

# Prevalence of hypertrophic scar formation and its characteristics among the Chinese population

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## Abstract

Each year in Hong Kong, about 350,000 surgical procedures are conducted for various types of conditions. Previous review indicated that the prevalence of hypertrophic scar among Caucasians ranged from 15% to 63% and that the incidence was even higher among non-Caucasians. This study aims to find out the prevalence rate of hypertrophic scar among the Hong Kong Chinese population after standardized surgical procedures. A systematic and objective scar measurement protocol is implemented in this study. The spectrophotometer, Miniscan XE plus was used to measure the scar pigmentation based on the theory of the CIE colour model. The tissue ultrasound palpation system (TUPS) was employed to measure scar thickness. From May 2001 to December 2003, 154 patients, who received surgical intervention at the Department of Orthopaedics and Traumatology of a large regional hospital, were invited to join a scar-screening test. One hundred and fifteen patients (74.67%) were found to have signs of hypertrophic scar based on thickness, pliability, pigmentation and vascularity (using the Vancouver scar scale (VSS) score). One hundred and one patients consented to have more comprehensive scar assessment. Results indicated that the scar thickness was  $4.91 \pm 1.03$  mm. Compared with the adjacent normal skin, the color of hypertrophic scar was significantly different in terms of lightness (d.f. = 100,  $t = -19.36$ ,  $p < 0.01$ ), redness (d.f. = 100,  $t = 15.75$ ,  $p < 0.01$ ) and yellowness (d.f. = 100,  $t = -11.48$ ,  $p < 0.01$ ) using paired  $t$ -test analysis. Fourty-six point five percent and 33.7% among patients reported pain ( $2.19 \pm 2.74$ ) and itchiness ( $1.47 \pm 2.53$ ) over the scar. The objective scar assessments showed that more than 70% of scars had increase in thickness and pigmentation after surgery. More than 40% of patients reported pain and itchiness. The results showed that more than 70% of the scars in the HK Chinese population had become hypertrophic in terms of pigmentation, thickness and physical symptoms such as pain and itchiness 1 month after the surgical intervention. More long-term follow up study should be done to find out the prevalence and that it is essential to provide early intervention before the scar becomes problematic in management.

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*Keywords:* Hypertrophic scar; Scar prevalence; Chinese; Objective measurement

## 1. Introduction

Around 350,000 surgical procedures are conducted in hospitals in Hong Kong each year [1]. Post-surgical hypertrophic scars seem to be a common problem reported by surgeons and patients. Hypertrophic scar is caused by the excessive deposition of collagen resulting in exaggerated wound healing response with progressive increase in collagen synthesis [2]. Clinically, hypertrophic scar is defined as an exuberant scar that remains in the area after

injury and leads to itchiness and pain, also leads to cosmetic problem with increased thickness, redness and stiffness [3]. Scar contracture will be developed over joints and this will reduce patients' functional performance in daily living [4].

When skin is injured, the process of wound healing will start with the vascular response followed by the inflammatory response, then to proliferation and maturation [5]. If these processes of wound healing are prolonged, it might lead to development of hypertrophic scar [6,7]. In general, surgical scar takes around 21 days for the collagen density level to return to normal. In some cases, it might take a long time and sometimes the abnormal scarring process may last for a year or more [6,8,9]. Previous studies, reported that the

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incidence of hypertrophic scar range from 5% to 37% in the White race population [10,11]. However, Bombaro et al. found that 62% of White race patients and 80% of the non-White patients had hypertrophic scar [12]. Lewis and Sun's genetic study reported 91.4% developed hypertrophic scar out of 58 post-deep thermal injury scars and 44.6% of 83 surgical scars among the Chinese population [13]. The incidence of hypertrophic scar on surgical and burn scar seems to be related to the skin pigmentation among people with different races. Chinese people seemed to have a higher incidence rate of hypertrophic scar.

None of the studies mentioned how they defined hypertrophic scar and how to measure these scars quantitatively. Most of the findings were mainly reported by researchers subjectively. Other than race difference, location of injured site, and depth of injury are suggested as contributors to hypertrophic scar formation. It is desirable to conduct a prevalence study on burns patients. However, there are a lot more confounding factors when studying the prevalence of hypertrophic scar on burns patients such as

depth of injuries, location of injured site and methods of wound management and surgical intervention, therefore, in this study, we have selected a group of patients who underwent similar orthopaedic surgeries as a preliminary study on scar prevalence. Patients were recruited from the Department of Orthopaedics and Traumatology after their surgery. They were asked to return back to hospital for follow up one month after their discharge. A standard scar measurement protocol would be implemented to determine if there was any hypertrophic scar developed at the surgical site. Patients who developed complications after surgeries would be excluded from the study.

**2. Materials and methods**

*2.1. Instrumentation*

A standard scar measurement protocol was implemented in this study. The Vancouver scar scale (VSS) was used as an

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<p><b>Pigmentation ( M )</b></p> <p>0 normal- colour that closely resembles the colour over the rest of one's body</p> <p>1 hypopigmentation</p> <p>2 mixed pigmentation</p> <p>3 hyperpigmentation</p>	<p><b>Vascularity ( V )</b></p> <p>0 normal- colour that closely resembles that colour over the rest of one's body</p> <p>1 pink</p> <p>2 red</p> <p>3 purple</p>
<p><b>Height ( H )</b></p> <p>0 Normal - flat</p> <p>1 &gt;0 to 1mm</p> <p>2 &gt;1 to 2mm</p> <p>3 &gt;2 to 4mm</p> <p>4 &gt;4mm</p>	<p><b>Pliability ( P )</b></p> <p>0 Normal</p> <p>1 Supple ( Flexible with minimal resistance )</p> <p>2 Yielding ( giving way to pressure,</p> <p>3 Firm (inflexible not easily moved resistant to manual pressure</p> <p>4 Banding rope (like tissue that blanches with extension of scar</p> <p>5 Contracture (permanent shortening of scar producing deformity or distortion)</p>

Fig. 1. Vancouver scar scale.

initial screening tool for hypertrophic scar formation. VSS was commonly used in clinics to report the progress of the hypertrophic scar [14]. Scar properties such as pigmentation, height, vascularity and pliability were assessed and rated. The items of pigmentation and vascularity were used in a descriptive manner, thickness and pliability were rated on ordinal scales. The inter-rater reliability was reported as  $0.5 \pm 0.1$  in Cohen's  $\kappa$  statistics. The higher score the scar rated, the more severe the scar would be (Fig. 1).

A commercial spectrophotometer (Fig. 2) was used to measure the pigmentation of the scar. The spectrophotometer is used commercially to provide the most accurate measurement of the scar color in terms of lightness ( $L^*$ ), redness ( $a^*$ ) and yellowness ( $b^*$ ) according to CIE  $L^*a^*b^*$  color model. The lightness and redness were proven to be highly correlated to the vascularity of scar, and the yellowness reflected the scar pigmentation from our previous study [15]. The test–retest reliability was also proved to be moderate to high (ICC = 0.95–0.99). Therefore, the instrument was adopted in this study to measure scar color.

The tissue ultrasound palpation system (TUPS) (Fig. 3a and b) was employed to measure the thickness of hypertrophic scar. The probe, is small enough to measure very narrow scar (less than 3 mm). It has been validated in another study and the results showed good inter-rater and test–retest reliability (ICC = 0.99) [16].

## 2.2. Sampling

In this study, the research team selected surgical scars for sampling instead of burn scar. The reason is that there is a decline of burn injuries in society after the introduction of Occupational Health and Safety Ordinances. There is a



Fig. 2. The spectrophotometer.

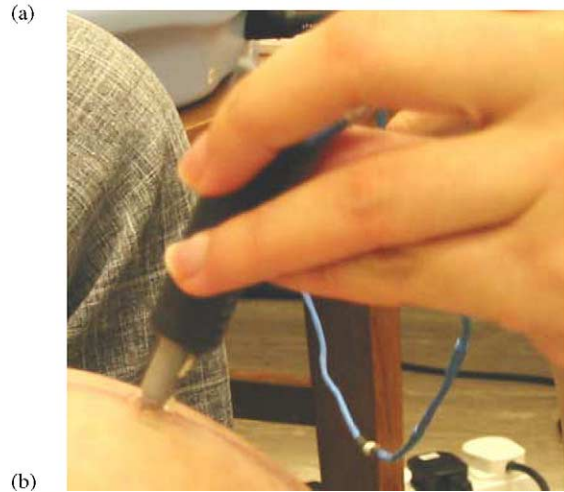


Fig. 3. (a) The microprocessor of tissue ultrasound palpation system and (b) the probe of tissue ultrasound palpation system.

reduction of industrial burn accidents and domestic burn accidents have also dropped. However, previous studies indicated a strong correlation of scar prevalence on burns patients and these other types of skin trauma such as surgical incisions could also induce scar formation.

Patients were recruited from the Department of Orthopedics and Traumatology of a large regional hospital in Hong Kong from May 2002 to December 2003. They all received orthopedic surgery procedures such as total knee replacement (TKR), total hip replacement (THP) or surgery in upper extremities (SUE). Both TKR and THP were classified as the standardized surgery as a team of surgeons followed the same surgery protocol for excision to create a neat wound, whereas SUE was conducted under various protocols and resulted in uneven wounds.

## 2.3. Method

This study adopted a cross-sectional research design to examine the prevalence of hypertrophic scar among the Chinese population. During the period of May 2003 to December 2003, patients admitted to Department of Orthopaedics and Traumatology were screened for hypertrophic scar formation after 30 days of surgery. An occupational therapist with more than 3 years of experiences

in burns unit assessed the scar physical characteristics including pigmentation, vascularity, height and pliability using VSS score. The criteria for defining hypertrophic scar are:

- 1) The total score of VSS rated equal to or higher than 4.
- 2) Each item of scale at least rated as 1 or higher than 1.

When a patient was identified to have developed hypertrophic scar based on the above criteria, he/she would be asked to conduct a more comprehensive scar assessment based on our measurement protocol. Upon their consent, they would then take a rest for 15 min in a room with constant temperature. The spectrophotometer and TUPS would be used to measure the scar pigmentation and thickness. Itchiness and pain over scar perceived by subjects were recorded by the use of visual analogue scale (VAS). The whole assessment lasted for 30 min.

### 3. Data analysis

Descriptive statistics were used to describe the prevalence among the sampled groups in terms of scar thickness measured by TUPS, scar color measured by spectrophotometer, the score of Vancouver scar scale. Mann–Whitney *U*-non-parametric analysis was to compare scar prevalence on gender difference, age group, different surgical procedures. Paired *t*-test was used to find out the color difference in terms of lightness, redness and yellowness between normal skin and hypertrophic scar.

### 4. Results

#### 4.1. Demographic data

One hundred and fifty-four patients (68 males and 86 females) were referred from the Department of Orthopaedics and Traumatology of PYNEH during the period from May 2002 to December 2003. Fifty-nine point seven percent received total knee replacement, 13.6% received total hip replacement and 22.7% received surgery in upper limb. They were aged between 14 and 85 with mean age 57.35 (S.D. = 19.74). Among the 154 patients, 115 patients (74.67%) were found to develop hypertrophic scar based on VSS screening criteria. Thirty-nine patients (24.7%) were found to have normal wound healing without scar problems (Figs. 4 and 5). One hundred and one patients (65.6%) agreed to conduct the scar assessment while 15 patients refused to join the objective scar assessment (Figs. 4–6).

There were 68 males (44.16%) and 86 females (55.8%) patients who developed hypertrophic scar after surgery (Fig. 6). The incidence rate was 76.7% and 72.1% of female and male, respectively. There was no significant difference



Fig. 4. Non-hypertrophic scar.



Fig. 5. Non-hypertrophic scar with flat appearance.



Fig. 6. Hypertrophic scar.

on incidence rate between female and male groups ( $p = 0.51$ ) (Table 1).

All patients were clustered into two age groups: (a)  $\leq 45$  and (b)  $>45$  years old. Thirty-nine subjects were in group aged  $\leq 45$  and 115 subjects were in group aged  $>45$ . There was no significant difference in the rate of incidence between the two groups (with 79.49% for younger group and 73.04% for the older group) (Tables 2 and 3).

4.2. Subjective assessment of hypertrophic scar

4.2.1. Vancouver scar scale

Among the 101 subjects who consented to have the comprehensive scar assessment, the mean total score on the Vancouver Scar Scale after 1 month of surgery was 7.54 (S.D. = 1.16). For each item of VSS, the mean score of pigmentation was 2.71 (S.D. = 0.54), height was 1.45 (S.D. = 0.54), vascularity was 1.82 (S.D. = 0.52) and pliability was 1.78 (S.D. = 0.52) (Table 2).

4.2.2. Subjective feelings of itchiness and pain

Forty-seven patients (46.53%) reported pain over the scar. The pain level was 2 out of 10 ( $2.19 \pm 2.74$ ). Thirty four patients (33.66%) reported itchiness over the scar ( $1.47 \pm 2.53$ ). One subject reported extreme pain over the scar, and one subject reported extreme itchiness.

Table 1  
Incidence rate of hypertrophic scar among different types of surgery

	Number of subject with formation of hypertrophic scar	Number of subject undergone normal wound healing	Incidence rate (%)
Age			
$\leq 45$ years	31	8	79.49
$>45$ years	84	31	73.04
Gender			
Female	66	20	76.74
Male	49	19	72.05

Table 2  
Scoring of Vancouver scar scale among 101 patients

Vancouver scar scale items	Mean of score
Pigmentation	$2.71 \pm 0.54$
Height	$1.45 \pm 0.54$
Vascularity	$1.82 \pm 0.52$
Pliability	$1.78 \pm 0.52$
Total score	$7.54 \pm 1.16$

Table 3  
Difference between normal skin and hypertrophic scar in CIE  $L^* a^* b^*$  model

	Normal skin <sup>a</sup>	Hypertrophic scar <sup>b</sup>	t-Value	d.f.	p
$L^*$ (lightness)	$58.27 \pm 3.96$	$49.32 \pm 5.09$	-19.36	100	$<0.01$
$a^*$ (redness)	$4.19 \pm 1.97$	$7.18 \pm 1.80$	15.75	100	$<0.01$
$b^*$ (yellowness)	$13.44 \pm 2.36$	$10.08 \pm 2.84$	-11.48	100	$<0.01$

<sup>a</sup>  $n = 90$ , mean (S.D.)

<sup>b</sup>  $n = 90$ , mean (S.D.)

4.3. Objective assessment of hypertrophic scar

4.3.1. Comparison of hypertrophic scar color and normal skin using the spectroradiometer

There was a significant difference among all color parameters ( $L^*$ ,  $a^*$  and  $b^*$ ) between hypertrophic scar and normal skin with lightness (d.f. = 100,  $t = -19.36$ ,  $p < 0.01$ ), redness (d.f. = 100,  $t = 15.74$ ,  $p < 0.01$ ) and yellowness (d.f. = 100,  $t = 11.48$ ,  $p < 0.01$ ). The hypertrophic scar was more reddish and darker but less yellow when compared with normal skin (Table 3).

4.3.2. Scar dimensions in hypertrophic scars

The scar thickness measured by TUPS was 4.91 mm (S.D. = 1.03), and the mean length was 17.26 cm (S.D. = 7.18 cm) of and the widest part of scar was 4.80 mm (S.D. = 4.74 mm).

5. Discussion

This study showed that the prevalence rate of hypertrophic scar among the Chinese population was 74.7%, 115 out of 154 subjects, had developed post-surgical hypertrophic scar after 1 month. When compared to the results

cited in previous studies [6,11,17], our finding indicated a much higher percentage of hypertrophic scar formation among the Chinese population after surgery. This is similar to Bombora et al's report in 2003 [12]. The rate of hypertrophic scar formation will be expected to be higher on the burn scar as the surface area is larger with deeper injuries on skin when compared with surgical hypertrophic scar.

Scars resulting from surgery will have impact on both the physiological and psychological well being of patients. The hypertrophic scar that we found appeared to look more reddish and paler, and less yellow when compared to the adjacent normal skin. Pigmentation of scar seemed to be a major problem among the Chinese. In terms of scar thickness, we found a mean of 4.91 mm among our subjects. The scar appeared raised and obvious on the skin surface when compared to adjacent normal skin (which is less than 2 mm in thickness usually). Some were firm and tough on palpation. More than 40% of patients reported pain and itchiness after 1 month of surgery.

Early intervention is therefore recommended to minimize the effect of hypertrophic scar on the changing color and thickness thus creating cosmetic problem increasing. In our clinical practice, patients were discharged 2 weeks after surgery when the wound was healed. In the past, there was little follow-up consultation to examine scar conditions. Patients also regarded "scar" as normal wound healing and often accept the unsightly appearance of the thickened and red scar. Itchiness and pain due to the humid and hot climate are common. Some patients would consult the medical services only when the scar became extremely itchy, painful, hard and raised. However, it might be too late for conservative management if the hypertrophic scar has been already developed. Often surgical excision may be needed. This is the first comprehensive study to look at the prevalence of scar conditions at 1-month post-surgery using a quantitative scar measurement system. Some patients after our assessment became more aware of their scar conditions and initiated requests for intervention.

From our study, we also observed that the scar maturation process seemed to be prolonged among the Chinese population. Further study exploring the prevalence rate among different races and population was suggested in the last meeting of International Society for Burn Injuries.

Some literature reported that there is a gender difference on the incidence rate of hypertrophic scar formation. A study on a Northern European population reported a difference between males (24%) and females (53%) [11]. However, another study on a population with darker pigmentation indicated that there is no difference between male and female patients [17]. Our study also demonstrated similar results that the incidence rate was more or less the same between females (76.7%) and male (72.1%).

This study indicated a very high prevalence rate of post-surgical hypertrophic scar. Lewis and Sun's study showed a relative higher rate of hypertrophic scar formation after thermal and burn injury (91.4%) than in surgical wounds

(44.6%) [13]. They commented that most burn wounds were more extensive and that surgical wounds tend to heal faster and create a smaller open wound area. Therefore, the incidence of hypertrophic scar was lower on surgical wounds. From this study, the incidence of hypertrophic scar on surgical scar was around 70%. It is not difficult to project that hypertrophic scar on burns wound would be more prevalent among the Chinese.

The subjects recruited in this study were mostly elderly with mean age 57.35 (S.D. = 19.74) years. From a previous study, it has been reported that the chance of the elderly developing hypertrophic scar was very low because of slow metabolism rate and less tensile strength in the skin [18]. However, our study found that there was a relatively high prevalence rate among Chinese elderly. This implies that Chinese elderly may also develop hypertrophic scar, and that the problem maybe more severe on the younger Chinese population. Further studies may need to be conducted to verify this observation.

In this study, all subjects were assessed 1-month post-surgery. It was reported that the normal wound healing process would take around 21 days. The screening test was implemented at 30 days after the wound has completely healed up. Results of our objective study reflected signs of hypertrophy as shown by the increase in thickness, pigmentation and vascularity. Patients also reported subjective pain and itchiness, thus demanding intervention. In Bombaro's study, the scar was followed up for 1 year and the prevalence rate was around 67% [12]. Though in our study, the period of assessment was 1 month after the wound was completely healed up, the clear indication of scar hypertrophy was seen. From our clinical observation, the maturation process of post-surgical hypertrophic scar may be different from burn scars and that after 6 months, the scar may become mature. Unlike surgical scar, the burn scar may take longer time for maturation and warrants more attention in management.

It was observed that the most severe site of hypertrophic scars formation was at or near the knee region. They were located on the quadriceps muscle over the thigh, which is the muscle for knee extension. The frequent movement of the scar tissue may induce excessive collagen fibers deposition, this leading to hypertrophic scar formation.

## 6. Conclusion

To conclude, this study reflected the higher incidence of hypertrophic scar among the Chinese population than in Western population. According to the statistics of the Hospital Authority (Hospital Authority Statistics Report, 2003), there were around 350,000 surgical procedures are conducted per year. With this projection, there would be around 250,000 surgical scars, which will have a tendency to become hypertrophic. The scar would become more severe without any early intervention. Early screening and treatment of hypertrophic scar is deemed necessary to

avoid excessive surgical or rehabilitation cost on the late complications of hypertrophic scar.

The objective assessment adopted in this study also provides a profile of the hypertrophic scar quantitatively in terms of its color and whole tissue thickness. This kind of measurement will serve as a screening tool in the future. In this study, we suggested that early screening should be investigated for detection of hypertrophic scar. An appropriate conservative treatment is suggested, including pressure therapy, silicone gel sheeting in order to improve the scar condition and act as prophylactic treatments. Regarding the high incidence rate, further study on comparing conservative treatments is suggested.

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