Dome osteotomy of the pelvis using a modified trochanteric osteotomy for acetabular dysplasia

Qin Sheng Hu · Rehan Ul-Haq · Kyung Soon Park ·
Taek Rim Yoon · Keun Bae Lee

Received: 19 January 2011 / Accepted: 14 March 2011 / Published online: 2 May 2011
© Springer-Verlag 2011

Abstract

Purpose Kawamura described his dome osteotomy of the pelvis using a standard trochanteric osteotomy. Here we present results of our modification of Kawamura's dome osteotomy using a modified trochanteric osteotomy.

Methods We retrospectively analysed 34 out of 36 patients operated upon between 1993 and 2008. We reviewed the mid-term functional and radiological results with a mean follow-up of 67 months. There were 23 females and 11 males with a mean age of 30 years.

Results The mean Harris hip score improved from 60 to 85 ($p < 0.05$) at the final follow-up. The functional results were excellent in 12, good in 14, fair in five and poor in three patients. Pain relief was a constant feature in all patients. Seventeen patients reported improvement in their ability to squat and sit cross-legged, 14 patients reported no change while three reported a worsening. Preoperatively 28 patients had an antalgic gait which improved in 14 patients following the surgery. Centre edge angle, acetabular angle, acetabular head index and weight bearing joint space improved significantly. This improved joint space was

maintained at the last follow-up. Three cases had converted to total hip arthroplasty at the last follow-up.

Conclusion The mid-term functional and radiological results of the dome osteotomy using modified trochanteric osteotomy were found to be satisfactory. We conclude that it is a reasonable treatment option for young patients with symptomatic acetabular dysplasia.

Introduction

For several decades, Chiari medial displacement osteotomy of the pelvis has been widely used for adult osteoarthritis secondary to hip dysplasia [1]. However, with the introduction of Salter's [2] and Pemberton's [3] osteotomies for childhood disorders and various periacetabular osteotomies [4, 5] that preserve the original articular cartilage for adult disorders, the indications for Chiari osteotomy have decreased significantly [6]. Nevertheless, in incongruent hips with disproportion between the femoral head and the acetabulum, Chiari pelvic osteotomy is still an important operative technique [7]. It may delay the need for total hip arthroplasty (THA) in younger patients, and the acetabulum created by Chiari procedure could facilitate later THA [8]. However, it is a technically difficult surgery especially through the anterior approach as originally proposed by Chiari.

The Kawamura [9] dome osteotomy is a modification of the original Chiari procedure done through a lateral trans-trochanteric approach [10]. It provides a dome rather than a flat shaped bone shelf to support the femoral head [11]. In the original Kawamura's technique, a standard trochanteric osteotomy is done, and greater trochanter reflected superiorly with the gluteus medius muscle [10] to visualise the outer table of the ilium.

Q. S. Hu · K. S. Park · T. R. Yoon (✉)
Center for Joint Disease,
Chonnam National University Hwasun Hospital,
Hwasun-Gun, Jeonnam, Korea
e-mail: tryoon@chonnam.ac.kr

R. Ul-Haq
Reader Orthopaedics,
University College of Medical Sciences & GTB Hospital,
New Delhi, India

K. B. Lee
Department of Orthopaedics,
Chonnam National University Medical School & Hospital,
Gwangju, Korea

We describe our modification of the Kawamura's technique. We asked the following questions: (1) What are the mid-term functional results of this procedure especially with reference to pain relief, range of motion (ROM), and gait pattern? (2) How do the radiological parameters for assessment of hip dysplasia improve following this procedure?

Material and methods

Between May 1993 and June 2008 dome osteotomy of the pelvis using a modified trochanteric osteotomy was done in 36 patients. We retrospectively reviewed 34 (35 hips) of these 36 patients with a mean follow-up of 67 months and a minimum follow-up of two years (range 24–213 months). Two patients were lost to follow-up and were excluded from the study. The indication for surgery was progressive hip pain or instability secondary to hip dysplasia not adequately controlled by conservative treatment. There were 23 females and 11 males of mean age 30 years (range 15–54 years). One patient had bilateral osteotomy. Developmental dysplasia of hip (DDH) and Perthes disease were the most frequent primary cause of acetabular dysplasia. One patient with DDH had been treated by open reduction and Salter's osteotomy in the past, while another patient with Perthes disease had a femoral varus osteotomy.

Operative technique

All operations were performed by the senior author (TRY). The patient was placed in the lateral position and a straight longitudinal skin incision of 12–15 cm was made. The incision was centred over the greater trochanter and extended from 4 cm below the vastus lateralis ridge to 5–7 cm proximal to the greater trochanter. The greater trochanter was osteotomised in a superomedial direction, retaining the attachment of the abductors and the vastus lateralis, using an oscillating saw. With the limb abducted to relieve tension on this musculo-osseous sleeve composed of the gluteus medius, greater trochanter and vastus lateralis, it was reflected anteriorly (Fig. 1a). This provided good exposure of the outer table of the ilium, for a precise dome osteotomy of the acetabulum. A Steinmann pin of diameter of 3.5 mm was then driven into the pelvis from the upper border of the capsule superomedially at an angle of approximately 15° from the horizontal (Fig. 1b). After confirming the height and angle of the Steinman pin by fluoroscopy, a dome-shaped osteotomy line was marked with a thin osteotome along the acetabular rim. The osteotomy was done along this line using an oscillating saw (Fig. 2a). The osteotomy was completed to the inner

table parallel to the Steinman pin. After the osteotomy was completed, with the leg already in abduction, the distal pelvic fragment was displaced medially. Medialisation was sufficient to achieve more than 80% of femoral head coverage. Internal fixation for the acetabular osteotomy was achieved using a single Steinman pin of diameter 2.4 mm. The greater trochanter was reattached using two cancellous screws (Fig. 2b) or stainless steel wire. The greater trochanter was advanced to increase the length of the abductor lever arm in 20 patients (21 hips) and it was fixed in its original place in 14 patients. Femoral varus osteotomy was done in two patients (Fig. 3) where preoperative anteroposterior radiographs of the pelvis showed improved congruency of the hip in abduction. The osteotomy was combined with excision of the torn acetabular labrum in one patient.

Postoperatively an abduction brace was used and ROM exercises recommended. The patients were allowed non weight bearing crutch walking within one week, depending on the general condition and level of comfort of the patient. The non weight bearing crutch walking was usually continued for three to four months until the radiological bone union was confirmed. The Steinman pin used for fixation of the osteotomy was removed at six to 12 weeks.

All patients were examined personally by one of the authors preoperatively and at one month, three months, six months, one year, and then every year postoperatively. Complete physical examination with particular attention to assessment of the gait pattern, range of movements and ability to squat and sit cross-legged was done. Depending upon its severity, pain was graded. Functional assessment was carried out using the Harris hip score (HHS) [12]. The functional results of the two patients with neuromuscular dysplasia (one with cerebral palsy and the other with poliomyelitis) were not considered during statistical analysis.

Good quality digital, standard anteroposterior radiographs of the pelvis with both hips, centred over the pelvis were taken preoperatively, immediately postoperatively and then at each follow-up. The centre edge angle of Wiberg [13], the acetabular angle of Sharp [14] and acetabular head index [15] were assessed on all radiographs. The joint space was measured in millimetres at two locations as described by McCarthy et al. [16]. The first measurement, the weight-bearing joint space, was performed at the superior aspect of the dome of the acetabulum, as determined by a vertical line through the centre of the femoral head, or at the lateral most margin of the acetabular dome if the centre edge angle was negative. The second measurement, the minimum joint space, was performed at the point of the greatest narrowing of the joint space perpendicular to the articular surface. The angle of osteotomy, height of osteotomy and percentage displacement at the site of osteotomy were assessed on the

Fig. 1 Different steps of the osteotomy procedure are represented by the photograph and simple sketch. **a** Intraoperative photograph showing the gluteus medius, greater trochanter and vastus lateralis lifted as a single musculo-osseous unit. **b** A Steinmann pin was used to determine the osteotomy angle

immediate postoperative radiograph. The software (Marosis PACS; Marotech Inc., Seoul, South Korea) allowed measurements of angles and distances to two decimal points after compensating for magnification, which was then rounded off.

Data were analysed for statistical significance using the Mann Whitney U test. A p value of less than 0.05 was considered significant. SPSS for Windows version 18.0 software (SPSS Inc, Chicago, IL) was used for the statistical analysis.

Results

The mean HHS improved significantly ($p < 0.05$) from 60 (range, 21–89) preoperatively to 85 (range 64–100) at the last follow-up. The functional results were excellent in 12, good in 14, fair in five and poor in three patients (Table 1).

Pain relief was a constant feature in all patients. Before surgery six patients had mild pain, 18 patients had moderate pain, while ten had severe pain. At the last follow-up 22

patients had no pain, eight had mild pain and four had moderate pain.

At the final follow-up, the ROM had no statistical significance, 17 patients reported improvement in their ability to squat and sit cross-legged, 14 patients reported no change while three reported a worsening.

The effect on the gait pattern was more variable. Preoperatively, 28 patients had an antalgic gait, which improved in 14 patients following the surgery. However, two patients developed a Trendelenburg gait. The number of patients who required use of a walking aid decreased from eight to three. No complication occurred related to dome or greater trochanter osteotomies in our series during the follow-up.

The mean centre edge angle of Wiberg, mean acetabular angle of Sharp, mean acetabular head index, and mean weight bearing joint space improved significantly following the surgery (Table 2). The minimum joint space also improved by a mean value of 1 mm but this was not statistically significant. At the last follow-up the centre edge angle of Wiberg had significantly improved further. The

Fig. 2 Different steps of the osteotomy procedure are represented by simple sketches. **a** A dome-shaped osteotomy line was marked and osteotomy was completed in accordance with it at the position of the affected limb abducted. **b** Internal fixation for the acetabular and greater trochanter osteotomies

Fig. 3 Serial radiographs of a 43-year-old female patient. **a** Anteroposterior radiograph of the pelvis shows left-sided acetabular dysplasia and coxa valga secondary to DDH. **b** Combined Chiari osteotomy with femoral varus osteotomy. **c** Radiograph at 23 months after surgery shows good remodelling and head cover. **d** Radiograph at 68 months after surgery shows that joint space is well maintained

weight bearing joint space and the minimum joint space did not decrease significantly during this time period.

The mean level of the osteotomy was 9 mm (3–16 mm). No patient had an osteotomy placed too close or distal to the joint. There were no penetrations of the osteotomy into the joint. The mean angle of osteotomy was 12° (range 4° – 21°) and the mean displacement of the head was 37% (range 23–55%).

In the follow-up radiographs, no sign of greater trochanter nonunion or avascular necrosis was observed in our series (Fig. 4). Three cases finally converted to total hip arthroplasty (THA) due to pain at the last follow-up (Table 3).

Discussion

In Chiari's original procedure, remodelling ultimately produces a dome shape [10], which is why some surgeons [7, 17] preferred to fashion an arched rather than a flat acetabular roof. The dome osteotomy shortens the remodelling time, reducing the chances of postoperative degenerative changes [10]. The osteotomy is more stable and other procedures like femoral osteotomy and trochanteric advancement can be done at the same time [11]. Ito et al. [18] reported that the outcome in patients where a transtrochan-

teric approach was used was superior, the osteotomy level was more appropriate and a Trendelenburg gait less common. Anwar et al. [11] reported their results of this procedure at a mean follow-up of 8.3 years. They advocated this procedure for patients aged 15–40 years with early osteoarthritis. Nakata et al. [19] published their results at a mean follow-up of 13 years. They concluded that dome osteotomy is an excellent procedure for pain relief and functional maintenance of the hip. But the standard trochanteric osteotomy used in the Kawamura's technique has the potential disadvantage of increased rate of avascular necrosis, nonunion and proximal migration of

Table 1 Preoperative and postoperative functional status as assessed by the Harris hip score (HHS). Two patients with neuromuscular dysplasia were not considered

HHS	Preoperative	Postoperative
<50	6	
50–59	10	
60–69 (poor)	13	3
70–79 (fair)	4	5
80–89 (good)	1	14
90–100 (excellent)		12

Statistically significant difference set at $p < 0.05$

Table 2 The preoperative, immediate postoperative and final follow-up radiographic parameters for assessment of hip dysplasia are compared

Radiographic parameters	Preoperative	Immediate	Final follow-up	P value	
				Pre-post op	Post op–last FU
Centre edge angle of Wiberg	17° (range −3 to 38°)	39° (range 14–58°)	41° (range 14–63°)	0.00	0.57
Acetabular angle of Sharp	45° (range 39–57°)	36° (range 25–48°)	35° (range 22–45°)	0.002	0.67
Acetabular head index	60% (range 48–82%)	81% (range 58–100%)	85% (range 62–100%)	0.00	0.419
Weight bearing joint space	5 mm (range 3–6 mm)	7 mm (range 5–11 mm)	6 mm (range 3–11 mm)	0.00	0.269
Minimum joint space	3 mm (range 1–6 mm)	4 mm (range 2–10 mm)	4 mm (range 2–6 mm)	0.077	0.521

Pre-post op preoperative and immediately postoperative, *Post op–last FU* immediately postoperative and last follow-up

the fragment [20]. Our modification of using a sliding trochanteric osteotomy can potentially decrease the chances of these complications. This osteotomy is widely used for THA. It was first described by English [21] in 1975 and later modified by Glassman et al. [22].

Excellent or good clinical results were observed in 76.5% of patients in our group. Relief from pain was observed in all patients. Rapid and continued pain relief has been reported as the most consistent effect following this operation [6]. Hogg et al. [23] reported pain relief in 80% of the patients in the short term and the therapeutic effect of the osteotomy was evident in 50% of patients even after 18 years. Anwar et al. [11] believed that the improvement of hip score after dome osteotomy is mainly due to pain relief and improved walking ability. Therefore there is sufficient evidence to show that early clinical results of dome osteotomy are maintained over a long period of time.

Squatting and sitting cross-legged are an integral part of Asian life style. Seventeen patients reported an improvement in their ability to perform these activities. Moreover the mean range of movements did not decrease in any directions following the surgery. Our results agree with other reports [23] which concluded that the range of movement at the hip had not been impaired by the Chiari procedure, although progressive osteoarthritis did eventually reduce this range. However, some authors [24] have reported significant loss of internal rotation after Chiari osteotomy. Because of these variable reports we believe that dome osteotomy should be done only if there is sufficient ROM. Based on our experience, we will perform dome osteotomy for patients with hip flexion over 100°, abduction over 30° and internal rotation over 10°.

The effect of the osteotomy on the gait pattern is more controversial. Hogg et al. [23] reported that gait is

Fig. 4 Serial radiographs of a 48-year-old female patient with modified Chiari osteotomy are shown. **a** Anteroposterior radiograph of the pelvis shows left acetabular dysplasia secondary to developmental dysplasia of hip (DDH). **b** Immediate postoperative radiograph after modified Chiari osteotomy shows good head coverage. The osteotomy has been fixed with a single Steinmann pin and greater

trochanter advanced and fixed with two screws. **c** Radiograph before the Steinmann pin removal shows good bone healing of the osteotomy site at three months after surgery. **d** Radiograph shows good remodelling at eight months after surgery. **e** Final radiograph at 36 months after the first surgery shows good remodelling, coverage of the head and maintenance of the joint space

Table 3 Demographics and functional status of the three patients converted to total hip arthroplasty

Patient	Before dome osteotomy				Duration (months)	Before THA				After THA	
	Age (years)	Gender	HHS	Diagnosis		Pain	HHS	Antalgic gait	Squat/cross-legged	Pain	HHS
1	19	M	64	LCPD	9	Severe	73	Yes	Ok	No	88
2	25	M	56	DDH	16	Severe	60	Yes	Ok	Mild	79
3	42	F	65	LCPD	132	Severe	63	Yes	Limited	No	81

M male, *F* female, *DDH* developmental dysplasia of hip, *LCPD* Legg-Calve-Perthes Disease, *HHS* Harris hip score, *THA* total hip arthroplasty

frequently improved after a Chiari osteotomy, and the risk that limp may be made worse seems to have been exaggerated. The Trendelenburg test indicates that abductor power has improved [7], although this is not a universal finding [25]. In our series 14 patients were relieved of the preoperative antalgic gait, but two patients developed a Trendelenburg gait. One of these patients had bilateral surgery which could explain the appearance of the gait; for the other patient, no surgical factor could be elucidated. Anwar et al. [11] reported 39% incidence of limping and 30% incidence of Trendelenburg gait after the dome osteotomy. They reported that the patients where the trochanter was moved distally less than 10 mm had a reduced chance of a successful result, a greater chance of postoperative limping and a positive Trendelenburg sign. Therefore, we now practice and recommend routine distal transfer of the greater trochanter.

The degree of preoperative dysplasia and stage of osteoarthritis have been reported as factors which affect the final results. The degree of preoperative dysplasia is worse in patients who have poor clinical results than those who have fair or good results [26]. There are increased chances of radiographic failure if the preoperative centre edge angle is less than 0°, or the acetabular head index is less than 50% [19]. However, others [11] did not find any correlation between preoperative degree of dysplasia and radiographic failure. Advance stage of osteoarthritis has also been identified as a cause of poor final clinical result [27]. In our series the eight patients who had fair or poor clinical results had significantly lower preoperative HHS as compared to the patients who had good or excellent results. Therefore, for patients who are younger than 50 years old, where relatively good hip ROM is maintained, and who do not have end stage osteoarthritis, our modified technique should be considered. Patients with advanced osteoarthritis should be managed by other methods. In our institution, we prefer to choose THA.

Placement of the osteotomy cut is critical. An osteotomy that is too inferior may lead to increased stress at the site of the new roof, and poor results can be expected. Likewise, a cut placed too high or too horizontal may lead to poor

results, but this can be corrected with bone grafting of the large gaps created when it occurs [5]. Matsuno et al. [26] showed that the optimum level of the osteotomy line is in zone I (according to the classification of Azuma et al. [28]) and that the clinical result is worse when the osteotomy level is too proximal (zone III) or too distal (zone 0). In our series, the angle of osteotomy was within normal range in all patients. This we believe was possible due to the good exposure provided by the transtrochanteric approach, which allowed complete visualisation of the outer table of the acetabulum and hence little chance of error. We also believe that intraoperative use of fluoroscopy helps to execute the osteotomy properly. Thus it is reasonable to conclude that the modified transtrochanteric approach allows the surgeon to achieve an accurate osteotomy which is important for a good final outcome.

Injuries to the sciatic nerve and intrapelvic arterial damage have been reported as complications of this procedure [10, 23]. There were no intraoperative complications in our series. Careful operative technique and wide field of vision provided by the lateral transtrochanteric approach helps to avoid them.

In our series, three patients finally converted to THA. Two patients underwent THA within two years after the osteotomy due to severe pain and limited ROM. No operative technical faults were found relating to the failures, nor were there any suggestive preoperative indexes such as OA grade, ROM, or radiographic parameters, etc. One patient progressed into secondary osteoarthritis of the hip 11 years after the modified dome osteotomy and underwent THA to relieve the pain.

The limitations of our study are that it is a retrospective study of a relatively small group of patients with a mean follow-up of 67 months. A longer follow-up is desirable in this cohort of patients to know the long-term survivability of this procedure. The study lacks a control group as the patients were not randomised to any other treatment group.

In summary, this study demonstrates that dome osteotomy appears to be a reasonable treatment option for young patients with symptomatic acetabular dysplasia in the mid-term. The sliding trochanteric osteotomy used by us

provides good exposure for exact execution of the osteotomy. It has potential advantages over the conventional trochanteric osteotomy like avoidance of nonunion, proximal migration and avascular necrosis of the fragment.

Conflict of interest No support in form of grants, equipment or other items has occurred for this project. The authors have received nothing of value. The authors declared that they have no conflict of interest.

References

- Chiari K (1974) Medial displacement osteotomy of the pelvis. *Clin Orthop Relat Res* 98:55–71
- Salter RB (1961) Innominate osteotomy in the treatment of congenital dislocation and subluxation of the hip. *J Bone Joint Surg Br* 43:518–539
- Pemberton PA (1965) Pericapsular osteotomy of the ilium for treatment of congenital subluxation and dislocation of the hip. *J Bone Joint Surg Am* 47:65–86
- Ganz R, Klaue K, Vinh TS, Mast JW (1988) A new periacetabular osteotomy for the treatment of hip dysplasias. Technique and preliminary results. *Clin Orthop Relat Res* 232:26–36
- Sutherland DH, Greenfield R (1977) Double innominate osteotomy. *J Bone Joint Surg Am* 59:1082–1091
- Sugano N, Nishii T, Takao M (2007) The Asian hip. In: Callaghan JJ, Rosenberg AG, Rubash HE (eds) *The adult hip*, 2nd edn. Lippincott Williams & Wilkins, Philadelphia, pp 1060–1077
- Reynolds DA (1986) Chiari innominate osteotomy in adults: technique, indications and contra-indications. *J Bone Joint Surg Br* 68:45–54
- Vukasinovic Z, Spasovski D, Slavkovic N, Bascarevic Z, Zivkovic Z, Starcevic B (2010) Chiari pelvic osteotomy in the treatment of adolescent hip disorders: possibilities, limitations and complications. *Int Orthop*. doi:10.1007/s00264-010-1126-1
- Kawamura B (1959) The transverse pelvic osteotomy. *J Jpn Orthop Assoc* 32:1181–1188
- Kawamura B, Hosono S, Yokogushi K (1982) Dome osteotomy of the pelvis. In: Tachdjian MO (ed) *Congenital dislocation of the hip*. Churchill Livingstone, New York, pp 609–623
- Anwar MM, Sugano N, Matsui M, Takaoka K, Ono K (1993) Dome osteotomy of the pelvis for osteoarthritis secondary to hip dysplasia. *J Bone Joint Surg Br* 75:222–227
- Harris WH (1969) Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end-result study using a new method of result evaluation. *J Bone Joint Surg Am* 51:737–755
- Wiberg G (1939) Studies on dysplastic acetabula and congenital subluxation of the hip joint: With special reference to the complication of osteoarthritis. *Acta Chir Scand* 83:29–37
- Sharp IK (1961) Acetabular dysplasia: the acetabular angle. *J Bone Joint Surg Br* 43:268–272
- Heyman CH, Herndon CH (1950) Legg-Perthes disease. *J Bone Joint Surg Am* 32:767–778
- McCarthy JJ, Fox JS, Gurd AR (1996) Innominate osteotomy in adolescents and adults who have acetabular dysplasia. *J Bone Joint Surg Am* 78:1455–1461
- Colton CL (1972) Chiari osteotomy for acetabular dysplasia in young subjects. *J Bone Joint Surg Br* 54:578–589
- Ito H, Matsuno T, Minami A (2003) Comparison of the surgical approaches for a Chiari pelvic osteotomy. *J Bone Joint Surg Br* 85:204–208
- Nakata K, Masuhara K, Sugano N, Sakai T, Haraguchi K, Ohzono K (2001) Dome (modified Chiari) pelvic osteotomy: 10- to 18-year followup study. *Clin Orthop Relat Res* 389:102–112
- Ebraheim NA, Patil V, Liu J, Haman SP (2007) Sliding trochanteric osteotomy in acetabular fractures: a review of 30 cases. *Injury* 38(10):1177–1182
- English TA (1975) The trochanteric approach to the hip for prosthetic replacement. *J Bone Joint Surg Am* 57:1128–1132
- Glassman A, Engh C, Bobyn J (1987) A technique of extensile exposure for total hip arthroplasty. *J Arthroplasty* 2:11–21
- Hogh J, Macnicol ME (1987) The Chiari pelvic osteotomy. A long-term review of clinical and radiographic results. *J Bone Joint Surg Br* 69:365–373
- Betz RR, Kumar SJ, Palmer CT, MacEwen GD (1988) Chiari pelvic osteotomy in children and young adults. *J Bone Joint Surg Am* 70:182–191
- De Waal Malefijt MC, Hoogland T, Nielsen HK (1982) Chiari osteotomy in the treatment of congenital dislocation and subluxation of the hip. *J Bone Joint Surg Am* 64:996–1004
- Matsuno T, Ichioka Y, Kaneda K (1992) Modified Chiari pelvic osteotomy: A long followup study. *J Bone Joint Surg Am* 74:470–478
- Ohashi H, Hirohashi K, Yamano Y (2000) Factors influencing the outcome of Chiari pelvic osteotomy: a long-term followup. *J Bone Joint Surg Br* 82:517–525
- Azuma T, Matsuno S, Masuda T, Takahashi M, Hasegawa I, Matsuno T (1984) The results of Chiari pelvic osteotomy. In: Ryozo U, Noriya A, Yasuto I, Hiroshi T, Shinichi Y (eds) *The hip. Clinical studies and basic research*. Excerpta Medica, International Congress Series 634. Elsevier, Amsterdam, pp 95–100