

# Relation between pH in the Trunk and Face: Truncal pH Can Be Easily Predicted from Facial pH

Sung Ae Kim, Bo Ri Kim, Mi Young Chun, Sang Woong Youn

Department of Dermatology, Seoul National University Bundang Hospital, Seoul National University College of Medicine, Seongnam, Korea

**Background:** The clinical symptoms of facial and truncal acne differ. Skin surface acidity (pH), which is affected by sebum secretions, reflects the different clinical characteristics of the face and trunk. However, no studies have been conducted on truncal sebum production and skin pH. **Objective:** We evaluated the differences and relationship between pH values of the face and trunk. We also evaluated the relationship between pH and the quantity of sebum produced in the trunk. **Methods:** A total of 35 female patients clinically diagnosed with truncal acne were included. We measured pH on the face and truncal area using the Skin-pH-Meter PH 905<sup>®</sup>. We measured truncal sebum secretions using the Sebumeter SM 815<sup>®</sup>. Statistical analysis was performed to evaluate the correlations and differences between pH and sebum. **Results:** Facial pH was significantly higher than chest and back pH values. The correlation between pH on the trunk and the face was significant. We used linear regression equations to estimate truncal pH using only measured pH from the chin. There was no significant relationship between truncal sebum secretion and pH. **Conclusion:** This was the first study that evaluated the differences and correlations between facial and truncal pH. We found that facial pH can predict truncal pH. In addition, we conclude that differences in pH and sebum secretion between the face and trunk are one of the

reasons for differences in acne symptom at those sites. (*Ann Dermatol* 28(2) 216 ~ 221, 2016)

## -Keywords-

Face, pH, Sebum, Skin-pH-Meter<sup>®</sup>, Trunk

## INTRODUCTION

Skin surface pH is associated with the pathogenesis, prevention, treatment, and wound healing conditions such as acne, irritant contact dermatitis, atopic dermatitis, and ichthyosis<sup>1,2</sup>. Skin surface pH is affected by sebum secretions and the presence of *Propionibacterium acnes*, which are important etiologies of acne. Thus, measuring skin surface pH could be an indirect way to elucidate the pathophysiology of acne. Most studies on facial acne, have considered biophysical parameters such as sebum secretion, skin surface pH, ultraviolet-induced fluorescence, and pores. Truncal acne is another aspect of acne development on low sebum secreting areas other than the face<sup>3</sup>. Although there is little information about truncal acne clinical characteristics and treatments, inflammatory lesions and scars are more easily developed on the trunk than on the face according to the practical field. The treatments for truncal and facial acne are similar, but the efficacy of acne treatment on the trunk is inferior, and scarring can easily occur more on the trunk than on the face<sup>4</sup>. If we assume that the development of truncal acne differs from that of facial acne, sebum secretion may help explain the possible difference. Using various bioengineering assessments, our research team has been studying the correlation between acne development and sebum secretion, as well as the acidity of the skin on the face<sup>5-7</sup>. We hypothesize that the truncal skin surface pH profile may be affected by the different sebum secretion characteristics of the trunk.

Received August 14, 2015, Revised August 28, 2015, Accepted for publication August 29, 2015

**Corresponding author:** Sang Woong Youn, Department of Dermatology, Seoul National University Bundang Hospital, Seoul National University College of Medicine, 82 Gumi-ro 173beon-gil, Bundang-gu, Seongnam 13620, Korea. Tel: 82-31-787-7319, Fax: 82-31-787-4058, E-mail: swyoun@snu.ac.kr

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Copyright © The Korean Dermatological Association and The Korean Society for Investigative Dermatology

However, to date, no study has examined the characteristics of truncal sebum production and skin pH. Therefore, our research team measured sebum production and skin pH on both the face and the trunk to analyze this relationship.

## MATERIALS AND METHODS

### Subjects

This study consisted of Korean females aged 19 years or older with truncal acne (more than grade 2 in the Leeds Revised Acne Grading System). Exclusion criteria comprised having taken isotretinoin within the previous three months, or a steroid within the past four weeks, before measuring skin sebum and pH. The Institutional Review Board of Seoul National University Bundang Hospital approved the study protocol (B-1307/211-003).

### Measurement of skin surface pH

On the face and trunk, we measured skin surface pH using the Skin-pH-Meter PH 905<sup>®</sup> (Courage+Khazaka Electronic GmbH, Cologne, Germany). We assessed skin surface pH measurements immediately after the sebum measurement. We calibrated the pH electrode before each measurement using two standard buffers (Mettler-Toledo, Greifensee, Switzerland) at a pH of 4.0 and 7.0, respectively. We washed the electrode with distilled water before each measurement and measured five sites on the face, as in the previous study<sup>5</sup>. We performed the truncal measurement at 10 sites (three on the anterior chest and seven on the back): at the sternal angle, at the right and left mid-clavicle from the anterior chest and the right and left scapular superior angle, at the middle of both scapular superior angles, at the right and left scapular inferior angle, at the middle of both scapular inferior angles, and at the twelfth thoracic vertebra. We divided the face and trunk into a high sebum-secreting zone consisting of the T-zone (forehead, nose, and chin), the FH-zone, and the BH-zone, and a low sebum-secreting zone consisting of the U-zone (cheeks), the FL-zone (FL1 and FL2), and the BL-zone (BL1, BL2, BL3, BL4, BL5, and BL6). To express mean regional pH levels that reflected regional differences in sebum secretion from the skin, we converted pH levels to the area-weight (AW) mean pH of the T-zone, the U-zone, and the entire face. We calculated these means using the following equations, considering the area ratio according

$$AW\ T\ pH = \frac{6 \times \text{forehead pH} + 1 \times \text{nose pH} + 2 \times \text{chin pH}}{9}$$

to the "rule of four"<sup>5,8</sup>:

$$AW\ U\ pH = \frac{5 \times \text{right cheek pH} + 5 \times \text{left cheek pH}}{10}$$

AW facial pH

$$= \frac{6 \times \text{forehead pH} + 1 \times \text{nose pH} + 2 \times \text{chin pH} + 5 \times \text{right cheek pH} + 5 \times \text{left cheek pH}}{19}$$

### Measurement of sebum secretion

Just before measuring the pH, we measured sebum levels on the same truncal sites using the Sebumeter<sup>®</sup> (SM815; Courage+Khazaka Electronic GmbH) on the same day. We asked participants not to wash within two hours of measurements. The same investigator performed all procedures in a room kept at constant temperature (22°C) and humidity (42%).

### Statistical analysis

We evaluated comparisons of mean pH values between the face and trunk, and high and low sebum-secretion zones using one-way analysis of variance (ANOVA). We tested intercorrelations of pH values between the face and trunk, and high and low sebum-secretion zones using Pearson's correlation coefficients and linear regression analysis. We also used Pearson's correlation coefficients to determine the correlations between sebum levels and pH levels at each site. We carried out statistical evaluations using PASW Statistics software version 18.0 (IBM, Armonk, NY, USA); we considered a *p*-value < 0.05 statistically significant.

## RESULTS

### Demographics

We included 35 female subjects (mean ± standard deviation age 25.1 ± 5.5 years, range 19~42 years) in this study. The study participants comprised four age groups: 19 years (n=5), 20~29 years (n=26), 30~39 years (n=2), and 40~49 years (n=2).

### Difference of mean pH values on the face and trunk

The mean pH values at five facial and ten truncal sites were 4.80~5.59 (range, 3.79~6.70). Among the five facial sites, the pH value was the lowest at the nose. The pH value of the AW T-zone was lower than that of the AW U-zone (5.41 and 5.54, respectively) (Fig. 1). Moreover, pH values were lower towards the lower back. Mean pH values on the face, chest, and back area were 5.48 ± 0.44, 5.17 ± 0.63, and 5.08 ± 0.54 respectively (Fig. 2A). The mean pH value on the back was significantly lower than

that on the face ( $p=0.007$ ). The differences in pH values between the face and chest ( $p=0.055$ ) and the chest and back ( $p=1.0$ ) were not significant. The mean pH of the high sebum-secreting zones (AW T-zone, FH-zone, and

BH-zone) and the low sebum-secreting zones (AW U-zone, FL-zone, and BL-zone) are in Fig. 2B and 2C.

### Correlations between facial and truncal pH values

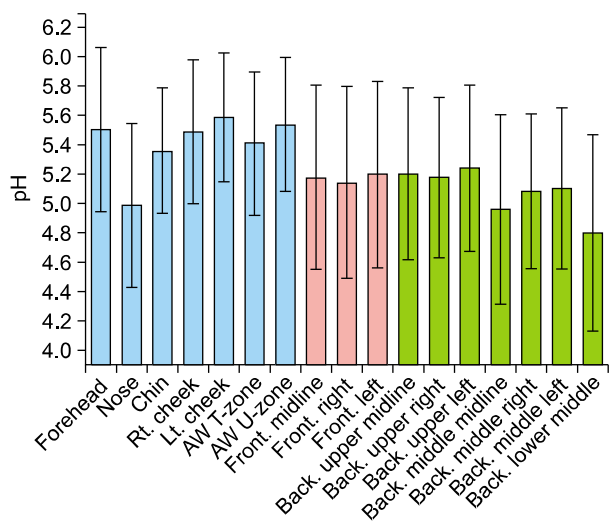
There were significant correlations between most facial and truncal pH values (Table 1). Among the five facial sites, the pH of the chin correlated most significantly with the pH of the chest ( $p<0.01$ ,  $r^2=0.67$ ) and back ( $p<0.01$ ,  $r^2=0.53$ ). The correlation coefficient between the face and chest pH was higher than the coefficient between the face and back pH. Based on the correlation between the pH of the chin and the pH of the chest or back, we derived the following two equations from the linear regression analysis (Fig. 3):

$$\text{Mean chest pH} = 0.981 \times \text{chin pH} - 0.080$$

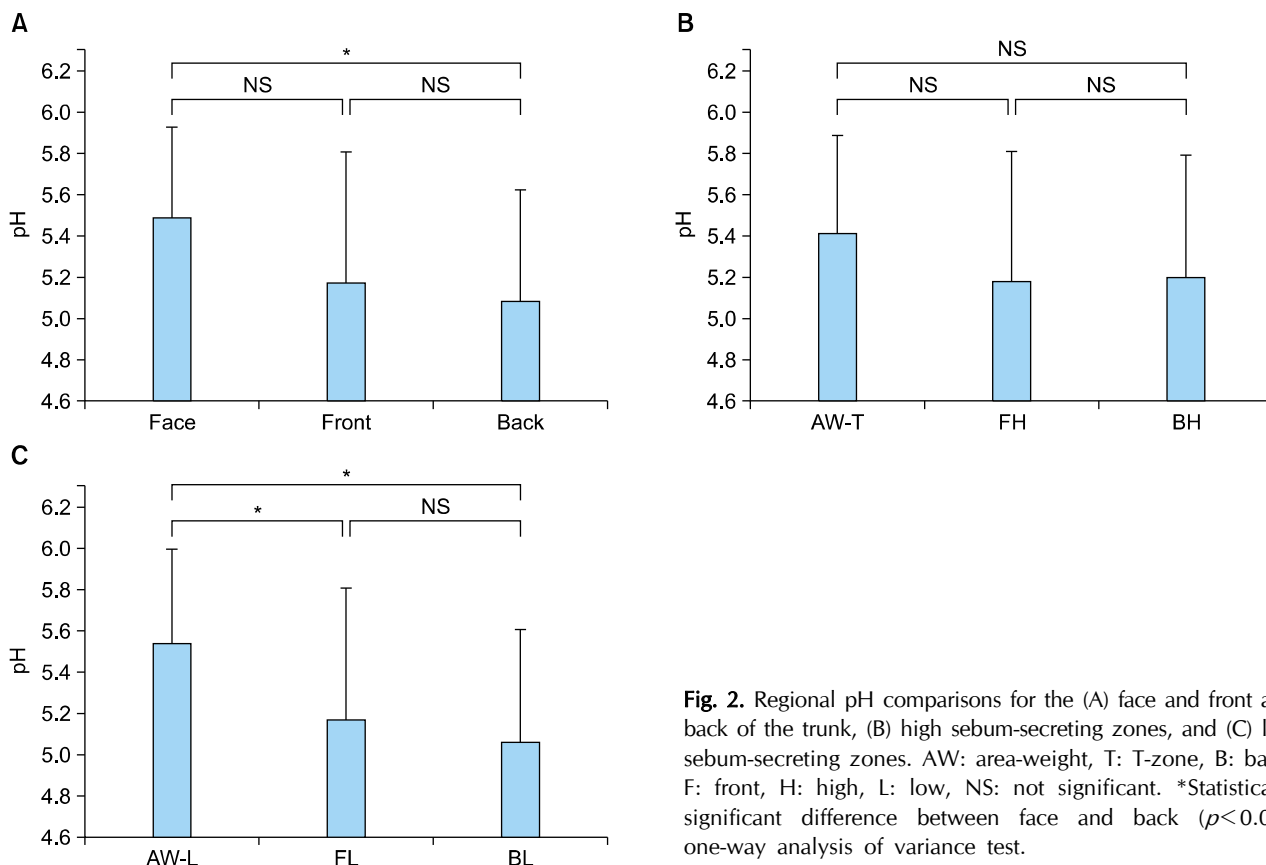
$$\text{Mean back pH} = 0.666 \times \text{chin pH} + 1.515$$

### Correlations between sebum casual levels and pH of trunk

In contrast to the correlation of facial sebum to the pH of the trunk found in a previous study<sup>9</sup>, we could not find any consistent correlations between sebum levels and pH



**Fig. 1.** Mean pH for each zone of the face and trunk. Blue bars: pH on the face, red bar: pH on the front of trunk, green bar: pH on the back. Rt.: right, Lt.: left, AW: area-weight, T: T-zone, U: U-zone.

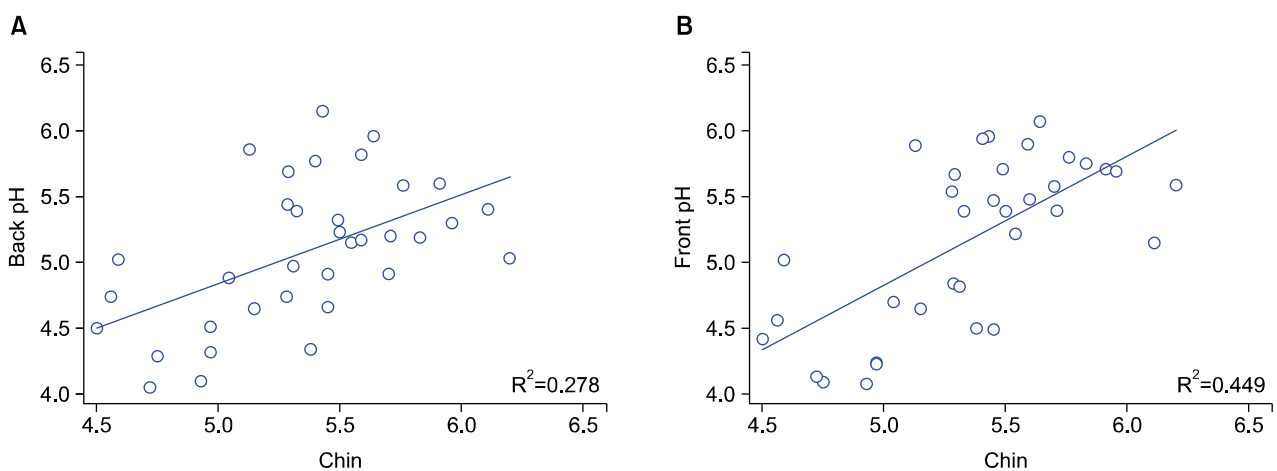


**Fig. 2.** Regional pH comparisons for the (A) face and front and back of the trunk, (B) high sebum-secreting zones, and (C) low sebum-secreting zones. AW: area-weight, T: T-zone, B: back, F: front, H: high, L: low, NS: not significant. \*Statistically significant difference between face and back ( $p<0.05$ ); one-way analysis of variance test.

**Table 1.** Correlations between facial and truncal pH

Variable	Forehead	Nose	Chin	AW T	AW U	Front	Back
Forehead	1						
Nose	0.530** (0.001)	1					
Chin	0.742** (0.000)	0.637** (0.000)	1				
AW T	0.979** (0.000)	0.659** (0.000)	0.846** (0.000)	1			
AW U	0.723** (0.000)	0.597** (0.000)	0.841** (0.000)	0.795** (0.000)	1		
Front	0.569** (0.000)	0.421* (0.012)	0.670** (0.000)	0.621** (0.000)	0.494** (0.003)	1	
Back	0.516** (0.001)	0.298 (0.077)	0.527** (0.001)	0.537** (0.001)	0.356* (0.033)	0.922** (0.000)	1

Data presented as Pearson’s correlation coefficients (*p*-value). AW: area-weight, T: T-zone, U: U-zone. \**p*<0.05, \*\**p*<0.01; correlation test.



**Fig. 3.** Correlations of pH values between (A) the face and front of the trunk; (B) the face and back of the trunk. Empty circles: subjects of pH levels.

**Table 2.** Pearson’s correlation coefficient between sebum level and pH at each truncal site

Site	FH	FL1	FL2	BH	BL1	BL2	BL3	BL4	BL5	BL6
Pearson’s correlation coefficient ( <i>r</i> )	-0.221	-0.226	-0.271	-0.017	-0.007	0.070	-0.145	-0.111	0.064	-0.113
<i>p</i> -value	0.201	0.192	0.115	0.922	0.969	0.691	0.405	0.526	0.720	0.516

B: back, F: front, H: high, L: low.

on the measurement sites of the trunk (Table 2). Pearson’s correlation coefficients ranged from -0.312 to 0.129.

## DISCUSSION

In the stratum corneum, acidic pH is important for cutaneous antimicrobial defense, as it regulates epidermal enzyme activity and expression<sup>10,11</sup>. Therefore, investigating truncal pH may be helpful for understanding diseases, such as acne, that develop on the face and the upper trunk and have different clinical features according to the region. By examining the differences in pH between the face and trunk, we were able to expand our knowledge of the pathogenesis of acne.

Various factors affect skin pH. Among them, physiologic factors may include age, anatomical site, sebum, sweat, and skin moisture<sup>2</sup>. Free fatty acids from sebum are one element that determines the skin’s pH<sup>10</sup>. Until the present study, sebum secretion on the face was found to have a negative correlation with pH. The nose is the highest sebum-secreting area with the lowest pH. However, when we compared the mean pH of the face with that of the trunk, high sebum-secreting areas of the face showed higher pH levels (range, 5.4~5.6) than those of the trunk (range, 5.0~5.2). These results suggest that the main determinant of skin surface pH is not only sebum secretion on the trunk. Indeed, our results showed no correlation between pH level and sebum quantity on the trunk.

Therefore, the hypothesis that sebum secretion negatively correlates with pH possibly applies only to the face, where high levels of sebum may suppress the effects of other determinants of skin surface pH.

Sebum overproduction, pH, and the presence and activity of *P. acnes* are involved in the development of facial acne<sup>12</sup>. However, because sebum secretion in the trunk is very low, other pH determinants more significantly influence the development of truncal acne. For example, pH changes in follicles could affect the physiology of the bacteria and thereby influence acne development<sup>12</sup>. An acidic pH environment is conducive to normal flora growth, so, as pH increases, pathogenic bacteria proliferate<sup>13</sup>. In particular, *P. acnes* grows well in an environment with a pH range of 6.0~6.5, but when pH drops to 5.5, its growth noticeably decreases<sup>14</sup>. *P. acnes* predominates in a sebaceous environment<sup>14</sup>. Therefore, *P. acnes* makes up approximately 90% of normal flora in the forehead, whereas, in the shoulder or the axilla, levels of *Staphylococcus* and *P. acnes* are similar<sup>15</sup>. Further, since *P. acnes* growth decreases in the low pH environment of the trunk, the influence of *P. acnes* may be lesser there. These differences influence clinical patterns of acne seen on the trunk and face. The correlations between sebum, pH, and facial acne development, as demonstrated in a previous study, may not apply to truncal acne<sup>5,6</sup>. Therefore, sebum control is important in facial acne treatment, whereas pH control may be more important in truncal acne treatment. Thus, the skin pH determined by the anatomical site can be assumed to be important.

Significant differences in pH were found between the trunk and the face. However, when examined in detail, mean pH between the back and the face showed a significant difference, but not between the chest and the face. This difference is because we measured the pH of the back at seven locations, and we noted a decreasing pH trend, further down the back. Moreover, the measurement location on the chest was relatively close to the face, and a sebum-prone site was chosen, which may account for the lack of significant differences between pH on the face and chest. In addition, significant correlations were found only between the pH values of the face, chest, and upper back. Because the results of this study showed that pH decreased further down the back, skin surface pH may have been partially affected by dermatome, even in the same body part.

Interestingly, correlation analysis found that chin pH correlated mostly with the pH on the chest or back. Using linear regression analysis, we were able to obtain two equations that could estimate truncal pH based on chin pH. Using these equations, we found that truncal pH under-

went similar changes as facial pH (especially chin pH) changes. With these equations, we were able to calculate the pH of unexposed trunk skin using the pH of easily measurable, exposed areas like the chin.

A limitation of this study was that the study subjects consisted of young females with mild acne. In the previous study, sebum secretion amount and pH were found to be affected by age and sex<sup>5,9</sup>. Therefore, further studies are needed that include men and broader age groups.

This was the first study designed to examine the differences in pH and sebum between the face and the trunk. Truncal pH was lower than facial pH, with a significant correlation between truncal pH and facial pH, accompanied by a steady linear pattern of change. However, the correlation between sebum and pH was not significant. We anticipate that facial pH can predict truncal pH. The differences in pH and sebum between the face and the trunk indicate an indirect approach to understanding the pathogenesis of diseases, such as acne, that affect the skin on both the face and trunk.

## ACKNOWLEDGMENT

This work was supported by Aestura Corporation and the Amore Pacific R&D Center in Seoul, Korea.

## REFERENCES

1. Rippke F, Schreiner V, Doering T, Maibach HI. Stratum corneum pH in atopic dermatitis: impact on skin barrier function and colonization with *Staphylococcus Aureus*. *Am J Clin Dermatol* 2004;5:217-223.
2. Rippke F, Schreiner V, Schwanitz HJ. The acidic milieu of the horny layer: new findings on the physiology and pathophysiology of skin pH. *Am J Clin Dermatol* 2002; 3:261-272.
3. Kim BR, Chun MY, Kim SA, Youn SW. Sebum secretion of the trunk and the development of truncal acne in women: do truncal acne and sebum affect each other? *Dermatology* 2015;231:87-93.
4. Del Rosso JQ. Management of truncal acne vulgaris: current perspectives on treatment. *Cutis* 2006;77:285-289.
5. Youn SH, Choi CW, Choi JW, Youn SW. The skin surface pH and its different influence on the development of acne lesion according to gender and age. *Skin Res Technol* 2013;19:131-136.
6. Kim MK, Choi SY, Byun HJ, Huh CH, Park KC, Patel RA, et al. Comparison of sebum secretion, skin type, pH in humans with and without acne. *Arch Dermatol Res* 2006;298:113-119.
7. Youn SH, Choi CW, Choi JW, Kim BR, Byun SY, Youn SW. Novel facial cosmetic area 'O zone' shows unique characteristics in sebum excretion and acne lesion distribution. *Skin Res Technol* 2014;20:164-169.

8. Yoon HS, Choi JW, Youn JI. Method of assessing involved facial areas: rule of fours. *Br J Dermatol* 2008;158:1022-1028.
9. Kim MK, Patel RA, Shinn AH, Choi SY, Byun HJ, Huh CH, et al. Evaluation of gender difference in skin type and pH. *J Dermatol Sci* 2006;41:153-156.
10. Schmid-Wendtner MH, Korting HC. The pH of the skin surface and its impact on the barrier function. *Skin Pharmacol Physiol* 2006;19:296-302.
11. Lambers H, Piessens S, Bloem A, Pronk H, Finkel P. Natural skin surface pH is on average below 5, which is beneficial for its resident flora. *Int J Cosmet Sci* 2006;28:359-370.
12. Greenman J. Follicular pH and the development of acne. *Int J Dermatol* 1981;20:656-658.
13. Elias PM. Therapeutic Implications of a Barrier-based Pathogenesis of Atopic Dermatitis. *Ann Dermatol* 2010;22:245-254.
14. Korting HC, Braun-Falco O. The effect of detergents on skin pH and its consequences. *Clin Dermatol* 1996;14:23-27.
15. Patel A, Calfee RP, Plante M, Fischer SA, Green A. Propionibacterium acnes colonization of the human shoulder. *J Shoulder Elbow Surg* 2009;18:897-902.