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Functional assessment of long bone fracture healing in Samburu County Referral Hospital (Kenya): the squat and smile challenge

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Abstract

Background: The burden of musculoskeletal trauma is increasing in low- and middle-income countries. Due to the low clinical follow-up rates in these regions, the Squat-and-Smile test (S&S) has previously been proposed as a proxy to assess bone healing (BH) capacity after surgery involving bone fractures. This study deals with various aspects of using S&S and bone radiography examination to obtain information about an individual's ability to recover after a trauma. In summary, we performed the S&S test to assess the possibility of recovering biomechanical function in lower limbs in a remote area of Kenya (Samburu County).

Methods: Eighty-nine patients (17.9% F; 31.7 ± 18.9 yrs) who underwent intramedullary nail treatment for femur or tibia fractures were enrolled in this study. Both S&S [evaluated by a goal attainment scale (GAS)] and x-ray (evaluated by REBORNE, Bone Healing Score) were performed at 6 and 24 weeks, postoperatively. An acceptable margin for satisfactory S&S GAS scores was determined by assessing its validity, reliability, and sensitivity.

Results: S&S GAS scores increased over time: 80.2% of patients performed a satisfactory S&S at the 24-weeks follow-up with a complete BH. A high correlation between S&S GAS and REBORNE at the 6- and 24- weeks' timepoint was found. Facial expression correlated partially with BH. The S&S proved to be accurate at correctly depicting the BH process (75% area fell under the Receiver Operator Curve).

Conclusion: The S&S provides a possible substitution for bone x-ray during BH assessment. The potential to remotely follow up the BH is certainly appealing in low- and middle-income countries, but also in high-income countries; as was recently observed with the Covid-19 pandemic when access to a hospital is not conceivable.

Keywords: bone healing, functional assessment, goal attainment scale, intramedullary nail, REBORNE, squat and smile test

1. Introduction

The rates of injury-related death and disability have been steadily increasing in low- and middle-income countries (LMICs). For every person who dies from injury, many more are injured with a temporary or permanent disability.[1] Causes of trauma are the increased use of motorized transport on poor road systems,[2] work injuries in a deficient context of laws for worker safety,[3] and stab wounds from sharp weapons or blunt wounds from gunshot.[4] Disability is often a consequence of underdeveloped trauma care systems.[5] The Disability Adjusted Life Year (DALY), provided by the Global Burden of Disease study, draws attention to the importance of nonfatal injuries and suggests that disability plays a major role in determining the overall health status of a population.[6] Addressing the consequences of an injury in LMICs has become a public health priority due to its social and economic burden.

In Kenya, motorcyclist trauma is increasing at an annual rate of approximately 29% with a 4-fold increase in motorcycle registration over the last 3 years.[7] Musculoskeletal injuries constitute 7% of total DALY in Kenya and 72% occur in people under 40 years old.[8] Data projections suggest that road traffic crashes will be the fourth leading cause of DALY in 2030.[9] Despite this large burden, there is an inadequate official response in terms of policy and funding devoted to injury prevention, trauma, and surgical care compared with other significant global health problems such as HIV, tuberculosis, malaria, and other infectious diseases.[1] The highest percentage of traumatic injuries are long bone fractures of the lower limbs.[10] Until recently, the most common treatment option available in LMICs was a long period of immobilization and skeletal traction, due to limited access to orthopaedic surgical resources. Infrastructure and specialized personnel are concentrated in major urban areas and

Find The Cure Italia NGO has granted all patients equality in early mobilization and access to the referral hospital.

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the poor development of satellite trauma centers is a major issue. A fair exception is the area of this study, the Samburu County Referral Hospital in Maralal, a remote part of the northern region, former Rift Valley Province.[11] The hospital accommodates 400 traumatic injuries yearly and performs 150 orthopaedic interventions. One surgeon performs the interventions by using intramedullary nails designed specifically for femoral and tibial bones by a humanitarian organization, Surgical Implant Generation Network (SIGN) Fracture Care International. SIGN seeks increased equality in fracture care worldwide by making intramedullary nails available to those who need them as well as the means to implant them at no cost, and relevant education to surgeons.

Development of a disability after trauma can easily push people into poverty through negative impact on access to employment and income-generating activities.[12]

Follow-up of traumatic injuries is a great challenge in LMICs, especially in rural and poor areas, due to the underdeveloped road systems, lack of health centers and transportation, unaffordable cost of traveling, insecurity related to tribal clashes, urban crimes, terrorism, and armed conflicts.[13] Due to these circumstances, once a patient has been treated in the referral hospital the effort can be ineffective due to the low rate of radiological follow-up, as periodic examinations of the bone healing process of the patient's fracture must be conducted. Thus, monitoring the healing phase after surgery and detecting early-stage complications, that is, nonunion, malunion, and deformity could be an impossible mission.

A novel method to monitor the bone healing (BH) process and the quality of life (QoL) that does not require radiographs or physical examination is therefore very appealing in this geographical context. Previous studies have shown that a patient's ability to perform a squat test can be used to assess his or her mobility and functional ability after an operative lower-extremity intervention.[14] Recently, the Squat-and-Smile functional test (S&S) has been proposed as a proxy for postsurgical care[15] after lower limb orthopaedic interventions with interlocking nails. This is a novel approach that permits physicians to assess the crosstalk between skeletal muscle and bone[16] as well as the functional evaluation of different joints. It is a case where the perspective is not limited to bone metabolism as the sole system responsible for healing.

Wu et al[17] demonstrated that squat depth and/or support needed to squat was correlated with both the patient's QoL and his or her need for reoperation. By contrast, Alves et al[18] reported a poor sensitivity and specificity of S&S in determining BH during the 1-year follow-up in patients who underwent intramedullary nail treatment for a femoral or tibial fracture. These contrasting findings highlight many issues, such as the standardization of a scoring system for the S&S, the optimal timing of the follow-up, and the role of the assessment of facial expressions, which still need to be well defined.

Thus, to investigate these issues, we serially carried out the S&S in a group of patients who had undergone intramedullary nailing of the tibia or femur, at 2 specific points after their surgery (6 and 24 weeks). This study deals with various aspects of using S&S and bone radiography examination to obtain important information about an individual's capacity to fully recover his/her biomechanical function in Samburu County.

2. Methods

This study was performed from July 2018 until May 2020. All patients were fully informed of the procedures and risks associated with the surgery and subsequent follow-up procedures before giving their verbal consent to participate in the study. The use of patient data for research purposes was approved by the committee on research ethics at the institution in which the research was conducted in accordance with the Declaration of the World Medical Association. The principles outlined in the Declaration of Helsinki (2013) of the World Medical Association have been followed. Any informed consent from human subjects was obtained as required. The study was deemed exempt from Institutional Review Board and Animal Use Committee Review.

All the surgical interventions, as well as the follow-up assessments during the 2 time points, were performed by the same surgeon using the SIGN nail system. An antegrade approach was used for all pediatric patients with femoral fractures and adults with proximal femoral fractures, proximal, and midshaft tibia fractures. A retrograde approach was used for midshaft and distal femoral fractures, as well as for very distal tibia fractures (tibiotalocalcaneal arthrodesis). The surgical techniques used were open reduction and fixation without fluoroscopy and closed reduction and fixation with fluoroscopy; interlocking was done using external jig aided intramedullary nails.

To reduce common factors responsible for low follow-up rate related to poverty, the following strategies were put in place: phone calls and short message reminders, transport allowances based on the distance from the home area to the facility, free x-ray, and free consultation fees for those patients selected by the social work department.

3. Clinical and functional assessment

All the clinical assessments before surgery as well as the clinical and functional assessments at 6 and 24 weeks postoperatively were carried out by the same experienced surgeon that performed the ortohpedic intevention. Additional follow-up beyond 24 weeks was only performed if BH was felt to be unsatisfactory. At each visit, patients underwent a S&S and a bone x-ray. To instruct the patient how to perform the S&S, the researcher first demonstrated the squat then performed the squat with the patient simultaneously. The patient then performed the squat unassisted and was photographed in 2 views (frontal and lateral) for analysis. The patient was instructed to keep the head and back aligned. They were allowed to use their hands on their thighs, when needed, to help maintain stability up to the maximum tolerated squat depth. Photographs were taken using a standardized technique, at a 4-meter distance from the patient, 1-meter in height, using special landmarks placed outside the radiology department. All of the research data including photographs were stored in a double-password protected database.

Scoring of the S&S was performed by the treating physician using a 5-point Likert scale based on a Goal Attainment Scale (GAS).[19] We customized our GAS as follows:

+2 = Patient achieves more than 90° of knee squat without support of the hands. He or she walks full weight bearing without crutches and has returned to normal daily life activities. He or she does not feel pain during the S&S. He or she has no sensation at all of having endured a trauma and a surgical intervention.
+1 = Patient achieves 90° of knee squat without support of the hands. He or she walks full weight bearing without crutches and has returned to normal daily life activities. He or she does not feel pain during the S&S. He or she has a mild sensation of having endured a trauma and a surgical intervention;

Figure 1. Sample images illustrating the scale adopted to evaluate facial expression when the patient reached the deepest point of the knee squat. Each score is represented as a possible variation independetly from gender. See the text for further information about the full score characteristics regarding smile and eye expressions. Patients provided written consent for the use of their images.

0 = Patient achieved 60° of knee squat without the support of the hands. He or she walks full weight bearing without crutches and has returned to normal daily life activities. He or she does not feel pain during the S&S. He or she has a sensation of having endured a trauma and a surgical intervention;
-1 = Patient achieves between 60° and 45° of knee squat with or without the support of the hands. He or she walks without full weight bearing by using crutches and has not returned to normal daily life activities. He or she feels pain during the S&S. He or she has a strong sensation of having endured a trauma and a surgical intervention;
-2 = Patient achieves less than 45° of knee squat. He or she walks without full weight bearing by using crutches and has not returned to normal daily life activities. He or she feels pain during the S&S. He or she has the sensation that the surgical intervention did not change at all his or her status after the trauma or made it worse.

Facial expression involving gestures of lips and eyes was considered as a proxy of pain.[20]

A smile was the desirable condition in case of successful intervention and BH. The facial expression was evaluated when the patient reached the deepest point of the knee squat and was customized as follows (see Fig. 1):

+2 = No sign of pain. Very clear smile, mouth open, and teeth visible. Eyes almost closed
+1 = No sign of pain. Clear smile, mouth open, and teeth visible. Eyes open;
0 = No sign of pain. Shy smile. Eyes open;
−1 = Mild/masked sign of pain. Smile undetectable. Eyes open;
−2 = Sign of pain. Expression of grimace. Eyes eventually closed.

The S&S score was correlated with the reparative phase of the fracture as shown by the radiological examination. To evaluate the BH process, we adopted the REBORNE bone healing score that was defined to perform a detailed evaluation of long bone nonunion consolidation in radiographs.[21]

We have analyzed 4 postoperative cortical views for each bone (medial and lateral cortices in anterior-posterior radiograph and anterior and posterior cortices in lateral radiograph). In every one of these cortices, 4 stages were assessed at each imaging examination, including fracture unchanged from preoperative views (stage 1; 1 point), presence of initial, noncontinuous callus (stage 2; 2 points), presence of continuous callus with fracture still apparent (stage 3; 3 points), and presence of callus with the same density as cortical (stage 4; 4 points). The minimum valid score was set at 4/16 (fracture unchanged in all 4 evaluated cortices). The maximum was set at 16/16 points (callus with the same density as cortical in all 4 cortices). This range was condensed in a value from 0, or more precisely from 0.25 (0/16 to 4/16 points, no detected bone consolidation), to 1 (16/16 points, maximum detected consolidation). A threshold for radiological consolidation was established from a score of 0.6875 (11/16), which means bridging in at least 3 out of 4 cortices, and initial presence of callus in the last one (3 + 3 + 3 + 2).

3.1. Study design and statistical analysis

This was a single-center, descriptive study, survey (cross-sectional) design. Values were expressed as mean (±SD). Sample size calculations determined that a sample of 15 participants would be adequate to detect a difference of 25% of BH between the participants, with a power of 0.80 (α=0.05). D'Agostino and Pearson's omnibus normality test was used to check if the values come from a Gaussian distribution and when the variables did not pass the normality test, they were treated accordingly with a nonparametric test. The statistical significance of the difference between 2 means was evaluated by Student *t* test (2-tailed, paired analysis), followed by Wilcoxon matched-pairs rank test. Regression analyses were performed using the least-squared residuals method. The level of significance was set at $P < 0.05$. Sensitivity and specificity of the S&S were assessed in S&S GAS (against REBORNE) and the area under the receiver operating characteristic (ROC) curve was estimated with 95% CI. All statistical analyses were performed using a commercially available software package (Prism 8.0: GraphPad, La Jolla, CA).

4. Results

A total of 89 patients were studied (17.9% F, 31.7 ± 18.9 yrs) and Table 1 shows their demographic, clinical, and surgical characteristics, as well as the socioeconomic support they could receive. Equal support was provided to all the patients to help them achieve early mobilization[22] with crutches and transport

Table 1

Clinical history of Samburu County Referral Hospital patients undergoing follow-up

	%
Provenance	
Samburu Central	58.4
Samburu North	24.7
Samburu East	3.4
Other Counties	13.5
Cause of injuries	
Road traffic accident	50.5
Fall	37.0
Gunshot	4.5
Others	8.0
Site, type of fracture, timing	
Tibia	59.3
Femur	40.7
Open	20.9
Closed	79.1
> 4 wks	15.1
0–1 wk	84.9
Internal fixation	
Open reduction	80.2
Closed reduction	19.8
Nail fixation	
Antegrade femoral	22.0
Retrograde femoral	18.7
Antegrade tibia	56.0
Retrograde tibia	3.3
Social allowance	
Crutches + transport	25.8
Crutches only	37.4
No allowance	36.8

allowances to access the Referral Hospital. The rates of accomplished follow-up sessions at 6- and 24-weeks' time points were 95% and 93%, respectively. The implants used were the Standard Nail with distal interlocking (10% of femoral and 58% of tibial fractures), the Finn Nail (23%), and the Pediatric Finn Nail (9%). One patient had bilateral femoral fractures and another patient had ipsilateral femoral and tibial fractures.

Figure 2A shows the BH REBORNEs scores at the 6- and 24-weeks' time points. Scores equal to or greater than 0.6875 (full bone healing) were reached in 49.0% and 87.1% at 6 and 24 weeks, respectively. There was a statistically significant increase in the average value of the scores after 24 weeks (0.85 ± 0.16) when compared with the 6 weeks score (0.64 ± 0.17).

Figure 2B shows the S&S scores at 6- and 24-weeks' time points. Scores equal to or greater than 0 (functionality reacquired) were reached in 78.0% and 84.6% of cases at 6 and 24 weeks respectively. Bad functionality at the S&S was represented in a few cases, both after 24 weeks (score −1 and −2, 14.2%) and after 6 weeks (21.9%). There is a statistically significant increase in the average value of the scores after 24 weeks (0.96 ± 1.10) when compared with the 6 weeks score (0.10 ± 0.33).

Figure 2C shows the pain assessment scores at 6- and 24-weeks' time points. Scores equal to or greater than 0 were equally distributed at 6 and 24 weeks, respectively. No statistically significant differences were found between the average scores at 6 and 24 weeks (0.17 ± 1.29 vs 0.08 ± 0.98, respectively).

Figure 3A and B shows a correlation between S&S and the BH REBORNE scores at 6 and 24 weeks, respectively. Essentially, 4 clusters have been found. A first cluster of patients during the follow-up had a satisfactory S&S score of 0 - +1 - +2 and a full BH with a score >0.6875 (41.7% and 80.2% at 6 and 24 weeks, respectively). A second cluster shows patients who did not have satisfactory scores both at S&S and at REBORNE during the 6th and 24th weeks (14.2% and 7.6%, respectively). A third cluster had a nonsatisfactory S&S score but with a complete bone healing score (7.7% and 7.6% at 6 and 24 weeks). Finally, the last cluster was represented by a satisfactory S&S score with no bone healing (36.2% and 4.4% at 6 and 24 weeks).

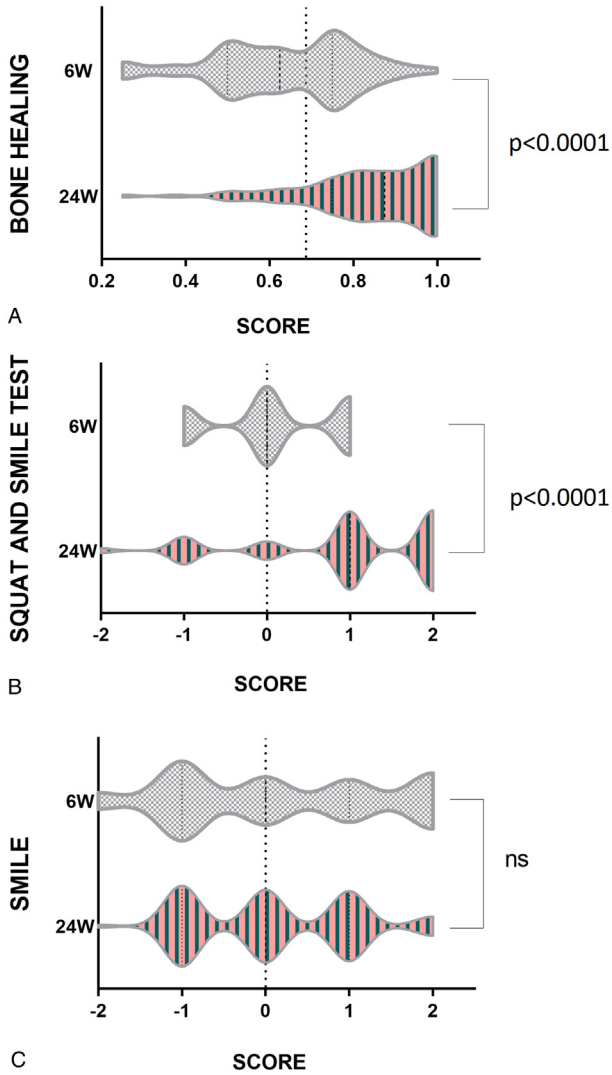

Figure 2. Violin plot graphs show the distribution of scores according to bone healing by radiological evaluation (A), the squat and smile test (B), and the facial expression evaluation (C), achieved at 6 and 24 weeks of follow-up. Vertical dotted lines indicate the score considered as a cut-off between a successful or failed result. The statistical significance of the average scores is indicated too.

All the pediatric patients had a full recovery with the highest scores both during the radiological evaluation (16) and the S&S GAS (+2).

The closed reduction and fixation procedure (CRIF), 18 cases (19.8%), had a higher and faster rate of recovery at the 6- and 24-weeks' timelines as indicated by the average value of S&S and BH scores.

During the analysis of the measurement of pain by analyzing the facial expressions, 56.1% of patients did smile among the 75 patients who exhibited a satisfactory S&S test and full BH. A

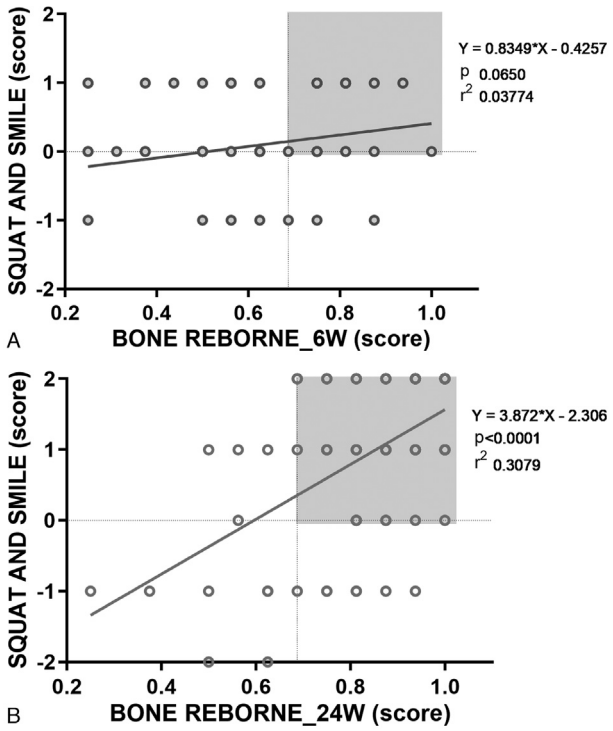

Figure 3. Correlation between squat and smile test and bone healing scores at 6 (A) and 24 weeks of follow-up (B). Vertical dotted lines indicate the score considered as a cut-off point between a successful or failed result. The gray areas are where the scores corresponding to full healing are expected to fall. The linear regression analysis is also shown.

positive score was noticed also in patients not healed and not able to perform a good S&S (10.1%). Thirty (33.7%) patients had no expression at all during the evaluation with a score of −1 and only 2 patients had a score of −2 with a clear expression of pain.

To build the ROC curve the 24 weeks S&S GAS were used as control for the 6 weeks S&S GAS: the true positive rate (sensitivity) was plotted in function of the false-positive rate (100-specificity) and for the S&S GAS cut-off point chosen (score = 0), the sensitivity to correctly detect a fully recovered capacity to squat was 67.3% and to detect the ineffectiveness to squat was 75.8%. The overall accuracy of the S&S GAS was 75% according to the area under the ROC curve (95% CI 0.67–0.82).

5. Discussion

This study demonstrates that a standardized S&S is a valid tool to follow up the BH process in patients having undergone intramedullary nailing of the tibia or femur at 6 and 24 weeks. The S&S GAS showed to have an internal consistency when compared with the REBORNE score and to be accurate in detecting a fully improved capacity to squat at the 24 weeks follow-up. More specifically, the present study showed that S&S performance was representative of the overall view of the QoL of the patient and of the socioeconomic burden of his or her life after the trauma.

In recent years, constant attention has been dedicated to the trauma system in LMICs, one of the world's major sources of trauma patients. However, most of the scientific and policy-maker's attention has been focused on the challenges of lack of equipment and orthopaedic implants. Very little has been done to cope with the low follow-up rates and outcomes of orthopaedic operations. In this regard, the results of the present study could hopefully foster the debate aimed at finding practical solutions to fight the poor follow-up rate of trauma patients in LMICs.

Table 2

Average rate of follow-up visits for long bone fractures in low middle-income countries

	Rate %	Range
Kenya	29	16–51
Tanzania	21	4–32
Ethiopia	35	5–57
Burundi	18	12–25
Chad	29	8–48
Cameroon	27	/
Ghana	37	29–43
Malawi	38	29–45
South Sudan	11	/
Nigeria	44	21–84
Niger	35	/
Angola	27	/
Liberia	22	17–27
Zimbabwe	19	14–24
DRC	12	/
Uganda	20	8–33

Since the hospitals supported by SIGN create a continuous relationship with their surgeons by providing quality education and regular incentives to record information in the charity's database, it is reasonable to assume that a stronger rate of follow-up can be found in SIGN's registers than in most government hospitals and other facilities. The online SIGN database is most likely the largest one as it relates to long bone fractures in LMICs, registering not only nail surgeries but also follow-up visits.[23] As it appears from the data reported in Table 2, the average rate of a follow-up visit in several LMICs is approximately 24% with substantial variation between the different trauma centers.

At the beginning of the present study, the second follow-up visit was scheduled at 12 weeks but the substantial number of patients who showed an unsatisfactory BH at this time point caused us to postpone the second follow-up visit to 24 weeks to explore the possibility for the patients to come to the facility no more than 2 times.

After having analyzed several factors that may discourage the patients from coming for the follow-up visits, we realized that transport and bone x-ray-related costs were the major concerns. To reduce the number of patients who encountered complications due to poverty, we introduced a transportation allowance system reimbursing the cost of transport (34% of the patients), and free x-ray checks (100%). On account of these changes, we have reached a 93% follow-up rate at 24 weeks. In our experience in remote areas, the low follow-up rates may not relate to the unwillingness or poor collaboration of the patients but rather to the extreme economic burden.

Losing follow-up sessions can lead to severe complications such as the 5.5% rate of malunion of long bone fractures reported in a study carried out in Tanzania.[17] This complication is frequently associated with loss of limb function, muscle atrophy, stiffness of the adjacent joints, diffuse limb osteopenia, and systemic deterioration especially in the presence of infections.[24]

Thus, taking into account the low rate of follow-up and the rate of malunion, it appears that it is of paramount concern to devise new strategies aimed at reducing the number of patients who may be susceptible to complications and disability.

Table 3

Samburu County: most relevant social and economic data

Total population	num	310.327
Area sq km	km^2	21.022
Household size	m^2	4.7
Population density (no. per sq. km)	No/km^2	15
Rural dwellers	%	80
Land suitable for agriculture	%	10
Life expectancy	yrs	61
Adult illiteracy rate	%	90
Overall poverty	%	80
Food poverty (less than 2250 kcal/d)	%	60
Tamak road	%	0.6
Unemployment	%	90
Population with piped water	%	10
Mean distance to nearest water point	km^2	5
Doctor to patients	Ratio	1:10.000
Doctor to patients accepted national	Ratio	1:1.000
Nurse to patients	Ratio	91:100.000
Nurse to patients accepted national	Ratio	55:100.000
Stunting (too short for age)	%	30
Wasting rate (weight against height)	%	20
Underweight rate (too light for age)	%	34
Teachers to pupils	Ratio	1:91

Samburu County is a disadvantaged area characterized by severe geographic isolation, poor road systems, prolonged periods of drought, an elevated rate of poverty, a low rate of literacy, food scarcity, and a high level of insecurity related to tribal clashes for cattle rustling (Table 3). Eighty percent of the population are pastoralists [25] and the prevalence of underweight individuals in the county stands at 34.3%.[26] Overall, this data gives an answer to the question of why the follow-up rate is so low in hardship areas.

5.1. S&S for assessing fracture healing

In our study, the S&S showed to be accurate in evaluating fracture healing at the 24 weeks follow-up. Our results differ from those reported at the 1-year follow-up in a recent survey of the SIGN database.[18] Different criteria adopted to assess radiographic records and to evaluate S&S performance are likely the reasons for this discrepancy. As outlined above, we did not utilize the Radiographic Union Scale for Tibia fracture (RUST) score [27–29] but we used the REBORNE bone healing score to perform a detailed evaluation of both tibia and femur bone healing.[21] In the present study, S&S performance was merged with an overall view of the QoL of the patient and of the socioeconomic burden of his or her life after the trauma.

Among the patients observed in cluster A, Figure 4A (satisfactory S&S performance and BH) we have all the pediatric patients. Following the approach proposed by Roaten et al,[30] in these patients, the femoral fracture was treated with interlocking nails and 100% of our patients had scored the maximum both in S&S performance (+2) and BH (16) at the 24 weeks follow-up visit.

The reasons responsible for the unsatisfactory BH observed in few patients are quite different: 2 of them had postoperative infections; in 3 cases comorbidity was present (psychosis, HIV, and associate second fracture); 2 patients did not accomplish a correct weight-bearing measure after surgery and 1 patient was severely malnourished. Although these results are to be considered a failure from a therapeutic point of view, they provide further support to the direct correlation between the capacity to perform a proper S&S and the BH process (Fig. 4B).

Particular attention must be paid to the analysis of the false-negative and false-positive patients in this study. Seven patients (7.7%) were unable to perform a satisfactory standardized S&S but showed a full BH in the x-ray. All these patients were affected by long-term malunion or deformity and had developed severe knee stiffness. The operations lead to a successful BH because the patients were able to bear weight after the surgical correction. However, the S&S was infeasible due to the stiffness of the knee, which may require an additional operation. These patients should be detected earlier, and the S&S could also be useful in achieving this goal. Since we were able to treat unstable fractures with internal fixation, no further similar cases came to our attention. Finally, we had 3 false negatives (3.4%) that were able to properly perform the S&S test and achieved a good clinical score but surprisingly a poor score on BH. They were very similar and had a compound tibia shaft fracture, Gustillo Type I. Our hypothesis is that periosteal stripping, an imperfect reduction, and the rigidity of the interlocking nail could be the key factor of no BH but with a full range of motion and clinical S&S.

5.2. Facial expression analysis

Pain is an unavoidable event in patients with orthopaedic trauma and is associated with an acute stress response including changes in autonomic nervous system activity, neuroendocrine secretion, and psychological distress. However, pain remains currently overlooked particularly in patients unable to readily communicate their pain intensity, such as patients with low health literacy. Health literacy (HL) is defined "as the cognitive and social skills which determine the motivation and ability of individuals to gain access to, understand and use information in ways which promote and maintain good health." A direct pain rating is not an option to explore pain in countries with financial deprivation, high prevalence of low social status, and low education.[31] It is most challenging and time-consuming in the majority of cases for physicians to enhance comprehension and HL of persons with low basic skills in literacy and numeracy as in Samburu County. Thus, our approach was to delve inside the pain of each of our patients by assessing their facial expression, a promising field of research characteristic in intensive care units where patients cannot speak or read.[32] We decided to use the analysis of this domain to open a whole new world of thoughts, a combination of anthropological, cultural, and technological issues. Normally, the communication process involves both verbal and nonverbal components. Nonverbal communication includes body language, such as gestures, posture, and facial expressions. Facial expressions are the delicate signals of a much larger field of communication.[33]

Our findings indicated that the presence of a smile was not directly correlated to a satisfactory squat and bone healing. Several factors may be involved in the lack of such correlation. Not smiling for a photo, a strong resistance to pain, uncomfortable sensation in front of a camera or a doctor, personal mood of the day, and family problems are among some of the sociocultural behaviors that may affect that correlation. This data corroborates previous findings [17,18] that facial expression in S&S is not a reliable measure of fracture healing. However, it may be useful to further investigate this domain in different social-cultural settings to better understand the expression of pain. If a smile is not a reliable parameter perhaps the absence of a pain-induced grimace could be a telling measure of patient

Figure 4. Squat and smile tests at 24 weeks follow-up in a fully recovered patient (A) and in a failed recovery (B). The corresponding anterior-posterior and lateral bone radiographs taken presurgery and after 24 weeks are represented. Patients provided written consent for the use of their images.

wellbeing, independent from cultural and socio economical limits. Further data are needed to make the Smile component of the S&S more reliable. An alternative approach to assess pain during the S&S could be to include a VAS pain scale during the examination.[34–36]

6. Conclusion

The S&S GAS evaluates an individual ability to perform squat at 6 and 24 weeks after the fracture-healing process in patients having undergone intramedullary nailing of the tibia or femur. The sensitivity of the S&S in determining patients' performance at various phases of BH is vital to take into account and it is worth highlighting, considering the recent Covid-19 pandemic, that the potential for remote assessment is particularly appealing not only in LMICs but also in any setting where a bone x-ray examination can be challenging for logistic reasons. S&S functional test could be used as a screening test, to redirect to the hospital only those patients who are really in need of a radiological check-up.

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