田原 英一，萩原 圭祐，矢久保 修嗣，南澤 潔，村松 慎一，和辻 直，花輪 壽彦：多施設での統一した舌診臨床診断記載の作成を目的とした日本の舌診文献調査．日本東洋医学雑誌，65(3)224-230，2014.

6）貝沼茂三郎，迎はる，原田裕士，並木隆雄，古庄憲浩：舌撮影解析システム（TIAS）を用いた舌色解析～舌色と内視鏡所見との関係について．第65回日本東洋医学会学術総会，2014.

7）関根 麻理子，若杉 安希乃，川鍋 伊晃，小田口 浩，花輪 壽彦北里漢方医学的所見プロジェクト　医師・鍼灸師が舌撮影解析システム（TIAS）を体験して，第65回日本東洋医学会学術総会，2014.

8）川鍋 伊晃，小田口 浩，並木 隆雄，Mi Xiaoyu，若杉 安希乃，関根 麻理子，花輪 壽彦：舌撮影解析システム（TIAS）を用いた舌形態判断の検討，第65回日本東洋医学会学術総会，2014.

9）林宏朋，中島正光，村上弘樹，高丸直也，古川冴次郎，並木隆雄，中口俊哉：開発中の舌色撮影装置の利点・欠点，第7回広島県臨床工学技士会学術大会，2014.

G．知的財産権の出願登録状況

なし。

以上

- 資料１　中華民国における伝統医療の診療機器（主に舌診機器）の視察報告書
  （明治国際医療大学鍼灸学部　基礎鍼灸学講座　和辻　直）

- 資料２　Proposal for a New Noncontact Method for Measuring Tongue Moisture to Assist in Tongue Diagnosis and Development of the Tongue Image Analyzing System, Which Can Separately Record the Gloss Components of the Tongue
  （BioMed Research International Article ID 249609）

- 資料３　The Development of an Abdominal Palpitation Model for the Fukushin Simulator: Towards Improvement and Standardization of Kampo Abdominal Diagnosis
  （International Medical Journal Vol. 21, No. 2, pp. 201-203, April 2014）

- 資料４　Study of Factors Involved in Tongue Color Diagnosis by Kampo Medical Practitioners Using the Farnsworth-Munsell 100 Hue Test and Tongue Color Images
  （Evidence-Based Complementary and Alternative Medicine Volume 2014, Article ID 783102）

- 資料５　多施設での統一した舌診臨床診断記載の作成を目的とした日本の舌診文献調査
  （日東医誌　Kampo Med　Vol. 65 NO. 3　224-230, 2014）

- 資料６　17th International Congress of Oriental Medicine PROGRAM

2014 ICOM 報告書

中華民国における伝統医療の診療機器（主に舌診機器）の視察報告書

明治国際医療大学鍼灸学部　基礎鍼灸学講座
和辻　直

中華民国における 17th ICOM(國際東洋醫學会)伝統医療の診療（主に舌診・脈診機器）における参加報告書

期間：2014 年 11 月 2 日(木)～11 月 3 日(火)

会場：中華民国 台北市中正區徐州路 2 號　台大醫院國際會議中心

(No.2, Xuzhou Rd., Zhongzheng Dist., Taipei City 100, Taiwan NTUH International Convention Center)

第 17 回國際東洋醫學会の概要；大会のメインテーマは「ヘルスプロモーションにおける伝統医学の過去、現在と未来」(傳統醫學促進健康的回顧與前瞻; Past, Present and Future of Traditional Medicine in Health Promotion) であった。大会では Plenary lecture が 4 題、学会貢献名誉賞の受賞講演(終身貢獻受獎演講, Acceptance speech of lifetime contribution award) 1 題があり、Plenary lecture には中田敬吾先生（国際東洋医学会会長）の講演（「題名：日本漢方の現況と今後の発展への期待」）があり、大会の最終講演となっていた。今回の大会では Topics が 13 項目設定され、それぞれに基調講演 15 題と招待講演 54 題があった。

17th ICOM 大会 Topics	基調講演 題数	招待講演 題数	口演 題数	ポスター 題数
1. 伝統医学と文化	1	6	1	49
2. 伝統中国医学における証の研究	2	3		10
3. 実証医学	1	6		30
4. 臨床報告	1	7		31
臨床研究と臨床報告		8		
5. 中医薬と健康ための食養	2	4		38
6. 鍼灸と統合医療	2	4	1	18
7. 長寿医学	2	2		5
8. 女性の健康	1	2	1	4
9. 癌における予防と治療	1	2	1	9
10. 伝統薬物の標準化研究	1	2		9
11. 世界的な生薬品市場		3	1	1
12. 台湾における薬用固有植物の開発と応用		3		6
13. 伝統製薬業の現況と展望	1	2		7
計	15	54	5	217

また韓国セッションの「臨床研究と臨床報告」が 2 セッションあり、日本セッションでは「臨床報告」セッションと「伝統医学と文化」セッションがあった。

また一般発表は口演 5 題、ポスター発表 217 題であり、大会の Topics と同様な区分がされていた。なお企業展示会場を視察したが、残念ながら診断器機の展示がなく、エキス剤、書籍、鍼灸具、健康器具や健康食品などであった。

大会の Topics が 14 項目

1.伝統医学と文化（傳統醫學與文化, Traditional Medicine and Culture)、

2.伝統中国医学における証の研究（證型診斷研究、Research on Diagnostic Criteria for Traditional Chinese Medicine Syndromes)、

3.実証医学(實證醫學, Evidence-Based Medicine)、4.臨床報告(臨床案例, Clinical Case Reports)、

5.中医薬と健康ための食養（中醫藥與食療保健, Herbal and Dietary Therapy in Health)、

6.鍼灸と統合医療（針灸與另類醫療、Acupuncture, Moxibustion and Alternative Medicine)、

7.長寿医学（長壽醫學, Longevity Medicine)、8.女性の健康（婦女健康, Women Health)、

9.癌における予防と治療（癌症防治, Prevention and Therapy in Cancer)、

10.伝統薬物の標準化研究（傳統藥物的標準化研究, Standardization of Traditional Medicine)、

11.世界的な生薬品市場（全球化的草藥市場, Global Botanical Products Markets)、

12.台湾における薬用固有植物の開発と応用（臺灣特有藥用植物之開發應用, Development and Application of Endemic Medicinal Plants)、

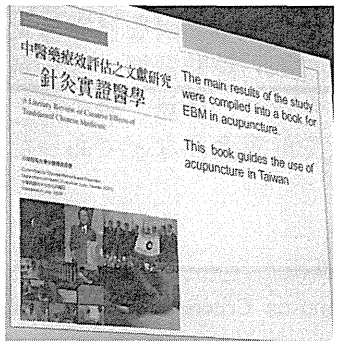
13.伝統製薬業の現況と展望（傳統製藥業的現況與展望, Current Status and Prospect of Pharmaceutical Industry in Traditional Medicine)

第17回國際東洋醫學会における参加報告(詳細)

11月2日9時20分より開幕式が行われた後に、学会貢献名誉賞の受賞講演「Acceptance speech of lifetime contribution award」として顔焜熒教授(ISOM 栄誉理事／台北医学大学栄誉教授 Prof. Kun-Ying YEN, Honorary Director of ISOM / Emeritus Professor of Graduate Institute of Pharmacology, Taipei Medical University)が講演された。

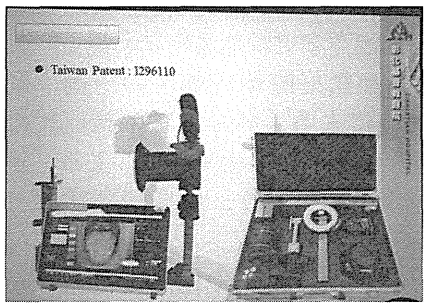
次にPlenary lecture 1(10:35~11:25)として「Opportunity and Challenge of Chinese Medicine to Meet Unmet Global Heath Needs」鄭永齊教授(Prof. Yung-Chi CHENG, Department of Pharmacology, Yale University school of Medicine) が講演された。中薬の研究に対して現状の分析と今後の課題について講演されていた。現代医学の知識や方法を用いて、生薬による効果を証明していく必要があることを強調していた。日本の漢方医学における研究は実証的分析であるとの良いコメントがあった。また伝統医学は単に治療だけでなく、予防に対する研究も行って行く必要があると話していた。中薬を処方する動物実験により、抗がん剤の副作用を抑える研究成果を発表していた。

Plenary lecture 2(11:25~12:15)では、「Evidence-Based Medicine in Acupuncture Analgesia」に関して、林昭庚 (Prof. JAUNG-GENG LIN, 國際東洋醫學會理事；中國醫藥大學中醫學系 School of Chinese Medicine, China Medical University, Taiwan.) が、鍼麻酔における研究について紹介された。例えば鍼通電刺激が特定のニューロペプチド（エンケファリンやβエンドルフィン等）とモノアミン（セロトニンやノルエピネフリン等）の放出を促進することを紹介した。林昭庚教授が研究された鍼麻酔の研究の結果、動物を用いた基礎研究、ランダム化された臨床試験などを発表していた。特に手術後における鍼（鍼通電）における鎮痛効果とモルヒネ管理の副作用への有用性について紹介されたことが印象的であった。写真は林昭庚先生の鍼麻酔の研究成果が掲載されている台湾の鍼灸テキストである。



12時15分から13時30分は昼食と展示会場とポスター会場への見学となっていた。午後からのセッションは、４つの会場で同時並行に行われた。

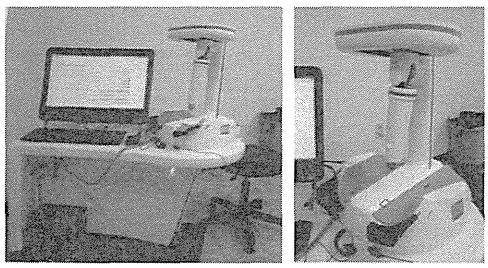
A2(13:30～15:35) Research on Diagnostic Criteria for Traditional Chinese Medicine Syndromes（證型診斷研究）は招待講演で、その演者は４名いた。その中でも「Modernization and Clinical Application of TCM Diagnosis」を発表された羅綸謙先生(彰化基督教醫院　彰基體系中醫部主任、副教授；Director Lun-Chien Lo, Department of Chinese Medicine, Changhua Christian Hospital, Taiwan)の発表は、台湾における「中醫藥傳統醫學の證診斷法」の研究であったため最も関心を持った内容であった。中醫藥の診断（望診・聞診・問診・切診）における客観的に測定器機の紹介があった。舌診では舌の撮影・診断シ



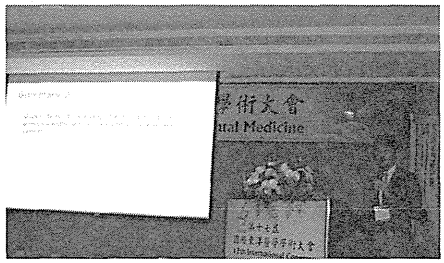
ステムにおける過去から現在までの簡単な紹介があった。最近に開発された舌診システムの特徴はアタッシュケースに入れて携帯できる自動化舌診システム(Automatic Tongue Diagnosis System)を紹介していた。舌写真の分析は舌質分析、舌苔の厚さの分析、裂紋分析、瘀斑分析などを事例に説明した。また舌写真の特徴的な画像を合成、分析結果を表示できるなども紹介していた（この舌診システムは後日、見学に行く國立中山大學工学部の先生が開発したものであった)。その他、爪甲による微小循環所見、音声分析、身体問診票(Body constitution questionnaire)、脈診測定装置（脈診儀）などを紹介し、望聞問切の四診による客観的測定により、病証を判断することを解説された。なお台湾では四診の診察は保険点数があり、このこともあって診断器機の開発は積極的に進められている。

このセッションでは日本の発表もあり、熊本赤十字病院の加島雅之先生より「中医学的診断の概念と日本漢方的診断を含めた診断のシステムの特徴（The Character of Diagnostic Systems; the Conception of Traditional Chinese Medicine and Including Japanese Kampo Diagnosis)」と題して、中医学の証判断と日本漢方の診断を比較し、その相違なども含めて、両者における今後の議論の必要性を説明されていた。

B1(13:30～15:35): Clinical Research and Case Reports (I) (KOREAN Session, 臨床研究與案例（ I ）)では、４人の招待講演あった。その中で関心があったDr. Hyunho Kim（慶熙大學，韓国）の発表を聴いた。この発表では、「Circadian Change of Radial Pulse Waveform Measured by Pulse Diagnostic Device」と題して、韓国の脈診解析システムを用いた脈診分析法を紹介していた。脈診解析システムは韓國韓醫學研究院(国立韓国東洋医学研究所)-脈診解析システム（KIOM-PAS; Korea Institute of Oriental Medicine – Pulse Analysis System）が開発したもので、この脈診システムは６チャンネルの圧抵抗センサーがあり、同時に心電図、光電式指尖容積脈波(Photoplethysmography)、呼吸検出による温度計測などを行って、臨床試験を実施していた。また脈診の指標はPulse Power index, Pulse Depth index, Pulse Volume indexなどを用いて、心電図や脈波、体温などを比較検討していた。



B4(15:50～18:00): Clinical Case Reports (Ⅱ) (JAPANESE Session, 臨床案例（Ⅱ))



元雄良治先生（金沢医科大学腫瘍内科学教授）と高山 真先生（東北大学大学院医学系研究科准教授）の司会により、日本セッションの臨床報告がなされた。ここでは題名と演者の紹介に留める。小川恵子先生（金沢医科大学附属病院耳鼻咽喉科・頭頸部外科和漢診療外来 特任准教授

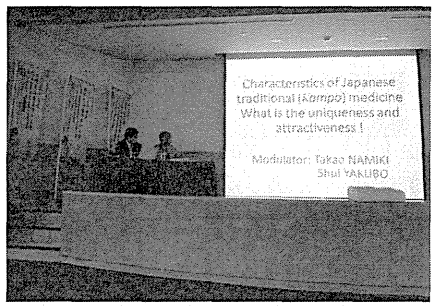
属病院耳鼻咽喉科・頭頸部外科和漢診療外来 特任准教授）による舌痛症・咽喉頭異常感症に滋陰至宝湯が有効であった３例、貝沼茂三郎先生（九州大学大学院医学研究院地域教育ユニット 准教授）による大柴胡湯合橘皮枳実生姜湯が舌痛症・有効であった好酸球性肺炎の一例、岡本英輝先生（千葉大学大学院医学研究院和漢診療学講座 特任助教）による「がん患者の諸症状に対する漢方薬によるマネジメント」、福間裕二先生（日高病院泌尿器科 主任医長）による「泌尿器科領域における漢方診療の過去・現在・未来」の４題の発表があり、他会場に比べて多くの聴衆者がおり、発表後に活発な意見交換がなされていた。

18 時から 18 時 30 分は情報交換・休憩と展示会場とポスター会場への見学となっており、その後、同センター内で Banquet dinner（晩餐）が開催された。

11 月 3 日 8 時 30 分から Plenary lecture 3(8:30~9:10)として「Future Oriented Roles and Functions of Traditional Oriental Medicine」の題名で第 18 回 ISOM 会長の Hwan-Young Che (Honorary President, Association of Korean Oriental Medicine) が講演された。

9 時 20 分から４つのセッションに分かれて講演が行われた。

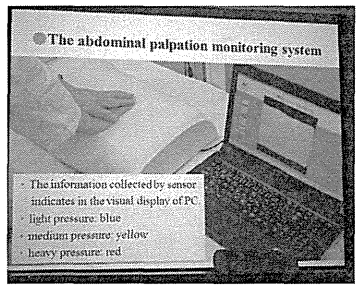
C1(9:20～11:00): Traditional Medicine and Culture (Ⅲ) (JAPANESE Session,傳統醫學與文化(Ⅲ))



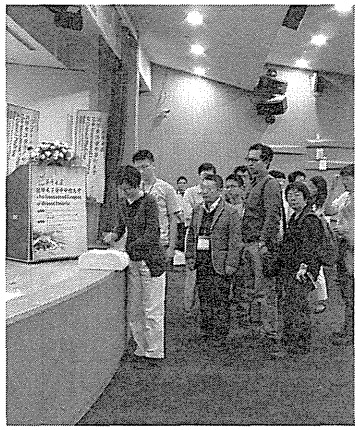
この日本セッションのコーディネーターは並木隆雄先生（千葉大学大学院 医学研究院 先端和漢診療学講座 准教授）と矢久保修嗣先生（日本大学医学部附属板橋病院 東洋医学科准教授）であった。このセッションでは日本の伝統医学、漢方医学の特徴について、その独自性や魅力を紹介すると話され、セッションが始まった。

最初に松岡 尚則先生(高知総合リハビリテーション病院 医師）より、「日本医学（漢方医学）の歴史（History of Kampo Medicine)」を紹介された。日本医薬の祖である大国主命と少彦名命の紹介や『医心方』を編纂した丹波康頼などを紹介し、また戦国時代末に西洋医学を日本に導入して日本初の病院をつくったポルトガル商人で医師のルイス・デ・アルメイダも紹介された。江戸時代には明医学や朝鮮医学の影響を受けながら日本化する医学、また江戸時代末の洋学の影響を受けた内容を含め、今日の漢方医学の歴史の概略を解説された。

次に並木隆雄先生より「腹診に関する歴史と研究（The history and studies regarding abdominal examinations (Fukushin)）を話され、日本古方派の代表腹診書の『腹証奇覧』、後世派の難経系腹診書である『百腹図説』、古方派以外の分腹診図（夢分流腹診）、古方派における腹診所見と診断根拠と処方を紹介された。最近の研究成果である『腹診のエビデンス』についても解説された。

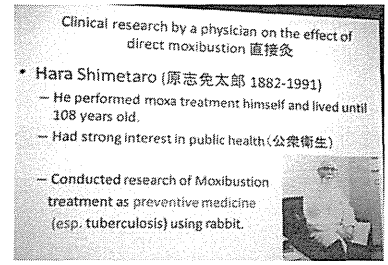


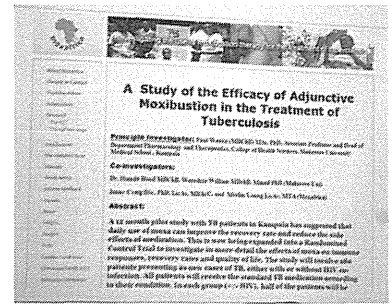
矢久保修嗣先生からは「漢方医学における腹証の標準化に向けて ～腹診シミュレータ腹部モデルの開発～ (Towards the Standardization of abdominal Pattern in the abdominal Palpation Diagnostic System of Kampo Medicine: Development of Abdominal Pattern



Models in the Fukusihin Simulator)」と題して、日本の腹診における客観化研究の状況、医学教育における腹診のシミュレータの開発の経緯を紹介された。また最近、開発された腹診のシミュレータを動画で紹介した。さらに日本から輸送してきた腹診のシミュレータを講演場に展示して、実際に参加者に触れてもらった。台湾の中醫師も腹診を行うために腹診のシミュレータの実演はとても関心を持ったようで講演参加者の列をなした。しかし講演時間の都合上デモ中断したのが残念であった。

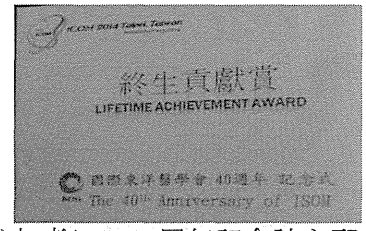
東郷俊宏（東京有明医療大学保健医療学部 鍼灸学科准教授）からは「日本における鍼灸実践と研究の文化的側面」と題して、江戸時代後半から昭和初期まで日本の鍼灸臨床に影響を与えた者を紹介した。特に明治維新後に多くの医師が西洋医学の知識で鍼灸治療の治効メカニズムを研究するようになったことを、石川日出鶴丸による鍼灸と自律神経二重支配との関連性や原志免太郎による直接灸の研究などを紹介された。また原志免太郎の研究成果は現在、Okyu(お灸：小さな艾柱の直接灸)をアフリカサハラ南部で肺結核の補助治療もしくは代替療法としてボランティア活動に利用されていることを紹介した（肺結核の薬物療法では薬剤耐性によって結核を流行させている状況であるため、その対策にもなっている。この活動はモクサアフリカ(Moxafrica)といい、2008年にイギリスの鍼灸師によって発足された登録チャリティ団体である)。





日本セッションは、台湾の参加者だけでなく、参加した日本人も応援に駆けつけた。日本セッションが終わった際に、中田敬吾先生や安井廣迪先生と演者、そして日本の参加者で記念撮影を行った。

テーマごとのポスター題数は以下の通り（1.伝統医学と文化；49 題、2.伝統中国医学における証の研究；10 題、3.実証医学；30 題、4.臨床報告；31 題、5.中医薬と健康ための食養；38 題、6.鍼灸と統合医療；18 題、7.長寿医学；5 題、8.女性の健康；4 題、9.癌における予防と治療；9 題、10.伝統薬物の標準化研究；9題、11.世界的な生薬品市場；1 題、12.台湾における薬用固有植物の開発と応用；6題、13.伝統製薬業の現況と展望；7題)。
なお発表題数が多いために、第１日目と第２日目によって張り替えていた。

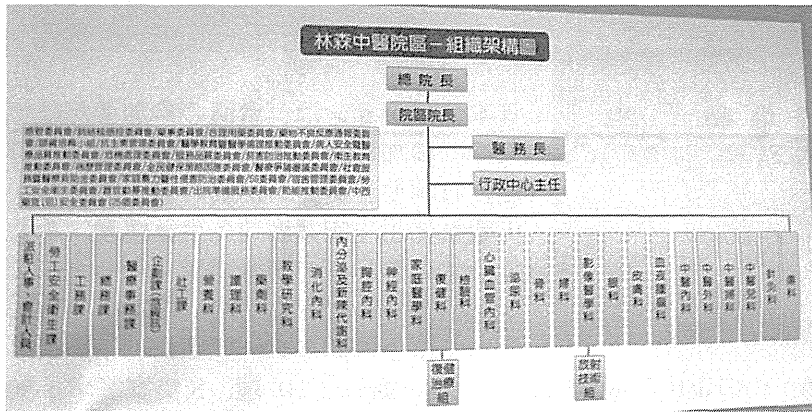


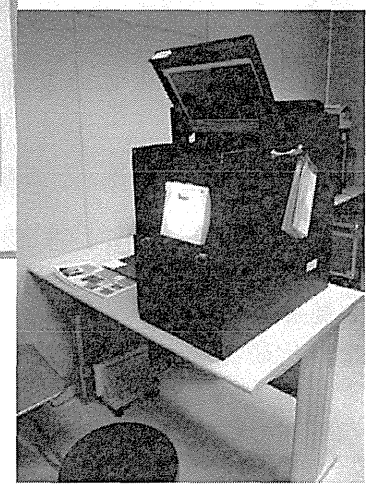
また本大会の初日 11 月 1 日の Welcome Reception & Lifetime Contribution Award Ceremony of ISOM 40th Anniversary (歓迎会と国際東洋医学会 40 周年記念式の終身貢献賞授与)が開催された。記念式では動画により過去の開催された ISOM の活動を紹介し、これまで ISOM の活動に貢献された方に「終身貢献賞」を渡していた。日本では室賀昭三先生、津谷喜一郎先生が受賞された。式典中に参加者に 40 周年記念誌を配っていた。また大会会場には、40th Anniversary Exhibition として特設ブースが設定され、パネルや過去の抄録や記念グッズが飾られていた。

台北駅から少し離れた台湾大学附属病院の隣、台大醫院国際会議センターで開催された。この国際会議センターではICOM 学会の開催でなく、同時に結婚披露宴や商業イベントなども同時に開催されていた。台湾では公営施設を積極的に運用していることが日本とは違った点で少し驚いた。

台北市立連合病院　中西醫診療センターの見学

ICOM で司会と講演された中國醫薬大学の張　恒鴻教授紹介で、中醫醫學部主治醫師の黄伯瑜先生の勤務先である台北市立連合病院　中西醫診療センター（臺北市立聯合醫院 林森院區 中西醫診療中心；臺北市鄭州路 145 號）を見学した（見学者は並木隆雄先生、矢久保修嗣先生と和辻の３名)。診療センターの見学の目的は、中醫における診断器機である。この病院は、中醫院と西洋病院と併設している。通常であると両方の組織は独立して連携は少しある程度もしくは対立することが多い。しかし、この病院では、元が中醫院であるために西洋医学の医師との連携は密に行えているという。患者の希望や医師の助言で各々の科へ行くらしい。

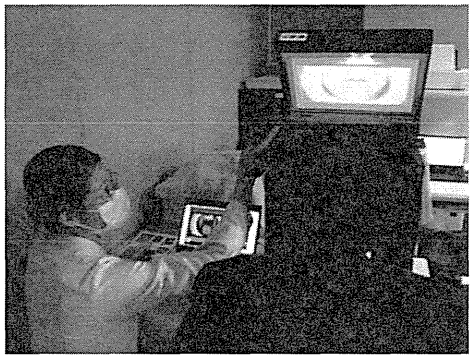




先の組織図は色分け左が事務系、右が診療系で西洋医学科と中醫科の色の区別はない（診療科は消化内科、内分泌及新陳代謝科、胸腔内科、神経内科、家庭醫學科、復健科、檢驗科、

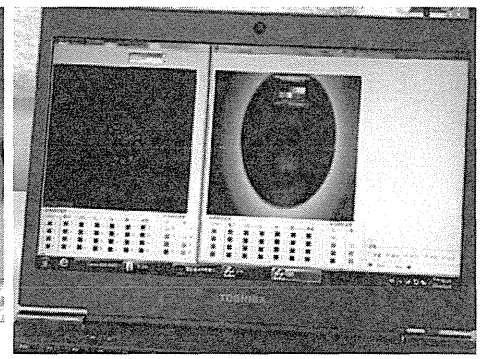
心臓血管内科、泌尿科、骨科、婦科、影像醫學科、眼科、皮膚科、血液腫瘍科、中醫内科、中醫外科、中醫婦科、中醫児科、針灸科、傷科の21科である)。

特殊検査室に移動して、中醫學の診断器機を見学に行った。10畳くらいの部屋に舌診撮影システムが1台、脈診システム1台、ベット1台と経絡測定装置があった。



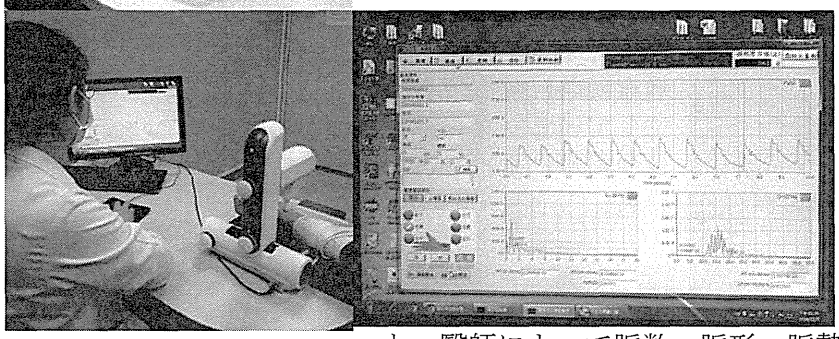
1）舌診撮影システムについて

舌診撮影システムは、既に実用化しているようで、検査技師が舌診の撮影を行った。光源はLEDであり、室内の光源を消して、外側からの遮光を行うためにボックス型になっている。撮影に10秒ほどかかるようであり、舌を長く出し続けるのが辛い。撮影する流れをシートしており、撮影姿勢や顔の位置、舌の出し方をわかりやすくしていた。舌写真はコンピュータにより画像解析が直ぐにできて、舌色や苔、舌下の静脈怒張などの抽出ができるようであった。



2）脈診システムの測定

脈診システムの測定(Huang-T1 Sphygmograph)は、最初に医師または技師が脈の位置を確認して、その部位にプローブを押し当て、自動で押圧して脈波を取る形である。右手の寸・関・尺部を測定して、次に左手の寸・関・尺を測定して両側6つの波形を測定する。測定された脈波はコンピュータによって直ぐに脈波の解析が処理され、各部における脈波分析における周波数分析と脈力、波形の記載が出力される。



脈診の測定用紙をみると、醫師によって脈数、脈形、脈勢、そして脈診の総合判断をするようになっている。なお判断の詳細は次のとおりである、脈数は心率（正常・数・

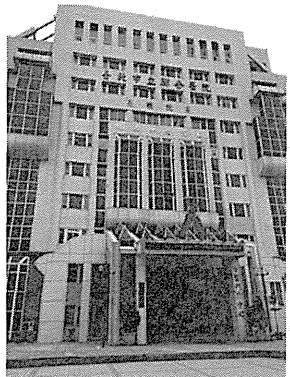
緩・遅）と心率（正常・結・代・促)。脈形は大小（適中・大・小）・平滑度（滑・平・弦・澀・短）・均匀度（均・不均)。脈勢は低頻（平・澀・陰虚・気滞）・高頻（滑・弦・勢（平・虚・實）・気滞))。

3）経絡測定装置について

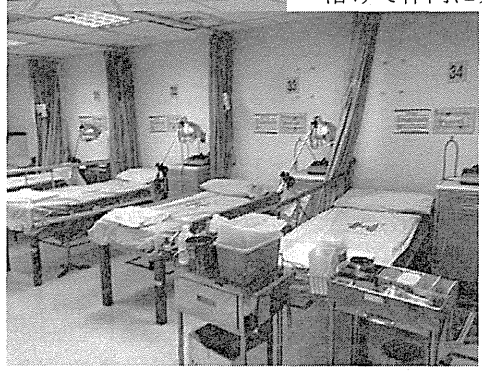
経絡測定装置は、日本で知られている良導絡測定装置の改良版である。台湾や韓国で根強く用いられている測定法である。分析法には整合分析、経絡分析、陰陽分析、気血分析、五行分析、循環分析などあるようである。見学では経絡分析の経絡虚實分析圖を出力され、十二経の値が棒グラフ上に出力された。

付記：良導絡測定は、故中谷良雄先生によって研究され、1952年に医学博士論文（京都大学生理学）を記載し、広く知られてようになった。現在でも日本良導絡自律神経学会で研究が続けられている。測定はノイロメーターという測定器によって良導点（及び反応良導点）を探索する。筒状の金属（陽極）の不関導子を手に握らせて、内経1cm の湿性の関導子（陰極）を各経の原穴（経によって原穴異なる部位あり）に当てて測定する。

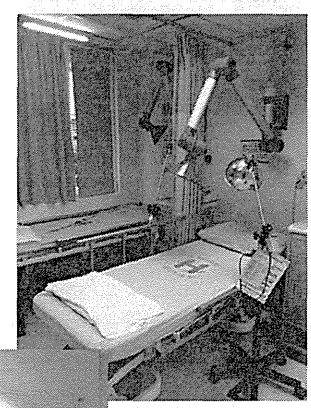
中西醫診療センターでは、特殊検査室の見学後に中薬の調剤局、病室などを見学した。また同センターの針灸治療室の見学は患者が多くて見学ができなかった。



しかし台北市内の同系列病院である台北市立連合病院　昆明中西醫診療センター（臺北市立聯合醫院 昆明院區　林森院區；臺北市萬華區昆明街100號）の針灸治療室を見学することができた。ここはベット数が多く、私達が見学したベット番号が 34 番であった。ここでは肥満症や代謝症候群に対して穴位埋線療法（特殊な注射器を利用して、外科手術にも使われる羊腸糸を経穴に埋め込む方法、埋め込んだ羊腸糸はタンパク質で作れているため、一定期間が経過すると自然に溶けて体内に吸収される）を行っている。



通常の針灸治療も行っており、施灸は天井から吊される換気用のノズルを使って、煙を院外に排出できるようにしている。なお針灸治療は中醫師によって行われている。



この病院では中醫臨床技能訓練と評価センター（中醫臨床技能訓練醫評量中心，Chinese

Medicine Clinical Skill Training and Assessment Center)が設置されており、問診室や病室の訓練室、カンファレンス室があった。問診室はマジックミラーやビデオカメラで評価できるように設備が整えてあった。通常は1室くらいだと思ったが何室も用意されており、一斉に多くの醫師を訓練する目的でセンターが作られたことが判り、施設として完備していることに非常に驚いた。大学卒業後に優秀な中醫師を育成するために活用しているとのことであった。このような取組は日本でも大学の教育機関で西洋医学の一般診療で行われていることが多いが、漢方医学や伝統鍼灸の分野では非常に少ないと思われる。

今回、施設案内していただいた中醫醫學部主治醫師の黄伯瑜先生は、教学研究科主任であり、中醫臨床技能訓練に精通しているようであった。中醫に関する特別な技術訓練器機はないものの、模擬患者を用いて技能訓練ができる施設があることは一定の技術を保持することに役立つと思われた。日本の漢方医学や鍼灸医学の教育研究者もこのような訓練法を参考にして、後進の育成方法を模索する必要があると感じた。

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Research Article

Proposal for a New Noncontact Method for Measuring Tongue Moisture to Assist in Tongue Diagnosis and Development of the Tongue Image Analyzing System, Which Can Separately Record the Gloss Components of the Tongue

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Tongue diagnosis is a noninvasive diagnosis and is traditionally one of the most important tools for physicians who practice Kampo (traditional Japanese) medicine. However, it is a subjective process, and its results can depend on the experience of the physician performing it. Previous studies have reported how to measure and evaluate the shape and color of the tongue objectively. Therefore, this study focused on the glossy component in order to quantify tongue moisture in tongue diagnosis. We hypothesized that moisture appears as a gloss in captured images and measured the amount of water on the tongue surface in 13 subjects. The results showed a high correlation between the degree of gloss and the amount of water on the tongue surface and suggested that the moisture on the tongue can be estimated by the degree of gloss in a captured image. Because the moisture level on the tongue changes during the course of taking photos, it became clear that we had to wait at least 3 minutes between photos. Based on these results, we established the tongue image analyzing system (TIAS), which can consistently record the gloss and color of the tongue surface simultaneously.

1. Introduction

Tongue diagnosis is one of the most important diagnostic methods for physicians who practice Kampo medicine. We use tongue diagnosis to determine a patient's condition and the progress of a disease by thoroughly observing the quality of and the coat on the dorsum and underside of the tongue. We perform tongue diagnosis by observing the color and moisture of the tongue surface, the shape of the tongue, and the characteristics of the coating on the tongue surface. Many studies have reported a correlation between the shape and color of the tongue and an individual's health [1, 2]. In addition, it has been found that the moisture of the tongue reflects the water metabolism in the body [3]. In other words, a high degree of tongue moisture may reflect an abnormality in the water metabolism in the body, which may signify some type of dysfunction in the internal organs. On the other hand, when the degree of tongue moisture is low and the tongue is dry, we suspect that the patient suffers from dehydration and heat production. Thus, with tongue diagnosis, we can noninvasively diagnose the state of the blood and humors of the whole body, the autonomic nervous system, and especially

the upper gastrointestinal tract. However, tongue diagnosis depends on the experience and subjective opinion of the physician, and the diagnostic results are qualitative and inconsistent. In addition, external environmental factors such as the type and direction of the lighting affect the appearance of the tongue.

In order to solve these problems, many researchers have developed computer tongue diagnostic support systems that use image processing [4–9]. However, with these techniques, gloss on the tongue is visible when the image is captured, and the systems cannot correctly obtain the color of the portion of the tongue masked by the gloss. For example, when the blood circulation stagnates, small purple spots may appear on the surface of the tongue. As the glossy area will change in response to slight movements of the tongue and to changes in the physician's line of sight, the reflective area is not fixed, and spots hidden by the reflective area will eventually be revealed through movement. In contrast, a systematized imaging environment prioritizes stability in general. It fixes the camera and subject positions and also limits the number of pictures taken, increasing the risk that spots will be masked by the gloss and will be overlooked. In tongue diagnosis in the practice of Kampo medicine, tongue moisture needs to be observed separately from the shape and color of the tongue.

In order to measure the moisture of the oral submucosa objectively, an electronic device named Mucus III (Life Co., Ltd.) was developed [10–12]. Since this device is based on the concept of the electronic condenser, it needs the probe of the device be pressed against the mucosal surface of the tongue for five to ten seconds while applying constant pressure of 200 g/cm^2. This is actually not easy for the operator to control the pressure, and furthermore it is unacceptable for some people that such unfamiliar device directly touches their tongue for long time. To address such problems, noncontact and shorter-time measurement method is highly required.

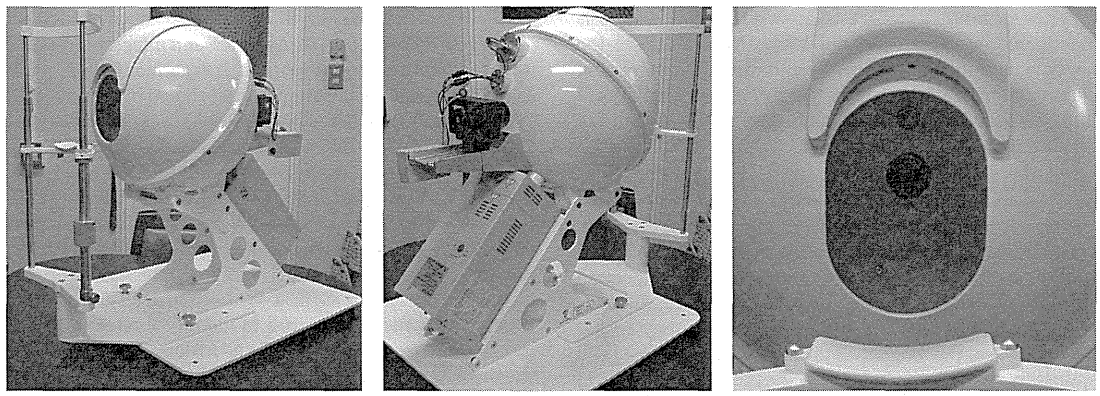
When the dorsum of the tongue is observed, the exposed part that protrudes from the mouth generally runs from the terminal sulcus to the proglossis. The lingual mucosa of the tongue surface is composed of tissues that are concave or convex, such as the median groove and the tongue papilla. Furthermore, since each tissue scatters light internally, if the tongue surface is dry, the tissue does not generate the gloss caused by the reflection of incident light. However, when powerful directed lighting illuminates the surface of the tongue body and a picture is taken, we generally observe a great deal of gloss. It is thought that liquid such as saliva adheres to the surface of the tongue body and covers the median groove and irregular parts of the lingual papillae, and the surface reflection on the liquid causes the gloss. Therefore, it is thought that the degree of gloss recorded with the camera is correlated with the amount of water that adheres to the surface of the tongue body. In order to analyze the correlation between the degree of gloss and the moisture of the tongue surface, a technique that can measure the degree of gloss on the tongue surface consistently and quantitatively is needed. However, detailed studies have not been performed up to now; here we investigate a quantitative method for measuring the degree of gloss on the tongue surface.

First, we examine which of the three imaging methods (45-degree lighting, polarizing plates, and integrating sphere) is best for controlling the gloss. This examination will enable us to take pictures of the tongue independent of the surrounding lighting environment. Next, we will examine noncontact and quantitative methods of measuring tongue moisture to extend our ability to record the condition of the tongue. We hypothesize that tongue moisture appears in images as gloss. First, we examine a method for measuring the gloss consistently. In order to record gloss, we record the specular reflection light with a camera by irradiating light that is strongly directed at the tongue surface. We need to determine suitable geometry for the lighting and to identify a camera that can record the gloss consistently. The third objective is to examine the method for calculating the degree of gloss from pictures and measuring the volume of water on the tongue surface. We then analyze the correlation between the degree of gloss and the tongue moisture. In addition, we evaluate the accuracy with which the tongue moisture was measured based on the degree of gloss. The fourth objective is to evaluate the recovery time needed for the tongue to recover its moisture. This evaluation is important for determining the duration to wait between taking photographs when repeatedly capturing images. Finally, we develop a new tongue image analyzing system (TIAS) that can separately record the gloss portion and nongloss portion of the image.

This research was carried out in accordance with the Chiba University Graduate School of Medical Studies Ethical Review Board number 812.

2. Method

2.1. Evaluation of Image Geometry That Controls the Gloss of the Tongue. The surface of an object is observed through a combination of surface-reflected light and internally reflected light based on a dichromatic reflection model. When observing a tongue surface, although the color of the tongue and the coating of the tongue appear as internally reflected light, the part to which liquids such as saliva adhere will radiate strong surface-reflected light (i.e., gloss) depending on the angle of the lighting. When the lighting direction and the observation direction are such that specular reflection is created, the surface-reflected light becomes very strong compared to the internally reflected light, and the internally reflected light is masked and cannot be observed. Therefore, in order to observe the color and coating of the tongue, a photographic method that can control gloss is needed. Generally, there are three kinds of measurement methods that can control gloss. The first involves using 45-degree lighting; the lighting is arranged so that light enters at an angle of 45 degrees to the normal line of a reflective surface and suppresses the specular reflecting light when observed from the normal (0°) direction. The second uses a set of polarizers; the angle of the polarizer in front of the lighting source and that of the polarizer in front of the camera differ by 90°. The third uses diffuse illumination within an integrating sphere. By photographing the dorsum of the tongue using the above three methods to suppress gloss, we can compare and evaluate which method is best for photographing the dorsum of the tongue



(a) (b) (c)

FIGURE 1: The appearance of the tongue image analyzing system (TIAS). (a) Front side: aperture and jaw stand. (b) Back side: camera and high direct light source. (c) Inside appearance of the integrating sphere from the opening.

in terms of the degree of gloss inhibition and the quality of the pictures.

2.2. Development of TIAS. We developed TIAS equipped with a diffused light source for recording the state of a tongue surface. The TIAS is shown in Figure 1. The inside diameter of the integrating sphere is 300 mm, and the inner wall is uniformly painted with barium sulfate. The area of the opening is about 7800 mm^2, and the shape is slightly elliptical so that it can fit into the mouth with the mouth open. Moreover, the system can be used to take a child's image; it is possible to reduce the size of the opening with a slide system cover. When the cover is closed, it also functions as internal protection for the integrating sphere when not in use. The camera (Lumenera Lw115 C-1280 × 1024-pixel color CMOS sensor) was set directly facing the opening. The camera was equipped with a lens with a focal length of 16 mm. A halogen light source (Moritex MHAB-150 W, color temperature 3200 K) of 150 W was installed in the lower part of the rear surface of the integrating sphere as a light source for diffuse illuminations. A baffle plate was installed so that this light source would not directly illuminate the photographic subject. In order to circulate the air inside the integrating sphere, air is evacuated through the hole used for light sources. Moreover, the jaw stand is movable from front to back and up and down, and it can be adjusted to a suitable position according to the subject.

In order to calibrate the characteristic changes of the camera or light source, calibration is performed only once when the power is turned on. For calibration, color charts (X-rite Color Checker Passport) of 24 colors are installed in the integrating sphere opening, an exposure is taken, and the color gain of the camera is adjusted automatically. The shutter speed of the camera is fixed at 20 ms. When using TIAS to take images of a subject, 10 tongue images are taken in 1 second at intervals of 0.1 seconds. The images are saved sequentially as lossless 24 bit RGB format color images. Then

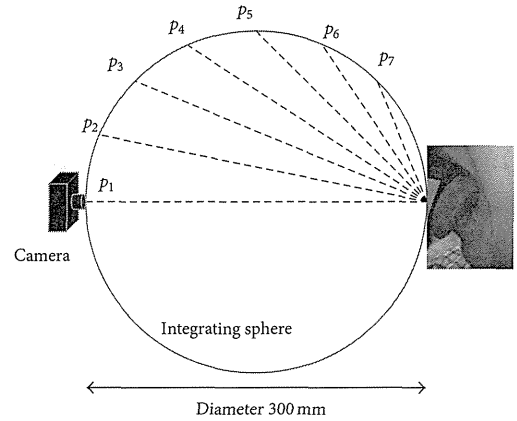


FIGURE 2: Placement of camera and LED lighting to determine the best photographic geometry.

the RGB values are converted to CIE1976 $L^*a^*b^*$ color space via XYZ color space. The conversion matrix from RGB to XYZ color space is estimated from the color charts by using the multiple regression method.

2.3. Measurement of Gloss. In order to determine the best placement for achieving suitable imaging geometry as shown in Figure 2, the camera was set at the front of the face. It was arranged so that the position of the LED lighting can change from p_1 (zero ascending vertical angle) to p_7 (67.5 ascending vertical angles) in increments of 11.25 degrees. In addition, since the system is premised on using for measuring gloss together with consistent measurement of tongue color, LED lighting was installed in the inner wall of the 300 mm diameter integrating sphere. Moreover, the LED was attached to a focusing lens with a 10-degree angle spread. In

this research, we compared and examined the optimal LED position for measuring gloss clearly and consistently.

2.4. Analysis of Correlation between the Amount of Moisture on the Tongue Surface and Gloss Degree. In order to quantify the degree of gloss from the images taken by the camera, two indices, gloss luminosity and glossy area, were considered. Since gloss is a specular reflection component of the illumination lights, a camera with a very high dynamic range is required in order to measure the gloss luminosity. However, high-dynamic-range cameras are expensive, specialty items that are not generally used. In this system, we measure the glossy area as an index of the degree of gloss on the assumption that a general-purpose industrial camera can be used to promote the spread of the system in a lower price range. In order to measure the gloss, it is sufficient to capture an image under lighting with high directivity. However, since the diffuse illumination light source for color measurement cannot be turned on and off frequently, the gloss must be photographed with diffuse illumination at all times. Therefore, in this study, by taking two images, one nonglossy image taken by irradiating only with diffuse illumination and another glossy image taken by irradiating with both a strong directional light source and diffuse illumination, the gloss component is detected by the following procedure. First the nonglossy image is subtracted from the glossy image. Since pixel values in the subtraction image can clearly be classified into two groups, one is gloss and another is dark noise, we obtain the glossy area by applying Otsu's thresholding method [13]. It is ideal to take the two pictures simultaneously in order to perform the picture subtraction, but since capturing simultaneous images by light separation greatly complicates the system configuration, we took two images in succession in a short time. The index of the glossy area was computed as the ratio of the area of the glossy part to the area of the whole surface of the tongue expressed as a percentage.

The next process was to measure the amount of moisture by extracting moisture from the tongue surface and measuring the weight of water gain. To select a material that extracts moisture from the tongue surface effectively, we compared filter paper, gauze, kitchen paper, and tissue paper. Among them, kitchen paper and tissue paper were easy to be torn and folded and very hard to handle; they were excluded from the candidates. Then we compared the amount of absorbed moisture under the controlled condition, and the filter paper (56 mg) absorbed three times larger than the gauze (17 mg). Based on the moisture absorbency and the ease of handling, filter paper was found to be the most suitable material. The procedure for measuring the amount of tongue surface moisture was as follows: filter paper cut into 10 mm squares and a sealing bag were weighed in advance using an electronic scale. Figure 3 shows the measurement in which 10 mm squares of filter paper were placed on the center line 10 mm from the tip of the subject's tongue for five seconds. This measurement position is determined by referring to the previous work [10]. At this time, the exact position of the filter paper was recorded by a picture for the image measurement. After five seconds, the filter paper was removed from the tongue and put into the sealing bag so that it would not lose any of the moisture

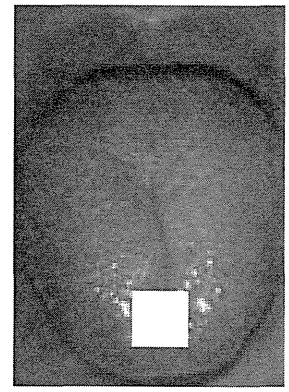


FIGURE 3: Filter paper used to measure the moisture on the tongue surface; a 10 mm square filter paper was placed at the center and 10 mm from the tip of the tongue.

that it had absorbed, and the weight of the filter paper was measured. The amount of moisture was calculated by deducting the weight of the filter paper and the sealing bag from the measured value.

Measurements were carried out on 15 subjects (8 males, 7 females) in two states: a normal state and another in which the tongue surface was thoroughly dried. Immediately after gloss and nongloss images were captured one by one using TIAS, the amount of water on the tongue surface was measured. Since the image is recorded in an instant, the tongue surface did not dry at all during the measurement. In the images captured using TIAS, the gloss component was determined from the difference between the gloss image taken using the LED light source and the nongloss image taken with the LED light source switched off. The area where the filter paper was placed on the tongue surface for the measurement of moisture was manually specified as the area of interest referring to the picture of the filter paper on the tongue, and the degree of gloss of the area of interest was computed. The average RGB value of the area of interest in each picture was converted into a CIE1976 $L^*a^*b^*$ color space, and the brightness (L^* value) of the picture was calculated. The difference in the brightness value of the area of interest between the nongloss picture and the gloss picture was calculated as the degree of gloss.

2.5. Examination of the Moisture Recovery Time of the Dry Tongue Surface. When repeating and carrying out moisture measurements on the tongue surface, we examined the recovery time and the degree of recovery of the moisture on the tongue surface between photos. Images were captured repeatedly to measure the serial change in the degree of gloss when the tongue was stuck out for 20 seconds. The procedure was then repeated after an interval, which varied from 10 seconds to four minutes.

3. Results

3.1. Examination of the Image Geometry for Suppressing Gloss. Figure 4 shows the results of the application of three kinds of

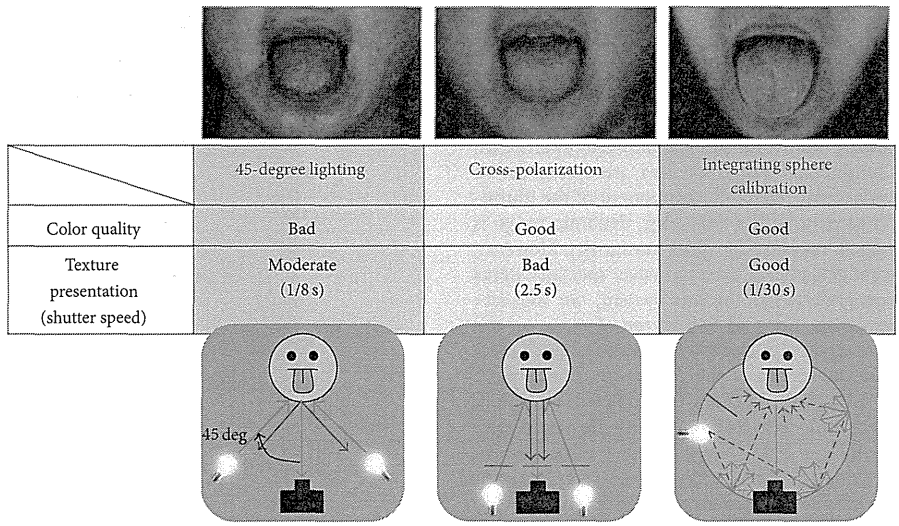


FIGURE 4: Comparison of three methods to capture nonglossy tongue image.

imaging methods to observe the tongue surface. It was found that the 45-degree lighting could not fully suppress the surface reflection light and gloss was partially recorded. Polarizer imaging suppressed the gloss sufficiently, but the weakness of the light intensity made a longer exposure necessary, and as a result, the sharpness of the picture decreased. Generally, since the tongue cannot be immobilized, it is desirable for the exposure time to be short. The integrating sphere controlled the gloss satisfactorily, and the sharpness of the picture was high. Thus, we concluded that the integrating sphere lighting was most suitable for recording the character of a tongue and the color of the tongue coating.

3.2. Measurement of Gloss. Figure 5 shows the results of photography with an LED lighting arrangement from p_1 to p_7. The gloss was recorded properly from p_2 to p_4. On the other hand, when the ascending vertical angle of the LED became large, a shadow of the upper lip appeared and blocked the posterior part of the tongue. Therefore, we determined the optimal arrangement angle of the LED to be 10 degrees in order to record a wide area including the posterior part of the tongue.

3.3. Extension of Function in TIAS. TIAS is enhanced by using the optimum arrangement of the high-directivity light source. The condenser lens of 10 degrees was attached to a high-intensity white LED (Luxeon LXK2-PWC4-0180, 180 lumen, color temperature 6500 K) as a high-directivity light source, and it was installed at a position 10 degrees above the subject. The microcomputer-controlled LED driving board was designed to enable on-off control of this high-directivity light source. The source of the diffused light is always set to on, and the LED light source is also turned on once per second; only one gloss picture is recorded. Since TIAS can shoot 10 pictures per second, nine color sheets of the lusterless tongue surface can be recorded in one second, and one sheet forms a picture that contains gloss. In order to calculate the degree of gloss, the difference between continuous gloss and nongloss pictures is used. The glossy area shown in Figures 6(a) and 6(c) can be obtained by the thresholding method from the subtraction image as described in Section 2.4. Figures 6(b) and 6(d) show the serial change of the degree of gloss as recorded by TIAS. Subject 1 had an approximately 5% degree of gloss immediately after sticking out his tongue; the amount fell to 4% after about 5 seconds and remained at about 4% for 20 seconds. On the other hand, subject 2 had a 3% degree of gloss immediately after the tongue was stuck out, and it decreased gradually over time and became 1.5% after 15 seconds. These results suggested that the degree of gloss varies by person immediately after the tongue is stuck out, and the rate of change of the degree of gloss after the tongue is stuck out also varies.

3.4. Analysis of Correlation between the Amount of Moisture on the Tongue Surface and the Degree of Gloss. We analyzed the photographic data for 12 subjects in a normal state and 13 subjects in a dry state. The cases in which the exposed tongue was nearly horizontal and the camera could not shoot it appropriately were excluded from analysis. Using the TIAS with enhanced functionality, the degree of gloss of the tongue surface was quantitatively measured, and the correlation between the amount of moisture on the tongue surface and the degree of gloss was analyzed. Figure 7 shows the plot of the correlation between the amount of moisture on the tongue surface and the degree of gloss. The blue plots represent the 12 normal-state cases and the red plots represent the 13 cases in a dry state. This result revealed that the Pearson product-moment correlation coefficient of the amount of moisture on the tongue surface and the degree of

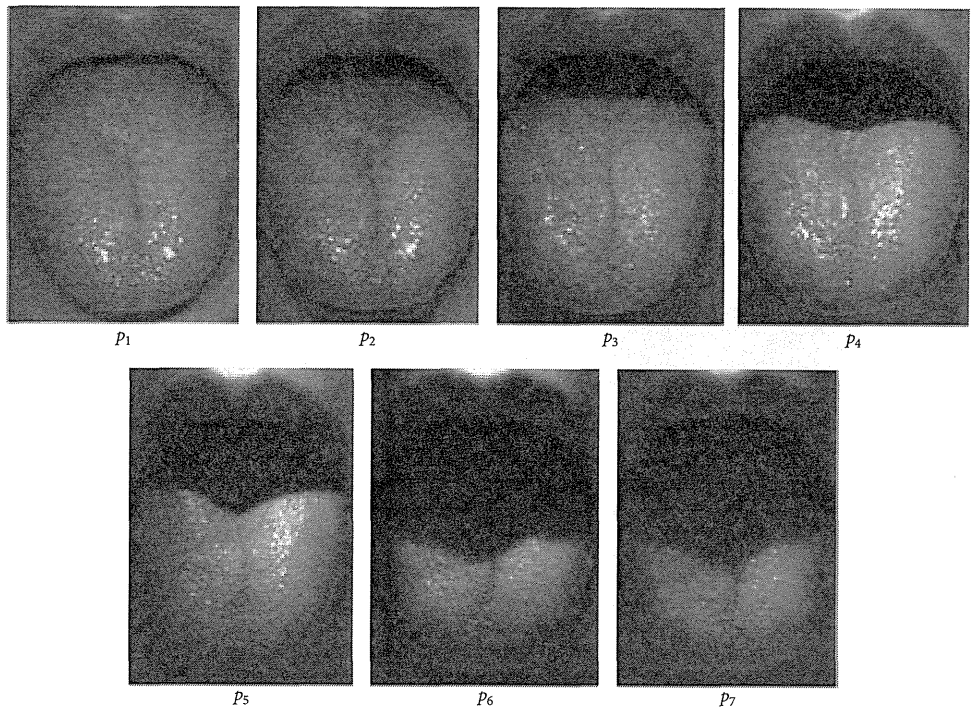


FIGURE 5: Shooting results with the arrangement of LED lighting from p_1 to p_7.

gloss was 0.80, and a significant relationship was obtained at the 1% level. The regression formula, which presumes a moisture amount on the tongue surface based on the gloss degree measured in the picture, is as follows:

$$\text{Amount of moisture (mg)} = 4.2 \times 10^{-4} \times \text{gloss degree} - 0.017. \quad (1)$$

3.5. Examination of the Moisture Recovery Time of the Dry Tongue Surface. Figure 8 shows the plot of the degree of moisture recovery of the tongue surface at different recovery times between image acquisitions. The blue plots in the first image series show that the degree of gloss decreased greatly in 20 seconds. In addition, when the recovery time between the acquisitions of images was set at 10 seconds, the moisture had not recovered, and the degree of gloss was decreased at the second image capture. This tendency continued up to a recovery time of two minutes; when the recovery time was set for three minutes or more, that gloss degree at the time of the second series had recovered to the same quantity seen in the first series. From the above results, it became clear that a period of three minutes or more was required for the recovery time between image acquisitions in order to repeatedly capture images for the purpose of stabilizing the measurement of the gloss degree.

4. Discussion

In this paper, we first examined several photographic techniques for controlling gloss in order to stabilize the color of the tongue surface and the coating of the tongue. We then developed TIAS using integrating sphere lighting. We explained our method of using polarizers with imaging techniques to control gloss, setting S polarization in front of the lighting and P polarization in front of the observation position. Only S polarized light struck the reflective surface, as the polarizing plate was placed before the lighting. Although surface reflection light was reflected with the state of S polarization maintained, internally reflected light became a mix of S polarization and P polarization due to the influence of dispersion. Only P polarization penetrated this reflection light, as the polarizing plate was placed in front of the observation position. This is a system in which the surface reflection light was intercepted and only some of the internally reflected light was observed. This method has the advantage that it can observe internally reflected light with high precision; however, the intensity of the observable light became weaker due to the polarizers. With diffuse illumination in an integrating sphere, the light emitted by the light source undergoes repeated diffuse reflection inside the sphere, and the reflective surface is uniformly illuminated from all directions. No specific specular reflection angle exists with diffuse illumination, and as a result we can observe internally reflected

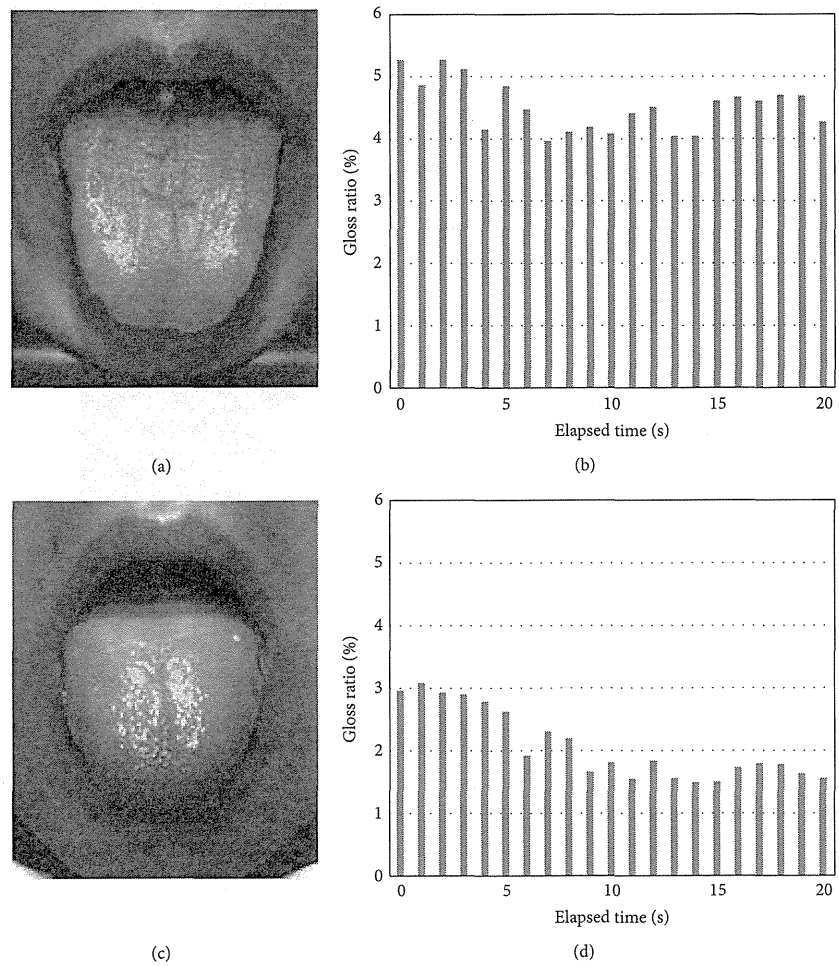


FIGURE 6: Serial change of the gloss ratio measured by TIAS. (a), (b) Subject 1. (c), (d) Subject 2. (a), (c) Gloss component shown as yellow area. (b), (d) Gloss ratio change over 20 seconds.

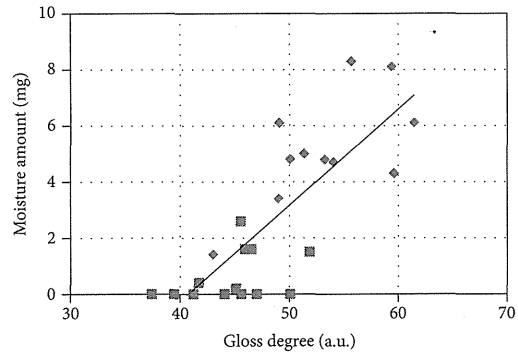


FIGURE 7: Relationship between the moisture amount and the degree of gloss on the tongue. Blue plot: normal condition. Red plot: dry condition.

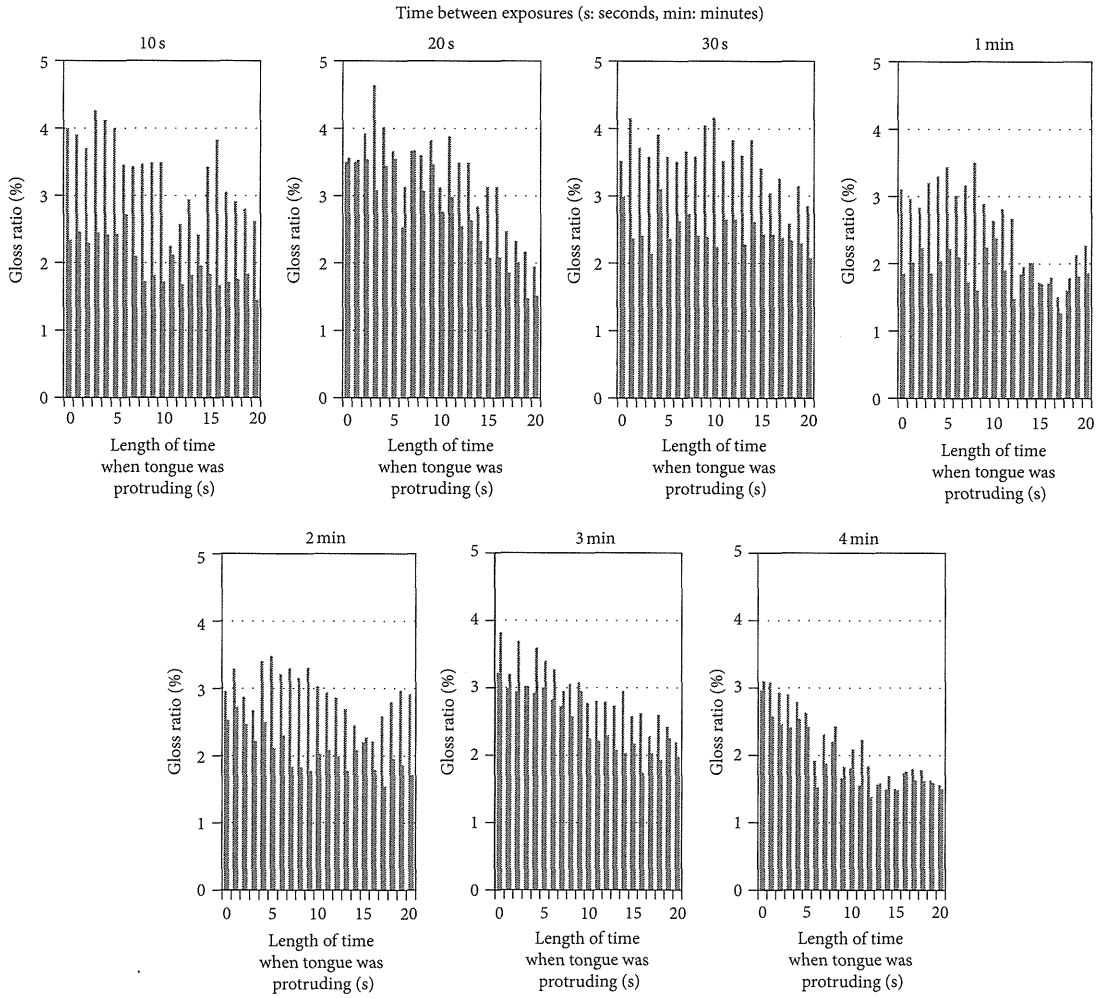


FIGURE 8: Degree of gloss on the tongue surface at each time point from 10 seconds to 4 minutes. Blue bar: gloss ratio in the first photo series. Red bar: gloss ratio in the second photo series.

light without the masking effect of a glossy surface. Based on these principles, we developed a photographic device using an integration sphere.

We then investigated methods for measuring the tongue moisture quantitatively without contacting the tongue surface. It was shown that moisture is represented by the degree of gloss recorded in a picture, and we determined the imaging geometry with which the degree of gloss was measured stably. There was a high correlation of $R = 0.8$ between the degree of gloss and the water weight of the tongue surface as measured using TIAS, and it was suggested that the moisture amount on the tongue surface could be estimated from the degree of gloss. Although regression formula (1), which presumes an amount of moisture on the tongue surface based on the degree of gloss measured in an image, can have substantial quantitative error, determining the strict moisture weight of the tongue surface is not required in Eastern medicine. Since the amount of moisture is characterized on the basis of a three-to-four-degree scale ranging from "nothing" to "high," we believe that regression formula (1) has sufficient accuracy to provide diagnostic support for Kampo medicine. As noncontact image-based measurement of the amount of moisture on the tongue surface becomes possible, it can be used for the diagnostic quantification of diseases such as Sjögren syndrome that present with abnormal amounts of moisture on the tongue surface and for determining the progress of medical treatment.

As this method enables us to visually identify the range and grade of dryness on a tongue surface, we expect to establish a quantitative evaluation method that differs from