INTRODUCTION

Ten methods can be used to assess the lower extremities. These methods are classified by assessment methods: anatomic, functional, diagnosis-based. The evaluator decides the diagnosis at first, then checks whether or not the individual has reached maximal medical improvement (MMI). The next step is to identify each part of the lower extremities (pelvis, hip, thigh, knee, foot, and toe). The evaluator estimates the disability using the ten items: amputation, leg length discrepancy, ankylosis, partial ankylosis (range of motion), nerve injury, muscle weakness, diagnosis-based estimation, joint replacement, vascular disease, skin loss, and then calculate the impairment rating. Assessment by muscle weakness is chosen when the other estimations are inappropriate. If lower extremity impairment is due to an underlying spine disorder, the evaluation of the impairment would be conducted with the spine impairment rating.

There are some methods to calculate the impairment rating scales that can be combined, but other methods cannot be combined. If the evaluator cannot determine which methods are correct, then the evaluator uses all methods that are related to the condition, and chooses the highest impairment rating.

MATERIALS AND METHODS

The Korean Academy of Medical Sciences comprises the Lower Extremities Committee of Korean Guideline for Impairment Rating in which orthopedic surgeons, neurosurgeons, physiatrists, and occupational and environmental medicine doctors participated. This committee analyzed the American Medical Association (AMA) Guides (1), McBride method (2), the guide of Korean Orthopaedic Association (3), the guide of Korean Neurosurgical Society (4), the Korean Academy of Rehabilitation Medicine (5) and created a new guide based on the AMA Guides.

Key Words: Disability Evaluation; Lower Extremity; Impairment
RESULTS

Methods of assessment

There are three methods to assess the disability of the lower extremities. These methods are based on anatomical, functional, and diagnosis-based estimations (Table 1).

Combination of evaluation methods

The amputation cannot be combined with leg length discrepancy, ankylosis, nerve injury, partial ankylosis, or muscle weakness. The leg length discrepancy cannot be combined with amputation. Ankylosis and partial ankylosis cannot be combined with muscle weakness and diagnosis-based estimates. Nerve injury and muscle weakness cannot be combined with each other. If there is arthritis without ankylosis, it can be estimated by muscle weakness. When we use the muscle weakness, it should be Grade III or IV by the manual muscle test. If the muscle power is less than Grade III, it should be assessed by the nerve injury. Diagnosis-based estimates cannot be combined with ankylosis, partial ankylosis, or muscle weakness.

Amputation

The impairment rate depends on the site of amputation and length of the stump. The impairment rate of lower extremity is presented in Table 2. The maximal impairment rate is less than 100% of the leg except hemipelvectomy. The hemipelvectomy is 110% of lower extremity function. In case of metatarsal amputation, if the remnant of the metatarsal bone is less than 25%, it is categorized as a Lisfran amputation. Tarsometatarsal amputation includes the proximal one-fourth transmetatarsal amputation. The length of stump is estimated by the radiography.

Table 1. Methods used in evaluating impairments of the lower extremities

| Assessment method        | Tools                                      |
|--------------------------|--------------------------------------------|
| Anatomic                 | Anatomic leg length discrepancy             |
|                          | Ankylosis                                  |
|                          | Amputation                                 |
|                          | Skin loss                                  |
|                          | Peripheral nerve injury                    |
|                          | Vascular                                   |
| Functional               | Range of motion                            |
|                          | Muscle strength (manual muscle testing)    |
| Diagnosis based          | Fractures                                  |
|                          | Ligament injuries                          |
|                          | Menisectomies                              |
|                          | Post-traumatic arthritis and fusion of the foot |
|                          | Joint replacements                         |

Table 2. Impairment estimates for amputations

| Amputation                        | Lower extremity (foot) impairment (%) |
|-----------------------------------|--------------------------------------|
| Hemipelvectomy                    | 110                                  |
| Hip disarticulation               | 100                                  |
| Above knee                        |                                      |
| Proximal                          | 100                                  |
| Mid-thigh                         | 90                                   |
| Distal                            | 80                                   |
| Knee disarticulation              | 80                                   |
| Below knee                         |                                       |
| Less than 8 cm                    | 80                                   |
| 8 cm or more                      | 70                                   |
| Syme (hind foot)                  | 62 (100)                             |
| Midtarsal joint                   | 52 (74)                              |
| Tarsometatarsal                   | 45 (64)                              |
| Transmetatarsal                   | 40 (57)                              |
| First metatarsal                   | 20 (28)                              |
| Other metatarsal                   | 5 (7)                                |
| All toes at metatarsophalangeal joint | 22 (31)                          |
| Great toe at MTP joint            | 12 (17)                              |
| Great toe at interphalangeal joint | 5 (7)                                |
| Lesser toes at MTP joint          | 2 (3) each                           |

MTP, metatarsophalangeal.

Table 3. Impairment due to leg length discrepancy

| Discrepancy (cm) | Lower extremity impairment (%) |
|-------------------|-------------------------------|
| 0-1.4             | 0                             |
| 1.5-2.9           | 5                             |
| 3-4.9             | 10                            |
| 5-9.9             | 20                            |
| 10+               | 35                            |
Knee joint
Impairment for flexion, valgus, varus, internal rotation, and external rotation. The optimal ankylosis position is $10^\circ$ to $15^\circ$ of flexion with neutral alignment. Ankylosis in the optimal position is a 67% lower extremity impairment (Table 5).

### Table 4. Impairment due to hip ankylosis

| Ankylosis (°) | Lower extremity (foot) impairment (%) |
|--------------|--------------------------------------|
| Flexion      |                                      |
| 0-15         | 85                                   |
| 15-24        | 70                                   |
| 25-39        | 50                                   |
| 40-59        | 70                                   |
| 60-75        | 85                                   |
| 75+          | 100                                  |
| Adduction    |                                      |
| 5-9          | 25                                   |
| 10-14        | 37                                   |
| 15+          | 50                                   |
| Abduction    |                                      |
| 5-14         | 25                                   |
| 15-24        | 37                                   |
| 25+          | 50                                   |
| Internal rotation |                  |
| 5-9          | 12                                   |
| 10-19        | 25                                   |
| 20-29        | 37                                   |
| 30+          | 50                                   |
| External rotation |                |
| 10-19        | 25                                   |
| 20-29        | 37                                   |
| 30-39        | 50                                   |
| 40+          | 50                                   |

### Table 5. Impairment due to knee ankylosis

| Ankylosis (°) | Lower extremity (foot) impairment (%) |
|--------------|--------------------------------------|
| Flexion      |                                      |
| 0-20         | 67                                   |
| 20-29        | 73                                   |
| 30-39        | 92                                   |
| 40+          | 100                                  |
| Valgus       |                                      |
| 0-9          | 12                                   |
| 20-29        | 25                                   |
| 30+          | 33                                   |
| Varus        |                                      |
| 10-19        | 12                                   |
| 20-29        | 25                                   |
| 30+          | 33                                   |
| Internal/external malrotation |          |
| 10-19        | 12                                   |
| 20-29        | 25                                   |
| 30+          | 33                                   |

### Table 6. Impairment due to ankle ankylosis

| Ankylosis (°) | Lower extremity (foot) impairment (%) |
|--------------|--------------------------------------|
| Plantar flexion or dorsiflexion |              |
| 20+ dorsiflexion | 42 (60)  |
| 10-19 dorsiflexion | 33 (47)  |
| 0-9 dorsiflexion | 25 (35)   |
| 0-9 plantar flexion | 25 (35)   |
| 10-19 plantar flexion | 30 (43)  |
| 20-29 plantar flexion | 37 (53)  |
| 30+ plantar flexion | 47 (67)   |
| Valgus position |                                      |
| 5-9          | 3 (4)                                 |
| 10-19        | 8 (11)                                |
| 20-29        | 12 (47)                               |
| 30+          | 25 (53)                               |
| Varus position |                                      |
| 5-9          | 8 (11)                                |
| 10-19        | 12 (17)                               |
| 20-29        | 25 (35)                               |
| 30+          | 37 (53)                               |
| Internal malrotation |                    |
| 0-9          | 8 (11)                                |
| 10-19        | 12 (17)                               |
| 20-29        | 25 (35)                               |
| 30+          | 37 (53)                               |
| External malrotation |                    |
| 10-19        | 8 (11)                                |
| 20-29        | 12 (17)                               |
| 30-39        | 25 (35)                               |
| 40+          | 37 (53)                               |

### Table 7. Impairment due to toe ankylosis

| Position | Lower extremity (foot) impairment (%) |
|----------|--------------------------------------|
| Great toe |                                      |
| Metatarsophalangeal Joint |                    |
| Neutral | 5 (7)                                 |
| 20 dorsiflexion | 8 (12)  |
| 20 plantar flexion | 11 (15)  |
| Interphalangeal joint |                    |
| Neutral | 2 (3)                                 |
| 20 plantar flexion | 2 (3)  |
| Other toes |                                    |
| Ankylosis | 1 (2)                                 |
Partial ankylosis (range of motion)

Lower extremity impairment can be evaluated by assessing the range of motion of its joints. If the restricted range of motion is based on organic abnormality, measurement is done for the range three times and use the greatest range as an evaluation (7).

Table 8. Hip motion impairment

| Hip motion (°)       | Lower extremity impairment (%) |
|----------------------|-------------------------------|
| Flexion              |                               |
| 80-100               | 5                             |
| 50-79                | 10                            |
| 25-49                | 20                            |
| <25                  | 35                            |
| Extension            |                               |
| 10-19 flexion contracture | 5                           |
| 20-29 flexion contracture | 10                          |
| >30 flexion contracture | 20                          |
| Internal rotation    |                               |
| 10-20                | 5                             |
| 0-9                  | 10                            |
| External rotation    |                               |
| 20-30                | 5                             |
| 0-19                 | 10                            |
| Abduction            |                               |
| 15-25                | 5                             |
| 5-14                 | 10                            |
| <5                   | 20                            |
| Adduction            |                               |
| 0-15                 | 5                             |
| Abduction contracture|                               |
| 0-4                  | 5                             |
| 5-9                  | 10                            |
| 10-19                | 20                            |
| 20+                  | 35                            |

Table 9. Knee impairment

| Knee motion (°)       | Lower extremity impairment (%) |
|-----------------------|-------------------------------|
| Flexion               |                               |
| 80-110                | 10                            |
| 60-79                 | 20                            |
| <60                   | 35                            |
| Flexion contracture   |                               |
| 5-10                  | 10                            |
| 10-19                 | 20                            |
| 20+                   | 35                            |
| Varus                 |                               |
| 2° valgus-0° (neutral)| 10                            |
| 1-7 varus             | 20                            |
| 8-12; add 1% per 2° over 12° | 35                       |
| Valgus                |                               |
| 10-12                 | 10                            |
| 13-15                 | 20                            |
| 16-20; add 1% per 2° over | 35                       |

Table 10. Ankle motion impairment

| Ankle motion (°)       | Lower extremity (foot) impairment (%) |
|------------------------|---------------------------------------|
| Plantar flexion (from neutral) |                               |
| 20-29                  | 2 (3)                                 |
| 10-19                  | 11 (15)                               |
| 5-9                    | 19 (27)                               |
| 0-5                    | 25 (35)                               |
| Flexion contracture    |                                       |
| 10-19                  | 15 (21)                               |
| 20+                    | 29 (41)                               |
| Dorsiflexion (from neutral) |                                   |
| 0-5                    | 25 (35)                               |
| 6-10                   | 15 (21)                               |

Table 11. Hindfoot impairment

| Hindfoot motion (°)    | Lower extremity (foot) impairment (%) |
|------------------------|---------------------------------------|
| Inversion              |                                       |
| 10-20                  | 2 (3)                                 |
| 0-9                    | 5 (7)                                 |
| Eversion               |                                       |
| 0-10                   | 2 (3)                                 |

Table 12. Forefoot impairment

| Forefoot motion (°)    | Lower extremity (foot) impairment (%) |
|------------------------|---------------------------------------|
| External rotation (from neutral) |                                   |
| 0-5                    | 2 (3)                                 |
| Internal rotation (from neutral) |                                   |
| 5-9                    | 7 (10)                                |
| 11-20                  | 5 (10)                                |

Table 13. Toe impairment

| Toe motion (°)          | Lower extremity (foot) impairment (%) |
|------------------------|---------------------------------------|
| Great toe              |                                       |
| Metatarsophalangeal, extension |                                   |
| 15-30                  | 2 (3)                                 |
| <15                    | 5 (7)                                 |
| Interphalangeal, flexion|                                       |
| <20                    | 2 (3)                                 |
| Lesser toes            |                                       |
| Metatarsophalangeal, extension |                               |
| <10                    | 1 (2)                                 |
estimated. The impairment rate due to partial ankylosis of the knee is presented in Table 9.

Ankle and foot

In ankle motion, plantar flexion, flexion contracture and dorsiflexion are estimated. In foot motion, inversion, eversion, valgus, and varus position are estimated. The impairment rate due to partial ankylosis of the ankle and foot is presented in Table 10-13.

Muscle weakness

Muscle weakness is measured by manual muscle testing. When we use muscle weakness method, it should be Grade III or IV by manual muscle test. If the muscle power is less than Grade III, it should be assessed according to peripheral nerve injury (Table 14).

Diagnosis-based estimation

Sometimes the diagnosis-based estimation is more precise

Table 15. Impairment estimate for the hip lesion

| Region and condition                        | Lower extremity (foot) impairment (%) |
|--------------------------------------------|--------------------------------------|
| Femur neck fracture                        |                                      |
| Malunion                                   | 30+ROM assessment                    |
| Non-union                                  | 37+ROM assessment                    |
| Femur shaft fracture                       |                                      |
| Angulation or malrotation                  |                                      |
| 10-14                                      | 25                                   |
| 15-19                                      | 45                                   |
| 20+                                        | +2/degree up to 62                   |

ROM, range of motion.

Table 16. Impairment estimate for the knee lesion

| Region and condition                                      | Lower extremity (foot) impairment (%) |
|-----------------------------------------------------------|--------------------------------------|
| Patella subluxation or dislocation with instability       | 7                                    |
| Patelllectomy                                             | 7                                    |
| Partial                                                   | 7                                    |
| Total                                                     | 22                                   |
| Meniscectomy, medial or lateral                           | 2                                    |
| Partial                                                   | 7                                    |
| Total                                                     | 7                                    |
| Meniscectomy, medial and lateral                          | 10                                   |
| Partial                                                   | 10                                   |
| Total                                                     | 22                                   |
| Cruciate ligament laxity                                 |                                       |
| Mild (<5 mm)                                              | 7                                    |
| Moderate (5-10 mm)                                        | 17                                   |
| Severe (>10 mm)                                           | 25                                   |
| Collateral ligament laxity                               |                                       |
| Moderate (5-10°)                                          | 2                                    |
| Severe (>10°)                                             | 7                                    |
| Tibial shaft fracture, malalignment                       |                                       |
| 10-14                                                     | 20                                   |
| 15-19                                                     | 30                                   |
| >20                                                       | +2 per degree up to 20               |

MRI, magnetic resonance imaging.
than other methods. This method includes fractures, ligament injury, meniscal injury, fractures with deformity. In fracture category, malunion, nonunion, angulation and malrotation are estimated. Joint instability due to ligament injury in the joint is evaluated by stress radiography (8).

**Table 18. Impairment estimate for the hip and knee joint replacement**

| Joint replacement | Lower extremity impairment (%) |
|-------------------|-------------------------------|
| Good results, 85-100 points | 35 |
| Fair results, 50-84 points | 50 |
| Poor results, less than 50 points | 75 |

**Table 19. Rating hip replacement results**

| Score | Score |
|-------|-------|
| a. Pain |  |
| None | 44 |
| Slight | 40 |
| Moderate, occasional | 30 |
| Moderate | 20 |
| Marked | 10 |
| b. Function | Fixed adduction |
| Limp | <10° |
| None | 11 |
| Slight | 8 |
| Moderate | 5 |
| Severe | 0 |
| Supportive device |  |
| None | 11 |
| Cane for long walks | 7 |
| Cane | 5 |
| One crutch | 3 |
| Two cane | 2 |
| Two crutch | 0 |
| Distance walked |  |
| Unlimited | 11 |
| 200 m | 8 |
| 100 m | 5 |
| Indoor | 2 |
| In bed or chair | 0 |
| c. Activities |  |
| Stairs climbing |  |
| Normal | 4 |
| Using railing | 2 |
| Cannot climb readily | 1 |
| Unable to climb | 0 |
| Putting on shoes and socks |  |
| With ease | 4 |
| With difficulty | 2 |
| Unable to sit comfortably | 0 |
| Sitting |  |
| Any chair, 1 hr | 4 |
| *Add the points from categories a, b, c, d, and e to determine the total scores which represent the result of replacement. Modified from Gross AE, Lavoie MV, McDermott P, Marks P. The use of allograft bone in revision of total hip arthroplasty. Clin Orthop Relat Res 1985; 115-22.*

**Table 20. Rating knee replacement results**

| Score | Score |
|-------|-------|
| a. Pain |  |
| None | 50 |
| Mild or occasional | 45 |
| Stairs only | 40 |
| Walking and stairs |  |
| Moderate | 30 |
| Occasional | 20 |
| Continual | 10 |
| Severe | 0 |
| b. Range of motion | Add 1 point per 5° |
| Range of motion |  |
| Flexion contracture |  |
| Add | 1 point per 5° |
| c. Stability |  |
| Anteriorposterior |  |
| Mediolateral |  |
| >5 mm | 10 |
| 5-9 mm | 5 |
| >9 mm | 0 |
| >15° | 0 |
| Deduction (minus) d, e, f |  |
| d. Flexion contracture |  |
| Flexion |  |
| >90° | 1 |
| >15° | 1 |
| >10° | 1 |
| 10-15° | 0 |
| >15° | 0 |
| e. Extension lag |  |
| >10° | 5 |
| >20° | 10 |
| >20° | 15 |
| f. Alignment |  |
| >0° | 0 |
| >5-10° | 3 points per degree |
| >11-15° | 3 points per degree |
| >15° | 20 |
| Deduction subtotal | - |

*The point total for estimating knee replacement results is the sum of the points in categories a, b, and c minus the sum of the points in categories d, e, and f. Modified from Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the Knee Society clinical rating system. Clin Orthop Relat Res 1989; 13-4.*
Joint replacement

The evaluation of joint replacement is based on the functional score in the hip (9) and knee joint (10) and the range of motion in the ankle joint (Table 18).

Hip joint replacement

Pain, function, activities, deformity, range of motion are evaluated. Each category has points and add the points to determine the total scores. Rating hip replacement results are presented in Table 19.

Knee joint replacement

Pain, range of motion, stability, flexion contracture, extension lag, and alignment are evaluated. Rating knee replacement results are presented in Table 20.

Ankle joint replacement

Only range of motion is evaluated. The impairment rate due to ankle joint replacement is presented in Table 21.

Peripheral vascular disease

Impairment due to peripheral vascular disease is based on clinical symptoms. Table 22 shows the lower extremity impairment rate due to peripheral vascular disease. This table provide impairment due to arterial disease, vascular disease, and lymphedema of lower extremity. These diseases should be confirmed by radiologic study, sonography or lymphoscintigraphy.

Table 21. Impairment estimate for ankle joint replacement

| Range of motion (°) | Lower extremity (foot) impairment (%) |
|---------------------|--------------------------------------|
| ≥20                 | 20 (28)                              |
| <20                 | 25 (35)                              |

Table 22. Lower extremity impairment due to peripheral vascular disease

| Class 1 (5%) impairment | Class 2 (15%) impairment | Class 3 (30%) impairment | Class 4 (60%) impairment | Class 5 (90%) impairment |
|-------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| No claudication         | Intermittent claudication on walking <100 m, at an average pace or | Intermittent claudication on walking 25-100 m, at an average pace or | Intermittent claudication on walking <25 m, at an average pace or | Severe and constant pain at rest or |
| No pain at rest and     | Persistent edema of a moderate degree, incompletely controlled by elastic supports or | Marked edema that is partially controlled by elastic supports or | Marked edema that can not be controlled by elastic supports or | Vascular damage as evidenced by such sign as amputations at or above the ankles of two extremities, or |
| Transient edema         | Vascular damage as evidenced by a sign such as a healed, painless stump of an amputated digit | Vascular damage as evidenced by a sign such as healed amputation of two or more digits of one extremity | Vascular damage as evidenced by sign such as an amputation of two or more digits of two extremities |
| In physical examination |------------------------------------------|--------------------------|--------------------------|--------------------------|
| – loss of pulses        |                                           |                           |                           | |
| – minimal loss of       |                                           |                           |                           | |
| subcutaneous tissue     |                                           |                           |                           | |
| – calcification of arteries (by radiography) |                                           |                           |                           | |
| – asymptomatic dilation of arteries or vein |                                           |                           |                           | |

In the lymphedema patient, lymphatic flow decrease is detected by lymphoscintigraphy. For stage II lymphedema and more than 3 cm circumference difference which needs elastic support is class 2. For stage III lymphedema and more than 5 cm circumference difference which needs elastic support is class 3.

Skin loss

Full-thickness skin loss in the weight bearing area makes a disability. Impairment due to skin loss of the foot is presented in Table 23.

DISCUSSION

Korean Guideline for Impairment Rating of lower extremities were developed mainly based on the criteria in the 5th edition of AMA Guides. It is different from AMA Guides in that Korean Guideline omits some classification which is not realistic in Korea. In the muscle weakness category, if muscle power is less than Grade III it would be evaluated in the peripheral nervous system. It may reduce inaccuracy. In this guideline, the method which can be modified by examinee such as gait derangement is excluded. Through this process we can make it simpler and more objective guideline than AMA Guides. When we use this new guideline for the evaluation of disability, the examiner should know about comprehensive medical history and review the all records. After understanding the patient’s symptoms and signs, evaluator
should do physical examination thoroughly. The physician should record lower extremity-related physical findings, such as range of motion, limb length discrepancy, deformity, reflexes, muscle strength, muscle atrophy, ligament laxity, motor and sensory deficits, and specific diagnoses such as fractures.

In summary, a stepwise approach of evaluating a lower extremity impairment is as follows;

1) Establish the diagnosis.
2) Determine whether maximal medical improvement has been reached.
3) Identify each lower extremity anatomic region with abnormalities that are related to injury in question.
4) Calculate impairment according to the text and tables for each applicable method.
5) Identify and calculate injury which is related to peripheral nervous system impairment.
6) Identify and calculate all injuries which is related to the peripheral vascular system.
7) The lower extremity impairment rating for each limb is then converted to whole person impairment.

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