견관와-상완 관절의 생역학: 견관절 치환술에 대한 영향

Biomechanics of the Glenohumeral Joint: Influence on Shoulder Arthroplasty.

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〔정상 Glenohumeral Joint Biomechanics에서 꼭 되새겨야 할 사항들〕

1. Static vs Dynamic Restraint
   Static: functioning at end range of motion.
   Dynamic: function during all the range of motion.

2. Force Couple: 서로 다른 기능을 하는 근육이 서로 다른 방향으로 일을 하는데 결과적으로는 같은 방향으로 작용을 하는 현상.

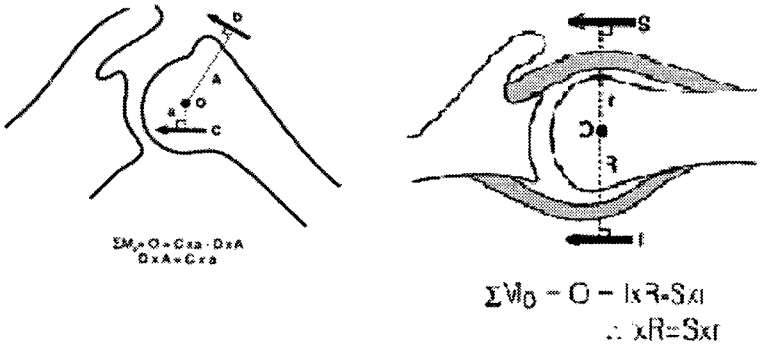

Fig. 1. (**A**) coronal force couple (**B**) Transverse force couple

3. Obligate Translation: capsule tightness에 의해 end range of motion에서 HH의 center가 이동되어 있는 현상. Tight한 capsule의 반대 방향으로 HH가 움직인다.
   : Active ROM시 전후, 상하로 2 mm 정도.
   Passive ROM시에는 전후 방향으로 8 mm, 상하 방향은 4 mm.

: TUBS-decreased posterior obligate translation in-internal impingement.
Over tightened antero-inferior capsule-increased oblig. Translation-
-관절 연골 손상 가능성이 커짐.

: Shoulder Replacement Arthroplasty에서 soft tissue balance가 중요하다.

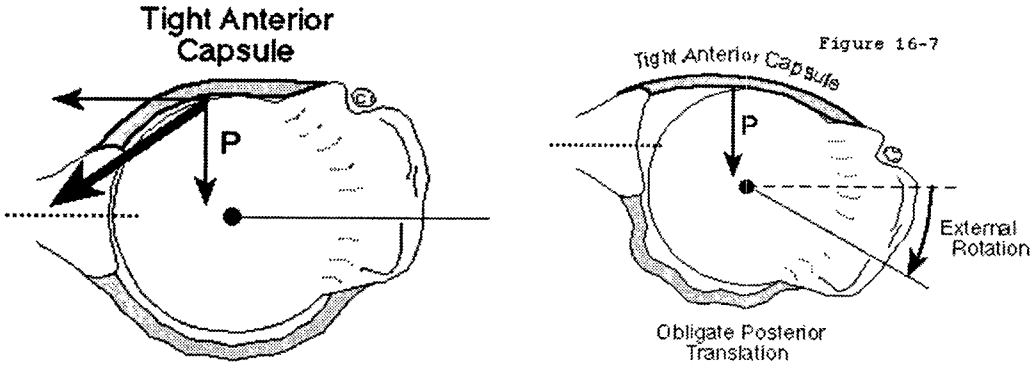

Fig. 2.

[INTRODUCTION]

* The goal of prosthetic reconstruction of the glenohumeral joint: relieve pain+improve shoulder function.

Anatomic and Biomechanical factors effect on prosthetic design.

1) Anatomic factors
   - humeral head size, shape, offset and humeral neck-shaft angle.
   - glenoid size, shape, offset and lateral glenohumeral offset.
2) Biomechanical factors
   - glenohumeral articular conformity and constraint.
   - periarticular muscular force.
   - ligamentous restraint.
   - normal glenohumeral kinematics.
   - prosthetic kinematics.

1. Anatomic Factors

1) Humeral head size:
   * Mean humeral head radius=24 mm (19±28).
   * Mean humeral head thickness=19 mm (15±24).
   * The ratio of humeral head thickness (BC) to humeral head radius of curvature(AC)는 0.7~0.9로 키와 상완골 간부 길이에 상관없이 항상 일정하다.
   * Head to greater tuberosity height (DE) is approximately 8 mm.

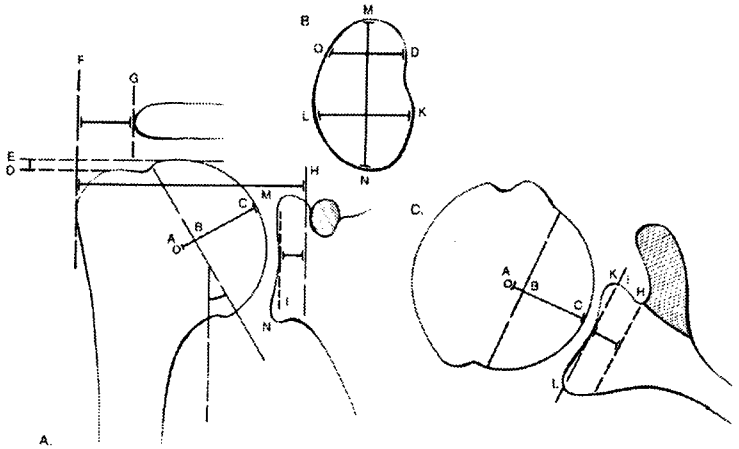

FIG. 1. Normal glenohumeral relations depicted in **(A)** the coronal plane include *(A)* humeral head center, *(AC)* humeral head radius of curvature, *(BC)* humeral head thickness or neck length, α humeral neck-shaft angle, *(HF)* lateral glenohumeral offset, *(FG)* greater tuberosity to acromion distance, *(DE)* greater tuberosity to humeral head distance. *(MN)* superoinferior glenoid dimension, and *(HI)* glenoid offset. **(B)** The glenoid dimensions measured in the sagittal plane include *(MN)* the superoinferior dimension, *(OP)* the anteroposterior dimension of the upper half, *(KL)* and the anteroposterior dimension of the lower half. **(C)** The glenohumeral relations in the axial plane include *(A)* the humeral head center, *(AC)* the humeral head radius of curvature, *(BC)* the humeral head thickness or neck length, *(KL)* the anteroposterior dimension of the glenoid, and *(HI)* the glenoid offset. (From ref. 17, with permission.)

2) Humeral head shape
   * central 80%=spherical,
   * peripheral 20%=elliptical
   The ratio of the axial plane radius to the coronal plane=0.92

3) Humeral head offset: distance between center of the humeral head (CH) and the central axis of the intramedullary canal (OA).
   In coronal plane; 7~9 mm medial to the central axis of the intramedullary canal.
   In axial plane; 2~4 mm posterior to the central axis of the intramedullary canal.

!! Humeral head offset is correlated with humeral head radius and thickness.
   Head to greater tuberosity height is approximately 8 mm.

4) Humeral neck-shaft angle: average 40~45 degrees (30~55).
   : Larger humeral heads=larger neck-shaft angles.

5) Glenoid size and shape
   Mean superoinferior dimension=39 mm (30~48).
   Mean anteroposterior superior half=23 mm (18~30).

Inferior half=29 mm (21~35). "pear-shaped"
Glenoid radius of curvature > humeral head: 2~3 mm. (Dr. Iannotti)
Less than 2 mm 80%, less than 3 mm in all specimens (Soslowsky)

6) Glenoid offset (HI)
: Perpendicular distance between the base of the coracoid process and the deepest portion of the glenoid articular surface.
: Average 2 mm (-0.5 to 5).
: Because the glenoid offset is less than 5 mm in all normal shoulders, it has little effect on lateral glenohumeral offset.

7) Lateral glenohumeral offset (HF)
: perpendicular distance between the base of the coracoid process and the mpst lateral extent of the greater tuberosity.
: The distance from the most lateral extent of the greater tuberosity to the lateral edge of the acromion process correlates with the lateral glenohumeral offset and is easily measured intraoperatevely.
: Lateral glenohumeral offset is important because it determines
- capsular tension
- resting length of the rotator cuff muscles
- moment arm for the deltoid muscle.
: Average 54~57 mm (43~68).
: Average distance from from lateral extent of the greater tuberosity to the lateral edge of the acromion process is 17 mm (15~21).

2. Biomechanical Factors

1) Glenohumeral articular conformity: conformity vs constraint
Conformity=difference btw. the radii of curvature of the HH and Glenoid.
; Congruent=confirming articulation of GH joint: equal radii.
Incongruent = nonconfirming: not equal radii.
; In normal—HH radius < glenoid radius (2~3 mm).

2) Glenohumeral articular constraint
Constraint=ability of the articular surfaces to resist translational motion of the humerus on glenoid.
Articular constraint is correlated with glenoid wall height (socket depth) and is independent of articular conformity.

3) Periarticular muscular forces
Deltoid: power movement
Rotator cuff: steering and stabilizing function (compress the HH on GL).

4) Ligamentous restraints
Ligaments act as checkrein to excessive rotation or translation if the HH at the extreme of GH motion.
Tension in any of the GH ligaments will cause obligate translation in opposite direction.

5) Normal Kinematics
Obligate translation in active motion is about 2 mm in any direction.
Obligate translation in passive motion:
Anteroposterior 8 mm (4배), superoinferior 4 mm (2배).

6) Prosthetic Kinematics
Normal radius mismatch=2~3 mm GL > HH
Ideal mismatch of prosthesis=4 mm GL > Humeral side.

[IMPLICATION FOR PROSTHETIC DESIGN]

1. Anatomic Factors

Humeral Prosthesis: modular system-advantages and disadvantages.
Glenoid component: sizes, shape.
Non-anatomic prosthesis: component impingement.

2. Biomechanical Factors

Confirmity: Too perfect conformity = rim loading.
Too much nonconformity=instability.
Constraint: protect the prosthesis dislocation.

[SUMMARY]

만약 Glenoid side를 해부학적으로 정확하게 치환하고, 상완골측의 prosthesis를 삽입할 때 실제 골두의 크기와 같은 prosthetic head를 쓰고, humeral stem의 위치 및 높이를 정확하게 맞추어 삽입하여, humeral head component의 center와 glenoid component의 center가 일치되고 lateral glenohumeral offset이 정상에 가깝게 수술을 시행하면 인공 치환물로 대치된 glenohumeral joint가 정상에 가장 가까운 kinematics를 가질 수 있다 (당연한 얘기

지만 이렇게 수술하려면 많은 경험이 필요).

따라서 Glenohumeral joint의 인공 관절 치환술은 항상 technique-dependant한 수술이며, 아무리 좋은 치환물도 훌륭한 수술 기법보다 더 중요할 수는 없다.

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