*Int. J. Oral Maxillofac. Surg. 2019; 48: 703–707*
https://doi.org/10.1016/j.ijom.2019.01.010, available online at https://www.sciencedirect.com

International Journal of Oral & Maxillofacial Surgery

Clinical Paper
Cleft lip and palate

# Management of velopharyngeal insufficiency by modified Furlow palatoplasty with pharyngeal flap: a retrospective outcome review

**L. S. Wong[1], E. Lim[2], T. C. Lu[3], P. K. T. Chen[4]**
[1]Department of Oral and Maxillofacial Surgery, Hospital Sibu, Sarawak, Malaysia; [2]University of North Sumatera, Medan, North Sumatera, Indonesia; [3]Craniofacial Centre and Craniofacial Research Centre, Chang Gung Memorial Hospital, Chang Gung University, Taoyuan, Taiwan; [4]Craniofacial Centre, Taipei Medical University Hospital and Taipei Medical University, Taipei, Taiwan

*L. S. Wong, E. Lim, T. C. Lu, P. K. T. Chen: Management of velopharyngeal insufficiency by modified Furlow palatoplasty with pharyngeal flap: a retrospective outcome review. Int. J. Oral Maxillofac. Surg. 2019; 48: 703–707.* © 2019 International Association of Oral and Maxillofacial Surgeons. Published by Elsevier Ltd. All rights reserved.

*Abstract.* The surgical approach for the correction of residual velopharyngeal insufficiency requiring secondary surgery at Chang Gung Memorial Hospital is the modified Furlow palatoplasty with pharyngeal flap (mFP-PF). The aim of this study was to describe the mFP-PF technique and to determine the results obtained with regard to improvements in velopharyngeal function in patients undergoing this surgery. This retrospective analysis included 58 non-syndromic patients treated during the period 1992–2015 who complained of hypernasal speech after primary cleft palate repair and failed postoperative speech therapy. All of them underwent mFP-PF surgery. Preoperative and postoperative perceptual speech assessment results were obtained. The male to female ratio in the study group was 1.2:1, and the mean patient age at the time of surgery was 8.27 years. The patients underwent nasoendoscopic examination and the velar closing ratio was categorized as 0.1–0.4 in 53.4% and 0.5–0.7 in 46.6%. The assessment of speech after mFP-PF showed statistically significant changes for all perceptual speech outcomes. The incidence of repeat surgery was 3.4%. This study revealed that 96.6% of patients did not require second surgery for velopharyngeal insufficiency. Further studies on obstructive sleep apnoea in post-mFP-PF patients and improvements to the surgical technique should be considered.

Key words: perceptual speech; velopharyngeal insufficiency; Furlow palatoplasty; pharyngeal flap.

Accepted for publication 17 January 2019
Available online 10 February 2019

The velopharyngeal valve is made up of the velum (soft palate), lateral pharyngeal wall, and posterior pharyngeal wall. These are important structures for normal speech production. Velopharyngeal insufficiency (VPI) is an anatomical or structural defect that prevents adequate velopharyngeal closure and is commonly seen in cleft palate patients. As a result, the speech of patients with VPI can be described as exhibiting hypernasality, nasal emissions, or poor intelligibility. The primary goal of

 © 2019 International Association of Oral and Maxillofacial Surgeons. Published by Elsevier Ltd. All rights reserved.

cleft palate repair is to create an anatomically and functionally intact palate in order to improve feeding and achieve normal speech, while minimally impacting maxillary growth and development[1].

The incidence of VPI after primary palatoplasty requiring secondary surgery ranges from 5% to 45%[2–4]. This wide range of incidence is due to the use of different techniques for the cleft palate repair[5]. Among the various techniques, the Furlow palatoplasty is the most commonly used. Chorney et al. reported that only 5.1% of their patients required a subsequent pharyngeal flap following the use of the modified Furlow palatoplasty, and this was not affected by the pre-surgical cleft width[6].

The surgical treatment of choice for VPI remains controversial. The commonly used surgical techniques to correct VPI include sphincter pharyngoplasty, posterior pharyngeal wall augmentation, pharyngeal flap surgery, and double opposing Z-palatoplasty[7–10]. These methods may deform the normal anatomy and can cause various complications such as obstructive sleep apnoea (OSA), snoring, mouth breathing, difficulty in clearing nasal secretion, and even hyponasal resonance[11–14].

At Chang Gung Memorial Hospital, two different surgical approaches for the correction of residual VPI requiring secondary surgery are applied. For those with a velopharyngeal closing ratio of $>0.7$, a modified Furlow palatoplasty is used to correct palatal muscle function by repositioning the levator veli palatini muscle. On the other hand, a closing ratio of $<0.7$ means that the patient has less optimal velopharyngeal closing function. From previous experience, these patients fare less well when their velopharyngeal insufficiency is corrected with a Furlow palatoplasty. Hence, a modified Furlow palatoplasty with pharyngeal flap (mFP-PF) is used to compensate for the poorly functioning soft palate. The effectiveness of this technique has not yet been assessed at Chang Gung Memorial Hospital.

The aim of this study was to describe the mFP-PF technique and to subsequently determine the results obtained with regard to improvements in velopharyngeal function in patients undergoing this surgery.

## Methods

The study received ethical approval from the Institutional Review Board of Chang Gung Memorial Hospital. Sixty-four patients who presented during the years 1992–2015 with a complaint of hypernasal speech after primary cleft palate repair and who also failed the postoperative speech therapy were initially recruited. The following inclusion criteria were applied: diagnosis of non-syndromic cleft with no other congenital anomalies, normal hearing, no palatal fistulae, no delayed speech development, and complete data collection. Fifty-eight patients fulfilled the inclusion criteria and were included in the final analysis. The preoperative and postoperative perceptual speech assessments were performed by experienced speech language pathologists. The postoperative speech assessment was performed at least 6 months after the surgery. Postoperative speech therapy was recommended if required.

The speech assessment covers phonation, nasality, nasal emission, velopharyngeal function, grimace, and articulation. The score for each variable was recorded as follows: (A) phonation: 0, tension in system; 1, reduced loudness; 2, hoarseness or breathiness; 3, normal; (B) nasality: 0, moderate hypernasality; 1, mild–moderate hypernasality/mixed hyper- and hyponasality; 2, mild hypernasality; 3, normal; (C) nasal emission: 0, audible, turbulent; 1, consistent visibility; 2, inconsistent visibility; 3, not present, nasal escape, reduced or absent; (D) velopharyngeal function: 0, inadequate; 1, marginal; 2, adequate; (E) grimace: 0, grimace; 1, without grimace; (F) articulation: 0, fair; 1, good.

### Statistical analysis

As outcome measures, the pre- and post-surgery perceptual speech outcomes were compared for the study group patients. The demographic data of the patient population were analysed using descriptive statistics. The paired *t*-test was performed to determine the effectiveness of the surgical technique with regard to perceptual speech outcomes. IBM SPSS Statistics version 20.0 (IBM Corp., Armonk, NY, USA) was used for the statistical analysis. A *P*-value of $<0.05$ was considered to be statistically significant.

### Surgical technique—modified Furlow palatoplasty with pharyngeal flap

The posterior pharyngeal wall is palpated before starting the surgery to identify the medialization of the carotid arteries or meningocele. The soft palate and posterior pharyngeal wall are infiltrated with topical anaesthetic and epinephrine for haemostasis after placement of a Dingman mouth gag with tongue plate. The modified Furlow palatoplasty begins with an initial Z incision on the soft palate, as shown in Fig. 1A. An anteriorly based oral mucosa flap is elevated on the right side, beginning from the base of the uvula medially and extending posterolaterally to the hamulus. Then, a posteriorly based oromuscular (oral mucosa and muscle) flap is elevated on the left side, as shown in Fig. 1A. The soft palate is split in the midline by a 'through-and-through' dissection.

Once the oral dissection is completed, the nasal mucosal flap layer becomes visible. The incision of the nasal lining differs from that of the ordinary Furlow palatoplasty, as shown in Fig. 1B. A 5-mm margin of nasal mucosa is reserved at the hard palate junction and the nasal lining is incised obliquely from the midline in a different direction. The end of the incision should reach the lateral pharyngeal wall near the eustachian tube bilaterally.

Next, a superiorly based pharyngeal flap is raised from the posterior pharyngeal wall. The superiorly based flap is preferred at the study centre, because it provides a clear view of the donor site during harvest and allows the harvest of a greater length. The dissection plane is above the prevertebral fascia. The width of the pharyngeal flap is tailored according to the velar closing ratio. For patients with poor closure (closing ratio of 0.1–0.4), a moderate-width pharyngeal flap (about two-thirds of the width of the posterior pharyngeal wall) is used, while for patients with somewhat better closure (closing ratio of 0.4–0.7), a narrow-width pharyngeal flap (about one-third of the posterior pharyngeal wall) is used. The base of the flap is around the level of C1. The donor site is closed with a suture to the level below the flap base (Fig. 1C).

The pharyngeal flap is inserted and sutured to the nasal lining at the central posterior margin of the nasal side incision with simple interrupted sutures (Fig. 1D). The nasal mucosa is trimmed and adjusted to facilitate better wound closure with the lateral pharyngeal flap. Nasal catheters are passed through the lateral ports to maintain patency and assist in appropriate sizing of the ports during suturing. The lateral margin of the pharyngeal flap is sutured with the nasal mucosal flaps bilaterally until they meet at the midline of the pharyngeal flap base. Below that point, the nasal mucosa is sutured to the margin of the posterior pharyngeal wall to form a tube-like portal opening bilaterally. Care is taken in order not to suture the nasal catheter to the nasal mucosa. These nasal catheters are removed on postoperative day 1 (Fig. 1E).

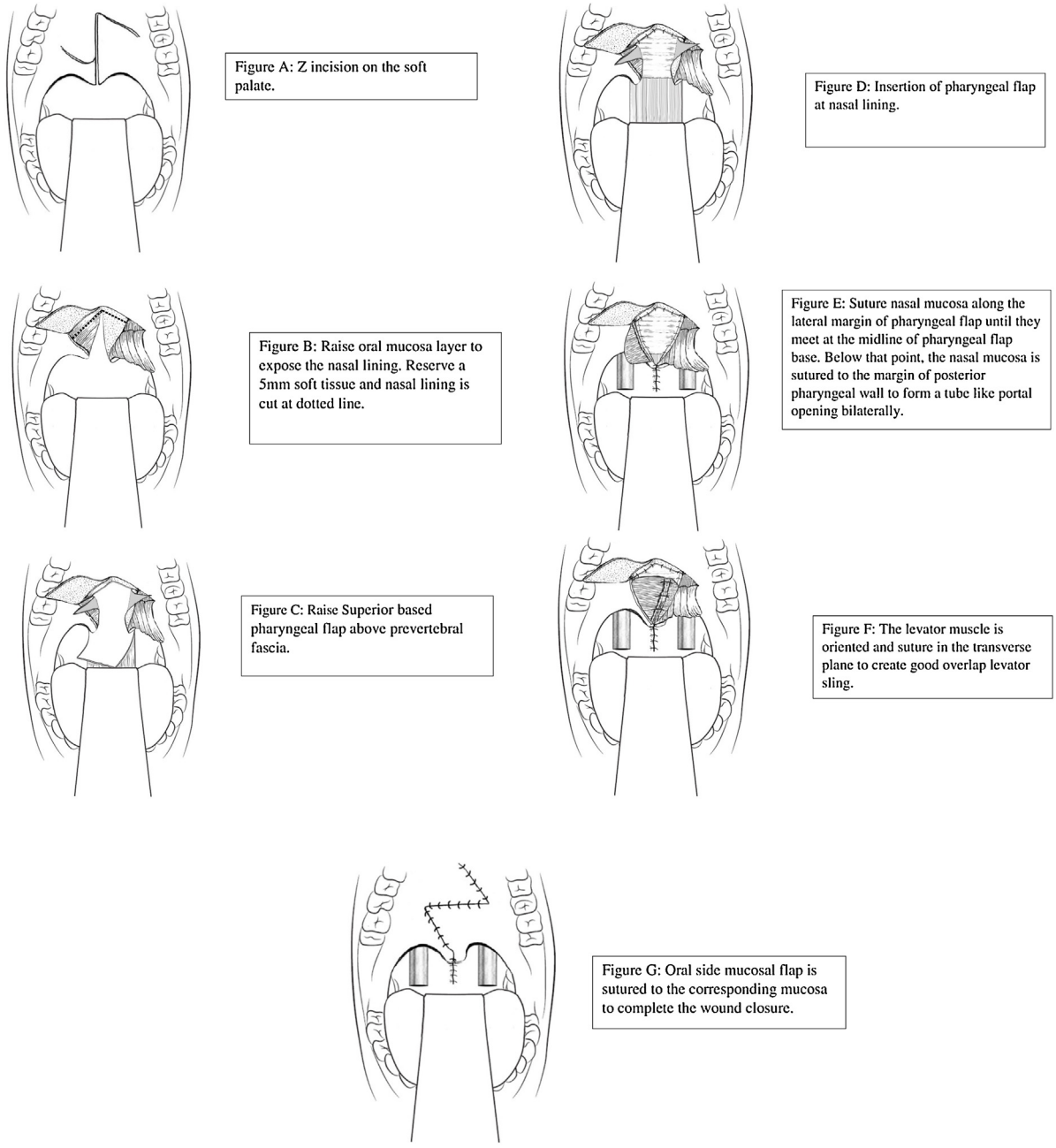


*Fig. 1.* Surgical technique—modified Furlow palatoplasty with pharyngeal flap.

The levator muscle is oriented and sutured in the transverse plane to create a good overlap levator sling (Fig. 1F). There is no further muscle mobilization on the right side of the muscle. Finally the oral mucosal flap is sutured to the corresponding mucosa to complete the wound closure (Fig. 1G).

## Results

Of the 58 patients who underwent mFP-PF, 32 (55.2%) were female and 26 (44.8%) were male, giving a male to female ratio of 1.2:1 (Table 1). The mean age at surgery was 12.91 years, ranging from 3.17 to 29.34 years. On nasoendoscopy, 31 (53.4%) patients had a velar closing ratio of 0.1–0.4 and 27 (46.6%) had a velar closing ratio of 0.5–0.7. Thirty-five patients had been diagnosed with complete unilateral cleft lip and palate, 10 patients with complete bilateral cleft lip and palate, and 13 patients with cleft palate. The operative time for the mFP-PF technique was 2–3 hours (average 2.5 hours). There were no intraoperative complications for any of the patients.

The assessment of speech after mFP-PF showed statistically significant changes for all perceptual speech outcomes, including phonation, nasality, nasal emission, velopharyngeal function, grimace, and articulation (Table 2).

The incidence of repeated surgery due to residual VPI was 3.4%. As there was an improvement in the speech assessment, most of the patients refused another post-surgery nasoendoscopic examination.

*Table 1.* Patient characteristics at baseline ($N = 58$)[a].

| Characteristic | |
|---|---|
| Sex | |
| Male | 32 (55.2%) |
| Female | 26 (44.8%) |
| Diagnosis | |
| Unilateral CLP | 35 (60.3%) |
| Bilateral CLP | 10 (17.2%) |
| Cleft palate | 13 (22.4%) |
| Surgery (months), mean (range) | 12.91 (3.35–29.34) |
| Velar closing ratio | |
| 0.1–0.4 | 31 (53.4%) |
| 0.5–0.7 | 27 (46.6%) |
| Repeat VPI surgery | |
| No | 56 (96.6%) |
| Yes | 2 (3.4%) |

CLP, cleft lip and palate; VPI, velopharyngeal insufficiency.
[a] Results are presented as the number and percentage (*n* (%)), unless stated otherwise.

Furthermore, two patients presented with severe OSA requiring pharyngeal flap release surgery. However, these two patients had no speech worsening post-surgery.

## Discussion

Residual VPI is not rare after the repair of cleft palate, despite complete closure of the palatal defect. The incidence of VPI after primary palatoplasty that may need secondary surgery ranges from 5% to 45%[2–4]. Surgical interventions such as posterior pharyngeal wall augmentation, redirection of anteriorly displaced levator muscles, palatal lengthening, sphincter pharyngoplasty, and pharyngeal flap pharyngoplasty can be used to correct VPI. Although these surgical procedures for velopharyngeal functional reconstruction have been advocated, the speech outcomes do not differ significantly among these techniques[13–17].

The underlying problems such as the length of the soft palate, the levator muscle repair, and the reduction of the enlarged pharyngeal space should be considered in VPI surgical repair. As well as the anatomical considerations of the designed surgical technique, the postoperative complications, especially OSA, need to be minimized if possible.

In this study, the mFP-PF technique achieved highly satisfactory functional speech results. This technique is a dynamic operation for restoring velopharyngeal function. The mFP-PF is able to achieve satisfactory results for speech function in VPI repair as a result of several specific aspects . First, the careful design of the modified Furlow Z-plasty on the soft palate is able to increase velar length effectively. Unlike the traditional Furlow palatoplasty, the nasal lining is incised and lengthened through continuous suturing at the lateral pharyngeal flap until it reaches the posterior pharyngeal wall. The extension of the nasal mucosa flaps improves raw surface coverage at the posterior pharyngeal wall, which is important in reducing contraction and scarring of the pharyngeal flap.

Second, the modified Furlow palatoplasty allows complete division of the palatal aponeurosis with precise dissection of the muscles and creates a transverse muscle sling for better velopharyngeal function. As the nasal lining is pulled downward and backward, the levator muscle is orientated along the velopharyngeal port. The main advantage of this is that the functional muscle sling is able to provide more competent velopharyngeal function during speech.

Third, the velopharyngeal port formed is a tube-like shape unlike that of the other techniques. The two tube-like velopharyngeal ports create better obturation of the nasopharyngeal space. This technique also reduces the width of the pharyngeal flap. With the previous technique, the pharyngeal flap width was determined by the preoperative nasoendoscopic velar closing ratio and ranged from two-thirds to three-quarters of the total width of the posterior pharyngeal wall. In the present study group, all patients with a closing ratio of 0.4–0.7 required only a narrow-width pharyngeal flap of about one-third of the posterior pharyngeal wall in VPI surgery. This is able to reduce the severity of OSA.

Each surgical approach has its strengths and limitations. Surgeon experience certainly contributes to outcomes, although the impact of experience is difficult to measure. Hence, periodic assessment of outcome data will help each surgeon to improve their surgical skill and approach to the management of these patients.

In conclusion, improved speech results were reported for all of the study patients and 96.6% of the patients did not require second VPI surgery. Further studies on OSA in post-mFP-PF patients should be performed and improvements to the surgical technique should be considered.

## Funding

None of the authors received any financial support throughout the research.

## Competing interests

None of the authors has a financial interest in any of the products, devices, or drugs

*Table 2.* Change in perceptual speech outcomes in the study group after modified Furlow palatoplasty with pharyngeal flap.

| Variable | Before mFP-PF Mean (SD) | After mFP-PF Mean (SD) | Mean score difference (95% CI) | *t*-statistic (df) | *P*-value |
|---|---|---|---|---|---|
| Phonation | 1.91 (1.08) | 2.48 (0.73) | 0.57 (0.30–0.84) | 4.22 | <0.01 |
| Nasality | 1.29 (0.84) | 2.72 (0.64) | 1.43 (1.18–1.69) | 11.17 | <0.01 |
| Nasal emission | 0.88 (0.50) | 2.31 (0.94) | 1.43 (1.18–1.69) | 11.61 | <0.01 |
| Velopharyngeal function | 0.17 (0.38) | 1.84 (0.41) | 1.67 (1.54–1.81) | 25.02 | <0.01 |
| Grimace | 1.86 (0.51) | 2.00 (0.00) | 0.14 (0.004–0.27) | 2.06 | <0.04 |
| Articulation | 0.19 (0.40) | 0.79 (0.41) | 0.60 (0.47–0.74) | 8.71 | <0.01 |

CI, confidence interval; mFP-PF, modified Furlow palatoplasty with pharyngeal flap; SD, standard deviation.

mentioned in this article. There is no conflict of interest regarding the publication of this article.

### Ethical approval

The study was approved by the Institutional Review Board of Chang Gung Memorial Hospital (IRB 201800824B0).

### Patient consent

Not required.

*Acknowledgments.* We thank the Director General of Health Malaysia for his permission to publish this paper. This project was assisted by the Craniofacial Research Centre Chang Gung Memorial Hospital (CMRPG3F0731).

### References

1. Fisher DM, Sommerlad BC. Cleft lip, cleft palate, and velopharyngeal insufficiency. *Plast Reconstr Surg* 2011;**128**:342e–60e.
2. Bardach J, Morris HL. *Multidisciplinary management of cleft lip and palate*. Philadelphia: Saunders; 1990.
3. Ysunza A, Pamplona C, Ramírez E, Molina F, Mendoza M, Silva A. Velopharyngeal surgery: a prospective randomized study of pharyngeal flaps and sphincter pharyngoplasties. *Plast Reconstr Surg* 2002;**110**:1401–7.
4. Bicknell S, McFadden LR, Curran JB. Frequency of pharyngoplasty after primary repair of cleft palate. *J Can Dent Assoc* 2002;**68**:688–92.
5. Agrawal K. Cleft palate repair and variations. *Indian J Plast Surg* 2009;**42**(Suppl): S102–9.
6. Chorney SR, Commesso E, Tatum S. Incidence of secondary surgery after modified Furlow palatoplasty: a 20-year single-surgeon case series. *Otolaryngol Head Neck Surg* 2017;**157**:861–6.
7. Sloan GM. Posterior pharyngeal flap and sphincter pharyngoplasty: the state of the art. *Cleft Palate Craniofac J* 2000;**37**:112–22.
8. Witt PD, O'Daniel TG, Marsh JL, Grames LM, Muntz HR, Pilgram TK. Surgical management of velopharyngeal dysfunction: outcome analysis of autogenous posterior pharyngeal wall augmentation. *Plast Reconstr Surg* 1997;**99**:1287–96.
9. Peat BG, Albery EH, Jones K, Pigott RW. Tailoring velopharyngeal surgery: the influence of etiology and type of operation. *Plast Reconstr Surg* 1994;**93**:948–53.
10. Pensler JM, Bauer BS. Levator repositioning and palatal lengthening for submucous clefts. *Plast Reconstr Surg* 1988;**82**:765–9.
11. Shprintzen RJ. Pharyngeal flap surgery and the pediatric upper airway. *Int Anesthesiol Clin* 1988;**26**:79–88.
12. Orr WC, Levine NS, Buchanan RT. Effect of cleft palate repair and pharyngeal flap surgery on upper airway obstruction during sleep. *Plast Reconstr Surg* 1987;**80**:226–32.
13. Morris HL, Bardach J, Jones D, Christiansen JL, Gray SD. Clinical results of pharyngeal flap surgery: the Iowa experience. *Plast Reconstr Surg* 1995;**95**:652–62.
14. Riski JE, Ruff GL, Georgiade GS, Barwick WJ, Edwards PD. Evaluation of the sphincter pharyngoplasty. *Cleft Palate Craniofac J* 1992;**29**:254–61.
15. Whitaker LA, Randall P, Graham III WP, Hamilton RW, Winchester R. A prospective and randomized series comparing superiorly and inferiorly based posterior pharyngeal flaps. *Cleft Palate J* 1972;**9**:304–11.
16. Hamlen M. Speech changes after pharyngeal flap surgery. *Plast Reconstr Surg* 1970;**46**:437–44.
17. Meek MF, Coert JH, Hofer SO, Goorhuis-Brouwer SM, Nicolai JP. Short-term and long-term results of speech improvement after surgery for velopharyngeal insufficiency with pharyngeal flaps in patients younger and older than 6 years old: 10-year experience. *Ann Plast Surg* 2003;**50**:13–7.

Address:
*Philip Kuo-Ting Chen*
*Craniofacial Centre*
*Taipei Medical University Hospital and Taipei Medical University*
*No. 250*
*Wuxing Street*
*Xinyi District*
*Taipei City*
*110 Taipei*
*Taiwan*
*E-mail: Philip.ktchen@gmail.com*