant ($p < 0.01$) positive improvement in vertical and horizontal mouth opening had been achieved, however measures had returned to lower limits of normal function and remained significantly ($p < 0.05$) reduced compared to the control group.

Conclusion: This study demonstrates that although positive gains can be achieved through non-surgical exercise after full thickness burn, the duration of rehabilitation is considerable and some degree of long term loss in functional mouth opening remains.

1. Introduction

Full thickness burns to the orofacial region represent damage which extends beyond the epidermal and dermal layers of the skin. Management of full thickness orofacial burns frequently involves both surgical management (including debridement with or without grafting) as well as non-surgical scar management post-operatively. Full thickness injury of the orofacial region is well accepted in the literature to be a complex area to treat. Despite intervention, this region is prone to persistent

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scarring and contractures that manifest in many functional and aesthetic sequelae [1,2] such as poor oral opening and closure for the purposes of oral intake, oral/dental hygiene, intubation, as well as deficits in communicative ability characterised by impairments in articulation and facial expression [3–8].

Several treatment techniques have been described to manage the patient at risk for orofacial contractures [9–22]. Early initiation of exercise, splinting, pressure, massage and silicone are currently accepted as standard burn scar rehabilitation practice [23]. However there is currently a paucity of evidence to support any one particular treatment regime and furthermore there is limited evidence to support the efficacy of orofacial treatment in adult facial burn, particularly with reference to functional outcome.

Only a handful of studies currently exist which describe orofacial contracture outcomes following full thickness orofacial burn. These include one cohort study [24], one small case series [7] and a number of single case reports [3–5,25–27]. The cohort study by Koller et al. [24] examined vertical and horizontal mouth opening outcomes in patients following surgical debridement of burns to the face. They identified that patients requiring surgical wound closure experienced greater loss of range of movement compared to those who did not require grafting. The limitations of this study however are that it is retrospective and outcomes were collected only following wound healing and maturation. Additionally, any non-surgical treatment that the patients may have received was not detailed. Only the single case reports and case series studies have documented functional outcomes both prior to and following non-surgical treatment for orofacial contractures. Non-surgical management was reported to involve varying combinations of exercise, splinting, massage, pressure and contact media [3–5,7,25–27]. The durations of treatment are difficult to ascertain as the focus was frequently on the time taken to achieve maximal gain. These studies all described utilising linear mouth opening measures in the vertical and horizontal dimension as their outcome measure and despite some differences in extent of benefit, positive gains were reported for all participants following non-surgical intervention.

Although this existing literature supports the benefits of orofacial contracture management for patients with full thickness burns, the predominance of single case studies and the lack of prospective cohort studies limits the quality of the evidence base available to date. The current study aims to quantify the extent of impairment post full thickness facial burn and describe outcomes relating to orofacial rehabilitation in a cohort of patients with full thickness facial burn, studied prospectively.

2. Methods

2.1. Participants

All patients attending Concord Repatriation General Hospital over a 3 year period (February 2011–February 2014) with full thickness orofacial burn were recruited to participate in the study. Full thickness orofacial burn was defined as a burn sustained to the orofacial region characterised by epidermal and dermal loss requiring surgical wound management (debridement and grafting) or greater than or equal to 21 days to achieve wound healing. Participants were excluded from the cohort if their prognosis was deemed poor and they were unlikely to survive hospital admission, had experienced previous burn to the orofacial region, had previous surgery to the lips (e.g. excision of squamous cell carcinoma), were unable to be monitored through to treatment completion (e.g. they were an overseas visitor), or demonstrated total non-compliance with completing non-surgical exercise. Based on these criteria, 9 patients were excluded from the study: five had passed away within week/s post injury, 2 were unable to be followed up due to overseas status, and 2 demonstrated complete non-compliance with non-surgical exercise. The final cohort of 12 patients who were eligible to participate consisted of 4 males and 8 females with a mean age of 41 years (range 17–61, SD 13.18). Individual patient and burn demographic data along with treatment and outcome data are detailed in Table 1.

All patients received early surgical debridement of their facial burns, with 7 receiving early facial grafting, and 5 initially receiving Biobrane® followed by subsequent facial grafting once either wound healing was not able to be achieved and/or donor skin became available. Seven patients subsequently required surgical mouth angle release due to non-surgical exercise being insufficient to maintain adequate mouth opening (Table 2). The point at which these 7 required contracture release varied with most undergoing surgery after their initial acute care admission. Table 2 details these 7 patients including their pre-treatment mouth opening measures, days to surgical mouth angle release, pre- and post-surgery mouth opening range (within 1 month of surgery), and final mouth opening range after treatment cessation.

2.2. Healthy controls

A group of 120 age-matched healthy controls (60 male, 60 female, mean age 41.5 years, range 16–80 years) was recruited to establish normative data for mouth opening range. Twenty male and 20 female control participants at each of the age ranges of 16–30 years, 31–50 years, and 51–80 years, were selected to ensure equal age and gender distribution. For inclusion, participants required no prior history of orofacial burn, and no head and neck or craniofacial surgery or other condition that may impact on oromotor function.

2.3. Orofacial contracture management

The therapy regime consisted of a combined exercise and stretching regime targeting active range of movement mouth stretches developed by the lead author and described in Rumbach et al. [11] p.189. A second clinician, trained by the lead author, also provided treatment and measured outcomes following the same therapy regime over the study period. The frequency of practice prescribed was 10 repetitions of each exercise, 5 times daily. A mouth splint regime was also instituted, consisting of 1 h application twice daily of the Free Access II Cheek Retractor® (www.morita.com) as described in Clayton et al. [3] and Clayton et al. [4]. Nine of the 12 patients required additional assisted vertical mouth stretching due to further loss of mouth opening despite adherence to active range of movement exercise and the mouth splint programme.

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Table 1 – Demographic and orofacial measurement data of burns participants (n = 12).

Pt no.	Age	Sex	Mechanism of injury	%TBSA	Medical treatment	Rehab duration (days)	Rehab	Initial VROM (mm)	Initial HROM (mm)	D/C VROM (mm)	D/C HROM (mm)	Surgical mouth release	Functional?
1	57	F	Flame	12	Graft	922	AROM Splint TheraBite®	12	45	42	60	Y	Y
2	61	M	Flame	80	Biobrane® + graft	464	AROM Splint TheraBite®	35	62	40	75	Y	Y
3	42	F	Flame	60	Biobrane® + graft	632	AROM Splint	45	62	50	65	N	Y
4	40	F	Flame	40	Graft	1235	AROM Splint Orastretch®	40	65	40	64	N	Y
5	40	F	Flame	8	Graft	564	AROM Splint Orastretch®	35	58	40	60	Y	Y
6	38	M	Flame	40	Graft	255	AROM Splint	36	56	42	70	N	Y
7	24	F	Flame	64	Graft	682	AROM Splint Orastretch®	12	50	43	62	Y	Y
8	34	F	Flame	45	Graft	552	AROM Splint Orastretch®	10	45	41	58	Y	Y
9	57	M	Flame	55	Biobrane® + graft	261	AROM Splint Orastretch®	31	61	42	62	N	Y
10	17	M	Flame	71	Biobrane® + graft	82	AROM Splint	35	50	50	65	N	Y
11	47	F	Flame	33	Graft	615	AROM Splint Orastretch®	30	55	34	62	Y	N
12	35	F	Flame	45	Biobrane® + graft	339	AROM Splint Orastretch®	15	65	32	80	Y	N

VROM: vertical range of movement.
HROM: horizontal range of movement.
AROM: active range of movement.

These patients received either the TheraBite® (www.therabite.com) or Orastretch® (www.craniorehab.com) device. The regime prescribed was five sustained stretches of at least 30 s duration, three times daily. Initially, all therapy was demonstrated, assisted and supervised by the treating clinician, until the patient was deemed competent with independent practice with or without family/carer assistance. The patient was also provided with brochures detailing the treatment regime in pictorial and written format. Once independent with the treatment programme, the clinician reviewed adherence on a daily basis whilst an inpatient and weekly as an outpatient through to treatment completion. Monitoring of treatment adherence involved observing the patient carry out the treatment regime in addition to taking

Table 2 – Orofacial measurement data and duration to surgery for the 7 patients requiring mouth angle release.

Pt no.	Initial VROM	Initial HROM	Days to release	Pre-surgery VROM	Pre-surgery HROM	Post-surgery VROM	Post-surgery HROM	D/C VROM	D/C HROM
1	12	45	373	32	60	36	62	42	60
2	35	62	94	32	67	36	72	40	75
5	35	58	436	38	51	40	59	40	60
7	12	50	96	30	52	36	60	43	62
8	10	45	175	32	55	38	61	41	58
11	30	55	207	30	55	34	62	34	62
12	15	65	304	24	60	28	80	32	80

VROM: vertical range of movement.
HROM: horizontal range of movement.

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linear measurements of mouth opening. Feedback was provided to the patient accordingly and progress documented in the patient's clinical file.

For all patients, orofacial contracture management was initiated within 48 h of admission. The patient continued treatment through their admission and wound healing, in accordance with a set protocol. If the patient received debridement and skin grafting to the face, all treatment was ceased at the time of surgery and active range of movement exercises were re-commenced at five days post grafting. Mouth splinting and TheraBite® or Orastretch® was re-commenced post-operatively following consultation with the managing Burns Surgeon, between day 5 and 7 post-operatively (mean 5.86, range 5–7, SD 1.07).

Patients were weaned from treatment once their orofacial burn wounds had healed, any indication of circumoral scar tissue had stabilised and functional goals had been achieved to the best of the patient's ability with no change over 3 months post scar stabilisation. Scar tissue was defined as the presence of tissue surrounding the vermillion evidently restricting maximal mouth opening range of movement. Scar tissue stabilisation was defined as the lack of further loss of mouth range of movement as measured by vertical and horizontal linear mouth opening. Targeted functional goals included the ability to achieve mouth opening ranges and functioning lip control which: could enable blind intubation if required (>35 mm) [28]; facilitate clear articulation; allow intake of all foods with no restrictions; allow drinking of fluids without anterior loss; enable full access to back molars for dental cares.

Treatment weaning started with the gradual cessation of TheraBite® or Orastretch® if being used, then the mouth splint, and finally active range of movement exercises. Once the patient completed treatment, they were monitored for a further period of at least 3 months to ensure that they did not regress in their mouth opening range. If at any point during the weaning process a decline in function and mouth opening range was observed, the previous level of treatment was re-commenced.

2.4. Outcome measures

Both prior to and at the completion of therapy, each participant underwent measures of maximal vertical and horizontal mouth opening. As previously described in the literature [3,5,29], vertical mouth opening range was documented as the measurement in millimetres from the inner border of the medial top lip to the inner border of the medial lower lip whilst in the stretched position. Horizontal mouth opening range was documented as the measurement in millimetres from one lateral oral commissure to the other lateral oral commissure whilst in the stretched position. Patients were also interviewed to determine presence of functional impairment as a result of restricted mouth opening. Patients were specifically asked if they experienced any adverse effect in their ability to: articulate, eat all foods, drink fluids without anterior loss, and brush their teeth with full access to back molars as a result of their degree of mouth opening since the burn. Vertical and horizontal mouth opening measures were compared to those reported by Clayton et al. [28] and found to be commensurate with range of movement required to facilitate blind intubation. Total duration of therapy (in days) was also recorded for all patients. Vertical and horizontal mouth opening was evaluated once only for the control group.

2.5. Data analysis

Non-parametric *t*-tests were used for group level analysis to record change in mouth opening measures pre to post treatment (Wilcoxon Signed Rank), and for comparisons between control and participant groups (Mann–Whitney *U*). Significance was set at $p < 0.05$. For individual analysis, each patient's data was compared to the control group mean and standard deviation. For the purposes of individual analysis, patient values which were more than 1 standard deviation of the control group mean were considered below normal range of function. Inter-rater reliability was calculated by having a second clinician assess the vertical and horizontal mouth opening measures for a subset of 50 healthy control participants. Correlations between the two raters revealed inter-rater reliability coefficients of $r = 0.55$ for horizontal measures and $r = 0.55$ for vertical measures. However direct calculation of the average degree of difference between the two raters revealed mean differences of 0.18 mm for vertical measures and 0.26 mm for horizontal measures, suggesting only a small degree of error in measurement.

3. Results

Healthy controls demonstrated orofacial measurements with a mean vertical range of movement (VROM) of 53.6 mm (range 40–75, SD 7.4) and mean horizontal range of movement (HROM) 69.1 mm (range 55–83, SD 5.8). One standard deviation below mean control group performance was determined to be 46.2 mm for VROM and 63.3 mm for HROM. Performance below this was considered outside normal functioning.

At commencement of intervention, participants with orofacial burns had significantly reduced vertical ($Z = -5.58$, $p < 0.001$) and horizontal ($Z = -4.78$, $p < 0.001$) mouth opening dimensions when compared to the control group (Figs. 1 and 2). At this point 100% individuals had VROM and 83% individuals had HROM measures which fell outside normal functioning. Overall average duration of rehabilitation was 550.25 days (range = 82–1235, SD = 313.0). Descriptive data analysis revealed that 33% of patients required up to one year of rehabilitation, and a further 50% required up to two years of intervention to achieve stable range of mouth opening. Two patients (17%) required in excess of two year's rehabilitation to reach contracture stabilisation.

After orofacial contracture management, the patient cohort demonstrated significant positive improvement in the extent of both vertical ($Z = -2.94$, $p < 0.01$) and horizontal ($Z = -2.95$, $p < 0.01$) mouth opening. At the conclusion of treatment, comparison between the patients and control group data revealed persistent significant differences in both vertical ($Z = -4.81$, $p < 0.001$) and to a lesser extent horizontal ($Z = -2.24$, $p < 0.05$) mouth opening range (Figs. 3 and 4). Despite improvements, by conclusion of treatment 83% of

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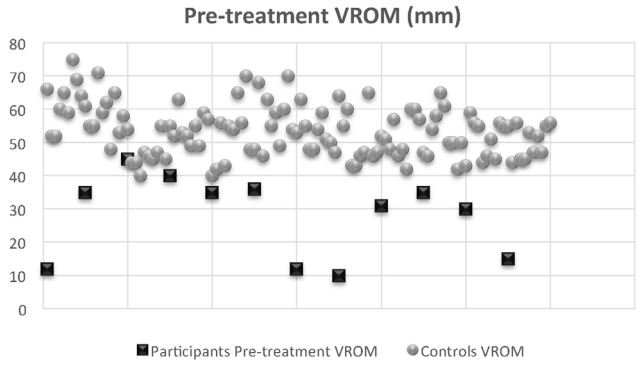

Fig. 1 – Pre-treatment VROM comparison between participants and controls (VROM: vertical range of movement)

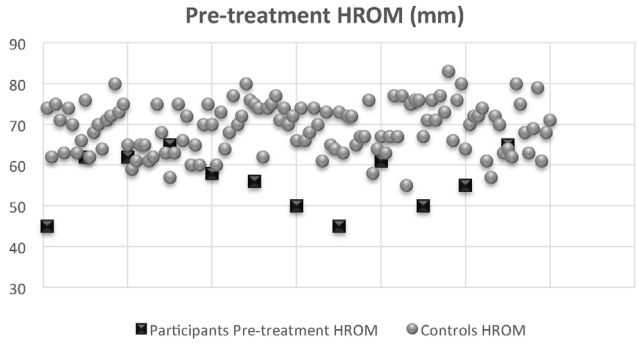

Fig. 2 – Pre-treatment HROM comparison between participants and controls (HROM: horizontal range of movement)

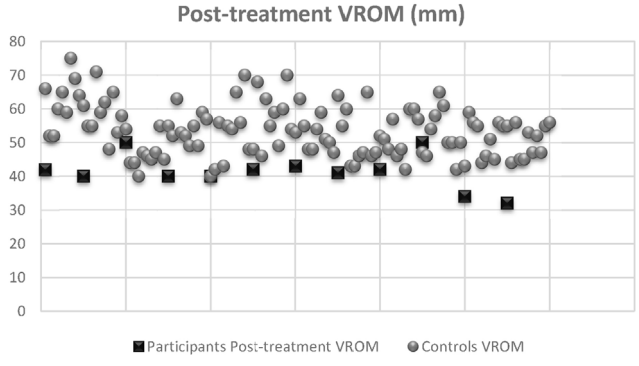

Fig. 3 – Post-treatment comparison between participants and controls (VROM: vertical range of movement)

patients had maximal VROM and 50% had maximal HROM measures which continued to remain below normal.

Ten of the twelve participants met the functional outcomes monitored by the time of discharge from treatment. The remaining 2 participants, failed to achieve functional mouth opening for the purposes of blind intubation based on vertical mouth opening range of movement, however reported no restriction in their ability to clearly articulate, eat all foods,

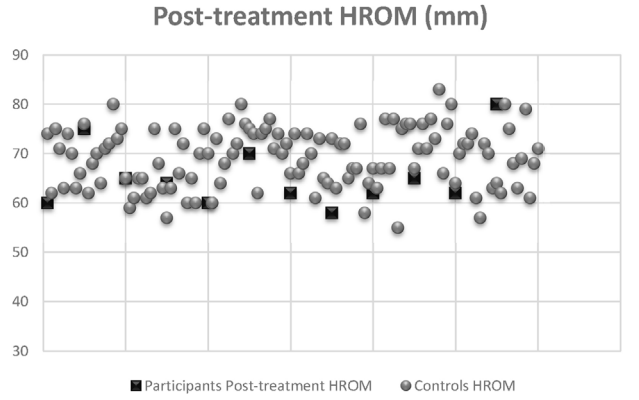

Fig. 4 – Post-treatment comparison between participants and controls (HROM: horizontal range of movement)

drink fluids with no anterior loss, or brush their teeth with full access to back molars. Both of these patients sustained burn as a result of self-immolation, using flammable liquid on flame. They also both had darker pigmented skin, were female and required early facial grafting, repeat grafting due to graft failure and subsequent oral commissure release. One of these patients demonstrated some variability in treatment compliance, with the other experiencing considerable medical complications including tracheal stenosis which resulted in a period of cessation of orofacial contracture management due to the requirement for non-invasive ventilation.

4. Discussion

The current study reveals that patients with full thickness facial burns have significantly impaired mouth opening range prior to commencing treatment. Despite significant improvements in mouth opening range as a result of treatment, many patients continued to have mouth opening dimensions significantly below the normal range at treatment conclusion in both the vertical and horizontal planes. Orofacial contracture management for this cohort of burns patients is lengthy and typically continues for up to 2 years or more after injury.

In the present study, the degree of mouth opening impairment prior to commencing treatment is more severe than that documented for partial thickness facial burns [29], however it does align with previously published literature on the treatment of full thickness facial burns. Published case studies [3–5,25–27] and a case series [7] have reported initial mouth opening measures ranging between 12–42 mm vertically and 40–55 mm horizontally for patients with full thickness facial burns, indicating similar reductions in range of movement as observed in the current cohort. Whilst there is consistency of mouth opening range within the literature, the authors acknowledge that it is difficult to control for the effects of pain and medications upon the patient's ability to participate in measurement of maximal mouth opening, particularly in the acute stages of treatment.

Treatment duration for patients in the current study was considerably protracted with many patients requiring between 1 and 2 years rehabilitation to reach their functional

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goals or contracture stabilisation. This appears longer than other studies previously published [3–5,7,25–27] however these studies do not clearly define that the scar tissue had stabilised at the point of treatment cessation and the focus appeared to be more on time required to achieve maximal gain. It is well accepted that scar maturation can take between 18 months and 3 years to fully establish, particularly in the presence of contracture release or reconstruction, so it not unreasonable that contracture management would also require a similar period of time to achieve functional goals [30–32]. Additionally, individual characteristics including age, gender, skin pigmentation, burn depth and presence of co-morbidities are known to affect burn wound healing time [33–35]. Therefore the risk of developing circumoral scar tissue and subsequent contractures with restricted mouth opening is very specific to each individual. Indeed in the current group of 12 individuals the period of rehabilitation varied substantially from approximately 3 months to over 3 years.

Significant improvement was observed in response to orofacial contracture management, for both vertical and horizontal mouth opening. The mean gains of 13.3 mm (vertical) and 9.1 mm (horizontal) in mouth opening range is comparable with previous studies of patients with facial burn. These studies describe gains of 2–26 mm in the vertical dimension and 5–33 mm in the horizontal dimension post treatment of both partial and full thickness facial burn [3–5,7,25–27,29].

Despite positive gains following intervention, the current cohort continued to demonstrate significantly reduced maximal vertical and horizontal mouth opening in comparison to the control group. Individual analysis revealed that very few patients had achieved vertical mouth opening within 1 standard deviation of the normal range and only half of the cohort had horizontal mouth opening dimensions within 1 standard deviation of the normal range at the time of treatment cessation. Koller et al. [24] similarly observed variable outcomes following intervention in their retrospective study of 23 patients with burns to the face requiring surgical debridement. They noted that patients who underwent surgical wound closure, such as those in the current study, experienced greater loss of mouth opening range when compared to those who did not require surgery.

Although treatment outcomes revealed most individuals had not resumed normative maximal VROM and HROM values, the majority of patients had met the functional oral status goals as defined by the patient interview by the time of treatment cessation. The 2 patients who failed to meet the set functional criteria both possessed a number of characteristics known to be predictive of poorer outcome [33–35]. These features were female gender, widespread facial and neck grafting, graft failure and subsequent need for repeat grafting, in addition to dark skin pigmentation. One of these patients also encountered substantial medical complications (tracheal stenosis) necessitating a period of orofacial treatment cessation in order to provide non-invasive ventilation, which likely also affected her ability to achieve an optimal outcome. The other patient demonstrated a degree of variable adherence with orofacial rehabilitation which also likely affected her ability to achieve optimal outcome.

Regardless of burn depth, the mouth region is challenging to treat and more prone to functional deficit when compared to the rest of the face [24]. Outcomes pertaining to functional capacity as well as maximal range of movement are therefore necessary to thoroughly determine treatment success. Despite persistent reductions in maximal mouth opening ability in the entire cohort, a large proportion of patients had achieved functional capacity as defined by the patient interview. As the functional tasks set in this study do not require maximal mouth opening, patients are likely to have achieved functional outcomes with residual maximal range reduction. A small number of studies have described functional outcomes following orofacial intervention. These studies report that positive functional gains have been achieved regardless of maximum range values after treatment falling below the normative data collected in this study [3,4,7,26].

A proportion of patients in the current study required subsequent surgical mouth angle release despite diligent orofacial contracture management. It is difficult to determine factors contributing to the need for contracture release as all patients demonstrated a high degree of compliance with intervention and all required similar surgical procedures to achieve wound closure. As described by Zweifel et al. [8] and Fraulin et al. [36], scar contracture around the mouth can be very aggressive and early behavioural interventions may prove to be insufficient to prevent the need for surgery. It may be postulated that the need for surgical intervention in the current study was due to not one, but multiple individual issues.

Three different devices were utilised in the treatment of patients within this study. The Free Access II Cheek Retractor® mouth splint has a vertical dimension of 40 mm, the TheraBite® has a maximal range of 44 mm and Orastretch® a maximal range of 50 mm. Considering that the maximal range of each of these devices is considerably less than the control group mean for maximal vertical mouth opening, it is not physically possible to achieve normal vertical mouth opening with these devices alone. Unfortunately, the market lacks vertical mouth opening devices that can stretch to within the normative range for mouth opening as defined by the current study. This implies the need for a device that can provide an assisted vertical mouth opening stretch beyond 50 mm. It also demonstrates key factors for the clinician to consider when selecting appropriate equipment for their patient at risk for oral contractures.

Whilst this study presents outcome data on the largest full thickness facial burn cohort to date, there are still limitations. It is acknowledged that the sample size is relatively small which raises issues with the generalizability of the current data. However, this may be countered by the fact that the cohort represented 86% of the surviving patients who presented with full thickness facial burns over the 3 year period. Larger numbers would only be possible to study through a multicentre trial. It is also important to note that this study proposes causative results based on one treatment approach. The relative efficacy of this treatment protocol compared to others is unknown. There remains a need for randomised controlled trials to examine the comparative efficacy of different treatment protocols in future research. The full extent of treatment adherence is also unknown.

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Whilst the treating clinician made all efforts to ensure maximal patient adherence with the orofacial treatment regime, it is acknowledged that once the patients were discharged, 100% adherence with the programme through to treatment completion could not be assured. As such, future studies which are able to relate extent of therapy adherence with outcomes will provide further insight into the positive impact of therapy. Finally, for more holistic understanding of orofacial contracture outcomes, future treatment studies should incorporate more extensive outcome measures. The current data fails to provide information on final scar tissue aesthetic outcomes or any insight into patient perceptions of their recovery. Such multidimensional information would be valuable in future studies comparing various treatment protocols.

5. Conclusion

This is the first published cohort study prospectively examining orofacial contracture management outcomes with specific reference to mouth opening range in patients with full thickness orofacial burn. The results from this study indicate that orofacial contracture management in full thickness burn is beneficial; however all patients continue to demonstrate a degree of reduced maximal vertical and horizontal mouth opening range even following intensive non-surgical exercise. Methods to further optimise patient outcomes, particularly in relation to recovery of VROM, need to be examined.

Authors' contribution

All authors contributed to the conception and design of this study, data analysis and interpretation, preparation and verification of this final manuscript prior to submission for publication.

Conflict of interest

The authors have no conflicts of interest to declare in both the conduct of this study or preparation of this manuscript.

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