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Burn contracture risk factors and measurement in low-middle income countries: A clinical perspective

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ABSTRACT

We find a lack of high-quality published evidence on risk factors for burn contracture formation. The vast majority of research is from High Income Countries (HICs), where many potential risk factors are controlled for by standardised and high-quality healthcare systems. To augment the published literature, burn care professionals with Low Middle Income Countries (LMICs) experience were interviewed for their opinion on risk factors for burn contracture formation. Participants were also asked for their views on identification and measurement of contracture. Seventeen semi-structured interviews were conducted (13 burn surgeons and 4 therapists). The average length of experience in burn-care was 13 years. Participants represented Ghana, Ethiopia, Malawi, Nigeria, South Africa, Nepal, and India. Participants reported ninety risk factors. Risk factors were later collated according to topic: Non burn individual factors (n = 13), Burn injury factors (n = 14), Family and community factors (n = 9), Treatment factors (n = 18), Complications (n = 2), Healthcare capacity factors (n = 19) and Societal and environmental factors (n = 12). The top five most frequently cited risk factors were lack of splinting, lack of physiotherapy, lack of early excision and skin grafting, low socioeconomic status and presence of infection. Although participants had no doubts that they could recognise a contracture, none provided a standardised system of measurement or an operational definition of contracture. Burn care professionals have a wealth of experience and untapped knowledge of risk factors for burn contracture formation in their own population base, but many of the risk factors highlighted by participants have not yet been explored in the literature. Variations in clinicians' diagnosis and measurement of a burn contracture underscores the need for an agreed, standardised, simple and easily reproducible method of diagnosing and classifying burn contractures.

1. Introduction

Burn related contractures can significantly reduce quality of life and create a high economic burden for the individual and health system [1–9]. The scale of the problem in low-middle

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income countries (LMICs) is such that burn contractures have been described as a 'Goliath' [10]. However, without comprehensive understanding of the risk factors for burn contractures, the effectiveness of prevention strategies will be curtailed, and defeat of 'Goliath' is unlikely.

Most literature on contracture risk factors originates from High Income Countries (HICs); the majority focus on factors relating to the burn itself (such as burn depth or TBSA) or on treatment factors (such as grafting and splinting) [11]. The literature available from LMICs, albeit from a limited number of papers, broadens the canvas of risk factors to include more socioeconomic factors and those related to access to care [11]. To augment existing knowledge, this study sought the opinions of experienced LMIC clinicians on the risk factors for burn contracture in LMIC settings.

The prior identification of risk factors from the literature [11] and the study reported here were undertaken to identify potential risk factors for inclusion in a planned study to investigate risk factors for burn contracture in a LMIC setting [12]. To enable risk factor analysis, the future study also required a standardised and reproducible measure of contracture outcome. Therefore, although the primary aim of this study was to determine the clinicians' views on risk factors, participants were also asked for their views on the definition and measurement of contractures in an effort to gain LMIC-specific guidance on contracture diagnosis and measurement.

2. Methods

2.1. Recruitment and participants

Purposive sampling was used to select clinical leaders with significant experience in LMIC burn care, including burn contracture management. Eligible participants were recruited via email or in person at burn-related meetings (April 2019); all were healthcare professionals with ≥ 3 years specialised experience in burn care in a LMIC setting.

Surgeons and therapists were particularly targeted as they are key decision-making members of burn teams in LMIC settings and are also the main authors of published literature on burn contractures [11].

Recruitment ended after 17 participants as saturation had been reached with this sample size, no new risk factors were being offered as the interviews progressed.

2.2. Data collection

Participants were interviewed in person by the primary researcher (RF) in The Global Centre for Burns Injury Policy and Research, (GCBIPR) Swansea University, during their visits to the centre, or remotely using electronic communications. A semi-structured guide of open questions was developed after review of relevant literature [11] and was structured to encourage participants to think as broadly as possible in their responses. The questionnaire was reviewed by the Ph.D. supervisory team (2 burn care clinicans) and 3 visiting burn care professionals from a LMIC setting.

Topics included in the interview were participant information (type and location of work, years of experience), their views on risk factors for contracture, preventability of contracture, definition and measurement of contracture, timing of contracture formation, and how they developed their opinions on risk factors for contractures. Interviews were completed in 30–60 min and were audio-recorded with written consent from participants.

2.3. Data management and analysis

All data were collected anonymously and stored securely. Data were extracted and categorised by the primary researcher (RF). Each stated risk factor was recorded only once per participant, regardless of how many times it was mentioned by that participant. Risk factors were categorised by grouping the responses which reflected similar themes.

Participants were also asked to state the risk factors which, in their opinion, were the top 5 most important or influential factors for burn contracture formation. A list was created of all the answers, then each was scored according to the number of participants who listed it as their first to fifth choice. The total scores for each risk factor allowed them to be ranked in order of popular opinion.

Ethical approval for the study was granted on 11th April 2019 by Swansea University (200219b).

3. Results

3.1. Participants

Seventeen participants were recruited - 3 general surgeons, 10 plastic surgeons, 2 physiotherapists and 2 occupational therapists; with 14 participants interviewed in person. Thirteen were from and currently worked in a LMIC. The remaining four (2 therapists and 2 surgeons) worked in HICs at the time of interview (USA 2, UK 2) but had significant experience of working in at least one LMIC. The average duration of experience in burn care was 13 years (range 3–30 years).

The countries represented were Ethiopia (3), India (3), Ghana (2), Nepal (2), Malawi (1), Nigeria (1), South Africa (1). The 4 participants currently based in HICs, had previous LMIC burn care experience in Bangladesh, Cote D'Ivoire, Ethiopia, Ghana, Haiti, India, Indonesia, Nepal, Sierra Leone, Sri Lanka, Togo, Zambia collectively.

Apart from one surgeon and one therapist who worked in the same institute in India, each participant represented a different burn care institution. Most participants worked in tertiary care (n = 13), 3 participants worked across all levels of healthcare, and 1 participant worked in the Ministry of Health. Two participants worked in private hospitals and 3 in Non-Governmental Organisations; the majority (n = 12) worked within the Government healthcare systems of their respective locations. One participant provided only paediatric burn care; all other participants treated children and adults. All participants treated both acute and reconstructive burn patients.

3.2. Risk Factors

A total of 87 different risk factors for contracture formation in LMIC environments were suggested by the 17 clinicians.

Participants did not report any protective factors. Categories of risk factors, reported in order of frequency were:

a) **Healthcare capacity (n = 19)**: factors related to the broad healthcare system, such as lack of primary prevention, lack of training of burn care team
b) **Treatment factors (n = 18)**: factors related to treatment of the burn, such as lack of skin grafting, lack of splinting
c) **Person/burn (n = 14)**: factors directly related to the burn injury, such as TBSA, depth and location of burn
d) **Person/non-burn (n = 13)**: factors specific to the person but not burn-related, such as age, treatment adherence, co-morbidities
e) **Societal and environmental (n = 12)**: wider problems such as low socio-economic status, lack of political support for burn care.
f) **Family and community (n = 9)**: factors related to the family or community of the patient, such as lack of awareness of burn injuries, illiteracy
g) **Complications (n = 2)**: factors related to complications of the burn or treatment, such as infection or graft failure

Forty-three risk factors were suggested by more than one respondent; 10 was the maximum frequency for any individual risk factor. Table 1 shows the 10 risk factors reported most frequently by participants. We found considerable variation in the types of factors considered most important, which included lack of therapy (e.g., splinting, positioning and physiotherapy), burn and patient factors, poor patient adherence to treatment and system issues (lack of staff).

The most frequently reported risk factors were slightly different from those which emerged as the highest scoring factors when the clinicians were asked to rank their personal 'top 5′ most important contributing factors (Table 2). A total of 31 different risk factors were selected as being within the 'top 5′ most important for contracture formation in their LMIC settings. Table 2 shows the 20 most cited risks identified from each clinician's 'top 5 most important', along with the frequency of inclusion and the overall ranking. Again, a wide range of factors were identified from all categories, but lack of splinting and physiotherapy input was considered most important. Only two burn factors (depth and location of burn) were included in the top 20 risks but several health system issues were mentioned.

The majority of risk factors were described as a 'lack of' something. A participant quote that reflected this theme well was:*"Contractures are due to lack of resources, lack of education, lack of suitable environment, lack of everything."*

Table 1 – Top ten risk factors most frequently cited by clinicians.

Risk factor	Frequency of report
Lack of splinting	10
Lack of adherence to care by the patient / family	9
Biology of the patient / tendency to scar	8
Location of burn	8
Lack of trained staff	8
Depth of burn	7
Wound infection	7
Delayed treatment	6
Lack of physiotherapy	6
Lack of positioning	6

3.3. *Preventability of burn contractures*

To determine the importance of risk factor identification in maximising prevention, participants were asked if they thought contractures were preventable. Eight participants responded "yes": of these, five added "definitely" or "absolutely" to their responses. All others indicated that most contractures were preventable theoretically, but provided less emphatic and more nuanced responses, as evidenced by the quotes in Table 3.

3.4. *Definition and measurement of burn contracture*

The clinicians were asked for their definition of a burn contracture, either in their own words or by quoting from literature. All participants appeared confident to provide a definition in their own words; none of the definitions provided were inconsistent with the literature, but we found considerable variation in approach. Examples of definitions given by participants are provided in Table 4; some described only anatomical features and others included functional effects.

We found considerable variation in the methods described by the clinicians to identify a contracture (Table 5). Sixteen participants were confident that they would be able to identify a burn contracture clinically. Ten added a further affirmative to their positive answer, such as "…absolutely" (n = 3), "…no doubt" (n = 4), "…definitely" (n = 2), "…it is very easy" (n = 1). The only participant who expressed doubt in identification of a contracture answered, "…sometimes it is difficult to be sure".

When combining the responses in Tables 4 and 5, it became evident that participants did not necessarily use the methods they cited for contracture definition or identification in their own practice. For example, one participant reported that a burn contracture would be identified by reduced function but did not report the use of any standard functional assessment tool or outcome in clinical practice to measure function. Therefore, although participants were confident to report a conceptual definition, they were not able to provide any operationalised definition or measurement system that was used routinely in their clinical practice. The wide range of methods of defining contracture is encapsulated in this quote from a participant: *"It may be difficult to define [a burn contracture] but you know it when you see it"*.

Although participants referred to various ways a contracture could be measured (Table 5), no participant could describe a measurement protocol or give a standardised operational definition of a contracture. When general topics of measurement were discussed (such as loss of range, loss of function, patient opinion), no standardised methods to capture these constructs were mentioned.

Table 2 – The 20 most frequently cited "Top 5" contracture risk factors identified by clinicians.

Factors cited by Clinicians as the "Top 5" contributors to contractures in LMICs	No of times included in "Top 5" Choices	Ranking Score	Rank	Category of Risk Factor
Lack of splinting	9	32	1	Treatment
Lack of physiotherapy	6	24	2	Treatment
Lack of early excision and grafting	5	18	3	Treatment
Infection	5	17	4	Complication
Delayed wound closure	4	17	4	Complication
Low socioeconomic status	5	12	6	Societal and environmental
Poor patient education	4	11	7	Person-non burn
Location of the burn	4	11	7	Burn
Poor compliance with treatment	3	9	9	Person-non burn
Poor positioning	2	9	9	Treatment
Lack of timely access to appropriate treatment	3	8	11	Healthcare capacity
Inadequate pain control	3	8	11	Treatment
Lack of family support	2	8	11	Societal and environmental
Inadequate resuscitation	2	7	14	Treatment
Depth and extent of burn	2	6	15	Burn
Lack of pressure garments	2	5	16	Treatment
Financial pressures	1	5	16	Societal and environmental
Lack of dedicated burn unit	1	5	16	Healthcare capacity
Lack of movement	1	5	16	Treatment
Inadequate expertise/training of the team	2	4	20	Healthcare capacity

Table 3 – Participants responses to 'Are contractures preventable?' (Each bullet point reflects an individual respondent).

- "In the ideal situation most contractures can be prevented"
- "Due to the big burden of burns it is difficult. If we had a multipronged approach to access and effective treatment [for the burns patients] then it would be possible to prevent it [burn contracture]. The task is not simple."
- "In the medical world we all accept that contractures are preventable, but there are multifactorial causes, some are more difficult to address than others …. If the patient presents to healthcare, they are preventable, but not if they don't present to healthcare …. I wouldn't say that we can prevent all contractures, but they are ALL preventable."
- "Yes, overall if you had everything that you could throw at it [burn care/contractures], with the multidisciplinary team working, then yes. But no in certain contexts – it depends on the resources available."
- "There are too many variables at play …. in summary it is not a yes or no question, it depends."

Table 4 – Definitions of contracture offered by clinicians.

Anatomical definitions (each bullet point reflects an individual respondent)

- *Where there is not full range of moment at any joint*
- *Excessive fibrosis tissue secondary to burn occurring across a joint*
- *Muscular contracture due to skin and muscle and tendons that contract causing limited movement*
- *Any restriction to normal anatomical movement, abnormal adhesion of tissues*
- *Deficit of tissues, including skin, fascia, and subcutaneous. There is an imbalance between skeletal structure and the soft tissue and range of movement is limited*
- *Any limitation in movement or any deformity in feature*
- *Affected mobility of a joint, or in a facial contracture the pulling of a feature*

Functional definitions (each bullet point reflects an individual respondent)

- *Scar that limits movement and has a functional impact*
- *Loss of range of movement that affects function after wound healing*
- *Limited range of movement to some degree that has impact on function*
- *Shortening of the skin and or the tendons leading to a limitation in the normal function of that joint or part of the body*
- *Shortening of soft tissue usually found across joints which leads to loss of function, deformity, tightness in the joint and depending on the stage of the contracture it can lead to limited or no movement of the joint*
- *Injured skin loses its elasticity and there is tightness of the skin, this leads to reduced range of movement and functional impairment. So, any tightness that means a loss of range is a contracture*

When asked which measurements participants used in their practices and how this was documented, only 4 clinicians used any objective measure for contracture. These four (3 therapists and 1 surgeon) used goniometer measurement, but no specifics or protocols were given. Two of those who used goniometer measurement, did so "when possible" and suggested that it was not routine practice, preferring visual estimation ('eyeball') of the angle rather goniometer use. One therapist's institution was conducting research into contracture measurement; the measures used were (a) goniometry (b) a scar scale (unnamed) and (c) activities of daily living (ADL) score, using a functional measure (unnamed).

Participants were also asked if they had experienced any difficulty in measurement of burn contractures. Twelve participants reported no difficulties and one participant (surgeon) delegated all contracture measurement to the therapist and was unable to answer. The remaining participants (3 therapists and 1 surgeon) reported difficulties in contracture measurement because of poor reliability of

Table 5 – How clinicians assessed contractures in practice (each box represents a participant).

Q: Can you explain how you would identify a contracture clinically?

- There are those contractures that incapacitate a patient and those that do not
- How much of the anatomical area has been involved
- How much limitation of range
- Functional, aesthetic, or social limitation
- Limited movement, impaired function
- Limits function and may be yielding or unyielding, permanent, or not permanent
- Any tightness of the skin or loss of elasticity is a contracture even if there is no loss of range or function
- Usually there is a lack of extension, there is a loss of function and range of movement, measured with a goniometer
- There are contracture classifications (not able to name any specifically)
- Loss of range of movement
- Type of scar e.g., thin scar band, thick scar band
- Measure the range of movement (angle), measure quality of life (no specific scales given), measure impairment of function (no measures given)
- Height of contracture (scar), colour of the scar, the feel of the contracture, yielding of the scar, whether the scar has rods / bands
- Measure impairment of function (no measures given)
- Range of movement – mentions the need to check the position of other joints
- Passive and active movement
- Whether the contracture is fixed or not
- Scar assessment – pliability, contractibility
- Look at ligament structures
- Assess movement through active or passive joint
- When assessing range of movement, it is necessary to check the position of other joints
- Observe function ability and compensatory movements
- Observe confounding factors (to movement) such as pain
- Assess if the contracture is yielding or not
- If the patient struggles to do a functional task, then I classify that contracture as severe
- Range of movement
- Vancouver scar scale
- Condition of the skin
- Range of movement and functional ability
- Therapists measure range with a goniometer, but I [surgeon) am unable to use one reliably
- Patients' perception as to if the contracture is problematic or not
- Assess tissue deficit
- Loss of movement and function
- Depth, width of scar
- Whether single or multiple joints are involved with the contracture
- I don't use any grading or classification system for contracture measurement, I am more interested in what the perception of the patient is

goniometer measurements, poor patient compliance, pre-existing reasons for limited range of movement, fear of movement by the patient, compensatory movements by the patient which interfered with joint measurement and the impact of the position of the adjacent joints on the joint being measured if the scar crosses more than one joint.

One participant reported "each contracture is so different" and that she "could describe a contracture consistently, but the next person would report a different description". She suggested that a measurement guideline was required but did not currently exist and that development of one would be complex.

None of the participants worked in an institution where any data were collected routinely on the incidence or severity of burn contractures at department or hospital level. Only 5 participants (4 therapists and 1 surgeon) reported documenting contracture measurements in patient notes; these tended to be subjective measurements.

3.5. *Timing of burn contracture formation*

The clinicians were also asked when a contracture was first noticeable and when a contracture was unlikely to change further. This was to ascertain appropriate time points for contracture measurement and to see whether clinicians' views on when a contracture became fixed corresponded with the time post-burn that the pathophysiological theory of scar maturation would suggest (i.e., around 2 years) [13].

Participants reported a range of 1 – 8 weeks as the time that a contracture may first become apparent (average reported time 2.5 weeks). Regarding the time at which a contracture became 'fixed', the average response was 8.5 months (range 6–18 months). Two participants added that the time at which a contracture became fixed would depend on the location of the burn, stating that eyelids and hands were more likely to contract earlier. Age of the patient was cited by three participants as a factor that affected the time at which a contracture became fixed (earlier if the patient was younger). One participant reported that severity of contracture would influence the point at which a contracture would become fixed - "*It [a contracture becoming fixed] relates more to severity than time, so if it is a moderate contracture, it is unlikely it will go away*".

Ten participants reported that the initial stage of care (first 4 weeks) after a burn is the period during which the outcome of a contracture can be most influenced. Three participants indicated that the first 3 months was the most influential period; 4 participants did not respond.

3.6. *Basis for clinician opinions*

To evaluate how much weight clinicians gave to published literature compared to clinical experience regarding risk factors for contractures, participants were asked what sources informed their knowledge. Sixteen (94 %) participants said, "Mainly from clinical experience"; only one participant reported "mainly from literature". Of the fifteen participants relying mainly on their clinical experience, three provided further quantification – "from experience 80 % and 20 % literature", "100 % from clinical experience", "70 % from clinical experience and 30% literature". None of the participants were able to mention an article or specific publication that had helped formulate their opinions on risk factors for burn contracture formation.

4. Discussion

We found limited published evidence on risk factors for burn contractures in LMICs [11]. Clinicians who specialise in burn

care in LMICs typically have extensive experience and exposure to hundreds of patients with contracture. Although the majority of risk factors for burn contracture reported in the literature (from both high- and low-income settings) are putative and based on clinical opinions [11], this is the first time the perceptions of risk factors for burn contracture amongst clinicians with LMIC experience have been formally explored and reported.

The clinicians interviewed were very confident to talk about contractures and had strong opinions. They identified a very large number of risk factors covering a broad spectrum of domains including the burn itself, the patient, and a range of treatment, health system and socioeconomic factors. Clinicians reported not only risk factors that had been previously identified in the literature (mainly burn and treatment factors) [11] but also several which have not been previously documented (mainly healthcare access, socioeconomic factors and other factors related to the patient or their family). The clinicians' views reinforced the existing literature from LMICs [11] which suggests that socio-economic factors and those related to access to care are important risk factors in the LMIC context; these factors often do not feature in HIC literature. The majority (63 %) of risk factors identified by the clinicians were not burn or treatment factors, presumably because socioeconomic and healthcare capacity factors limit access to appropriate treatments and may even supersede the effects of burn injury risk factors.

Of the top 10 most frequently cited risk factors in this study, half related to perceived deficiencies in provision of appropriate treatments, including system failures such as delayed treatment and lack of trained staff. Eight of the clinicians' top-ranked factors were related to treatment deficiencies or failures. Of the 31 factors included in the clinicians' 'top 5′, over one third (11/31) were socioeconomic (n = 6) or health system problems (n = 5). The perceived contribution of these types of risk factors to burn contracture formation in LMICs seems much greater than suggested by HIC literature, highlighting the potential impact of the social determinants of health [14] on this burn morbidity.

Risk factors generated by this study are poorly defined and need further exploration. Proximal and distal risk factors require differentiation; proximal factors are risks that directly affect health/contracture such as depth of burn, distal factors e.g. low income, may indirectly affect contracture incidence and severity.

Many risk factors reported by the LMIC clinicians would not be relevant in HIC settings due to the provision of readily accessible, specialist, standardised burn care in HICs without the same socioeconomic restraints faced by patients in the LMICs. This underpins the importance of exploring risk factors in LMICs separately rather than assuming that the risk factors identified in HICs are transferable to LMIC contexts.

Notably, the clinicians interviewed based their knowledge of contractures and what influences them mainly on their own experiences rather than published evidence; this is in keeping with previous observations on the predominance of putative rather than research evidenced risk factors in existing literature [11]. It also emphasises the need for wider research and publication on risk factors for contracture in LMIC settings.

It was also notable that although participants had no doubts that they could recognise a contracture, none provided a standardised system of measurement or an operational definition of contracture. A lack of consistency and objectivity in the measurement of contracture has also been identified in HIC literature [15]. Goniometry is the most common method of contracture measurement reported from HICs [16–18], but in the present study goniometry was rarely used in routine practice and visual estimation was the norm. Standardised contracture definition and measurement is essential for reliable studies of treatment efficacy as well as risk factor identification but is notably absent from many contracture studies which examine risk factors in HIC or LMIC literature [11]. It would have been interesting to explore in more detail how clinicians quantified the severity of a contracture, as well as its presence or absence.

None of the institutions represented by participants collected any data on contracture prevalence, outcome, or treatment and consequently could not contribute to the published knowledge base, despite (or perhaps because of) their high patient volumes.

Although participants' perceptions of the average time at which contractures are first identifyable (2.5 weeks) was similar to the timing of many HIC reports which are based on contracture prevalence at discharge from hospital [19–22], we found a discrepancy between their opinion of the time at which a contracture would become fixed (mean 8.5 months) and the normally accepted 2-year process of scar maturation [13]. Whether this is the result of more burn wounds becoming infected, or healing by secondary intention rather than skin grafting, or due to a lack of other ameliorating therapies in participants' LMIC settings is unknown; more work is indicated to explore if or why contractures appear fixed sooner in low-income environments.

5. Limitations

Participant numbers in this study may appear small but as saturation had been reached, the sample size was considered adequate. However, participants were drawn from a limited number of professions. Although the selection of doctors and therapists reflects the predominant authorship of LMIC articles on burn contractures [11], other burn team members (e.g., nurses and psychologists) might have given useful or different input. Expanding the interviews to other professions in the multidisciplinary team could be beneficial but burn team membership is limited in LMICs. Patient views on the risk factors for burn contractures would also be valuable, these were later collected as part of the broader study.

Participants also knew the interviewer was a physiotherapist, which may have influenced them to report risk factors supporting the role of therapy within burn care; lack of positioning, lack of splinting and lack of physiotherapy were amongst the most cited risk factors.

Independent verification of the categorisation process of the risk factors would have been helpful, although many of the items listed were clearly articulated and factual. Further investigation of these topics would enhance the robustness of these findings.

6. Conclusion

This study of LMIC clinicians' perspectives reinforces the emerging hypothesis [11,12] that the most important risk factors for burn contractures in LMICs may be very different from those identified in HIC settings.

The lack of clinical reliance on published literature for information on contracture risk factors may be due to a lack of relevant LMIC literature; efforts to redress this imbalance are urgently required. Robust risk factor studies may be difficult to conduct in LMIC settings, but LMIC clinicians have extensive exposure to contractures and their experience can provide a valuable resource. Many of the risk factors identified by the clinicians interviewed need better definition and detail, but all merit further investigation, particularly with respect to the impact of socioeconomic and health system issues on the development of contractures after burns. The majority of the factors reported by the clinicians are potentially modifiable but extend well beyond medical factors, requiring health and socioeconomic policies to increase available burn care resources and improve access for burn patients who are often already living in poverty.

The observed diversity of clinical practice with respect to diagnosis and measurement of a burn contracture is likely a global phenomenon in both high- and low-income health systems. As stated by others [23–28] we have a pressing need for an agreed, standardised, simple and easily reproducible method of diagnosing and classifying burn contractures if we are to improve our understanding of the treatment and prevention of burn contractures, especially in LMICs, where the scourge of disabling burn contractures is most common.

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Declaration of Competing Interest

There are no conflicts of interest for any of the authors.

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