Evaluation of the Anatomical Position of the Lateral Canthal Ligament: Clinical Implications and Guidelines

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Controversy exists in the literature as to the precise anatomical location of the lateral canthal ligament. The ligament is a 3 mm-wide, two-tailed band; its average length is approximately 13 mm, while the width of the rima palpebralis is about 26 mm. The authors evaluated three different groups to pinpoint the anatomical position of the ligament’s attachment to the lateral orbital wall, and to establish guidelines for placement of the ligament during surgery. In 90% of the cases, the ligament was attached to Whitnall’s tubercle, which is located approximately 4 mm posterior to the lateral orbital rim, and 17 mm above the intersection of the lateral and inferior margins; this area is 9 mm below the zygomaticofrontal suture. Based on these anatomical criteria, a standardized procedure is suggested.

Key Words: Transconjunctival incision, lateral canthotomy, craniofacial, orbital surgery, trauma, lateral canthal ligament

The transconjunctival incision with lateral canthotomy, lateral canthopexy, and lateral canthoplasty are indispensable techniques for craniofacial and oculoplastic surgeons. The transconjunctival incision with lateral canthotomy is relatively easy to perform and provides excellent exposure of the inferior, medial, and lateral orbit, including the zygomaticofrontal (ZF) suture, the body of the zygomatic bone, and the infraorbital region [1–6].

One of the advantages of the procedure is minimal postoperative scar [5, 7]. The postoperative results are generally good, and the complications are mostly due to vertical and horizontal dystopia of the lateral canthal ligament (LCL) [3]. Complications include exposure keratopathy, entropion, ephelides of the septum orbitale, scleral show, “sad face” appearance, and blunting of the lateral canthal angle [1, 7–13]. These complications frequently necessitate secondary, corrective procedures and may present with unpredictable results. Prevention of these complications is dependent on the proper reattachment of the lateral canthal complex.

Many surgical techniques describe the lateral canthotomy [1, 3, 5–8, 11, 14–20], but surprisingly few are based on sound anatomical criteria [21], and none of the studies published gives a precise description as to where to reattach the ligament and why that site was chosen [1, 2, 6, 12, 16, 18, 22]. Since the early 1900s, the anatomy of the lateral canthal region has been a rather controversial issue [21, 23]. The different opinions range from describing a true ligament that attaches the lateral corners of the tarsal plates to the lateral orbital walls to denying its existence altogether, stating there is only a tendinous attachment of the orbicularis oculi muscle to the orbital wall, or the periorbita. Wolff, in his “Anatomy of the Eye and Orbit,” questioned the existence of a tendinous attachment, calling it a “descriptive verbage” [24]. Numerous anatomical and histological studies have been undertaken since then that clearly identify and confirm the unquestionable existence of the LCL and clarify the anatomy and function of the lateral canthal complex [7, 21, 23, 25]. The LCL is a band of connective tissue that attaches medially to the lateral angles of the superior and inferior tarsi and laterally to the frontal process of the zygomatic bone on the lateral orbital wall [26]. There is a triangular- or dome-shaped bony prominence to which it attaches in 95% of the population according to Whitnall, who examined 2,000 skulls [27].

The purpose of the study was to define the osseous and soft-tissue landmarks that are least variable and best correlating, and therefore most acceptable, for orientation during orbital surgery to reattach the LCL.

Materials and Methods

Three different groups were studied: group 1, cadaver; group 2, dry skull; and group 3, patient photographs.
Fig 1 Cadaver soft-tissue landmarks with measurement parameters: height, width, RimaPalp, MedCPup, and LatCPup. (See legends to Tables 1 and 2 for abbreviations.)

Fig 2 Cadaver dissection (A), with measurement parameters: SupCrus, InfCrus, LatAng, and APLat (B). (See legends to Tables 1 and 2 for abbreviations.)

Group 1

Twenty orbits in 10 randomly selected fresh cadavers were measured for soft-tissue orbital and ocular dimensions before commencing with the dissections. Orbital height and width, rima palpebralis, and lateral and medial pupillocanthal distances were obtained (Fig 1). The measurements were taken on straight lines, and all measurements were performed with a digital caliper (Mitutoyo Digimatic CD-15D, Mitutoyo Corporation, Japan). Magnifying loupes (magnification × 2.5) were used.

By dissecting the skin, the orbicularis oculi muscle, septum orbitale, anterior limb of the LCL, fascia temporalis superficialis, and the galea aponeurotica were identified (Fig 2A). The posterior limb of the LCL was identified and carefully dissected; care was taken not to alter its anteroposterior and vertical dimensions. The length of the ligament’s superior and inferior crus and the distance from the lateral palpebral fissural corner to the place of insertion of the ligament at the frontal process of the zygomatic bone were measured (Fig 2B). The superoinferior as well as anteroposterior position of the insertion of the LCL to the lateral orbital wall (Whitnall’s tubercle, when present) was evaluated and measured. The position of the lateral horn of the levator aponeurosis, the lateral check ligament, and Lockwood’s ligament were located but not measured.

The sex of the specimens was taken into consideration (6 female and 4 male). The age distribution was unknown.

Group 2

Ten randomly selected dry skulls (20 orbits) were measured with the same digital caliper. Nine measurements were obtained (Fig 3). Orbital height and width, bizygomatic, interorbital, and intersutural distances were measured. The lateral orbital walls were examined for the
Fig 3 Dry skulls with bony orbital landmarks and measurement parameters: height, width, intercrestal, intersutural, and bizygomatic distances. (See legends to Tables 1 and 2 for abbreviations.)

Fig 4 Dry skull orbit detail of Whitnall’s tubercle (arrow) in relation to ZF, ZMax, ZS sutures, and VertCor. (See legends to Tables 1 and 2 for abbreviations.)

location of Whitnall’s tubercle, which varied in its morphology from a distinct bony prominence to a mere light reflex on the lateral orbital wall (Fig 4). The anteroposterior as well as superoinferior location of the tubercle was related to the ZF and zygomaticosphenoid (ZS) sutures. Unfortunately, age, sex, and race distributions are unknown.

Group 3
In 10 randomly selected clinical patients (20 orbits), 1 to 1 photographs were obtained during the deep phase of general anesthesia with complete muscle relaxation in supine position. The patients were operated on for different and unrelated reasons. The photographs were traced for the positions of the medial and lateral canthi and the pupillary position in relation to the bicanthal line. The medial and lateral pupillocanthal distances, the interpupillary distance, the width of the rima palpebralis, and the medial intercanthal distance were measured. The position of the lateral canthi in relation to the bicanthal line was evaluated. All measurements were performed with the caliper.

There were 6 females and 4 males (mean age, 45 years; range, 16–65 years).

RESULTS

Group 1

Measurements

Ten measurements were obtained from group 1 (Table 1 and Figs 1, 2). (Abbreviations used in text are given in legends to Tables 1 and 2.) Whitnall’s tubercle was located just behind the lateral orbital margin. In one cadaver we were unable to identify Whitnall’s tubercle bilaterally. The lateral horn of the levator aponeurosis, the lateral palpebral ligament, the lateral check ligament, and Lockwood’s ligament make up the lateral palpebral complex, and the lateral palpebral ligament is composed of two limbs, anterior and posterior, and is an integral part of the lateral palpebral complex. The anterior or superficial limb is continuous with the orbital septum medially and laterally with the superficial temporal fascia and galea aponeurotica (see Fig 2A). It is usually a thin, wide band; it did not provide significant support to the palpebral complex, and its severance did not produce pronounced lid laxity. The posterior or deep limb of the LCL attaches medially to the superior and inferior tarsi via superior and inferior cruri (see Fig 2B). Its width is approximately 3 mm.

The mean length of the superior crus anteroposteriorly from its superior tarsal insertion to the lateral orbital wall (either Whitnall’s tubercle, or lateral peri-orbita) was 13.3 mm (see Table 1). The mean length of the inferior crus from its medial attachment at the lateral edge of the lower tarsus to the lateral orbital wall was 13.3 mm. The lateral palpebral angle or fissure between the medial insertion of the superior and the inferior cruri is located anteroposteriorly from the posterior insertion of the lateral palpebral ligament at a mean distance of 13.7 mm. The superoinferior (vertical) position of the lateral canthal insertion was determined by measuring the distance to the corner formed by the intersection of the inferior and lateral orbital margins. The mean distance was 16.8 mm. The anteroposterior insertion of the LCL was located a mean distance of 4.1 mm from the lateral orbital rim. The rima palpebralis had a mean width of 26.0 mm. The mean distance between the medial canthus and the center of the pupil was 15.1 mm. The mean lateral pupillocanthal
Table 1 Measurements: left-right differences

| Parameter       | Group No. | Mean (Bilateral) | SD (Bilateral) | Range (Bilateral) | Mean (Left) | SD (Left) | Mean (Right) | SD (Right) | p<
|-----------------|-----------|------------------|----------------|-------------------|-------------|-----------|-------------|-----------|<
| Height          | 1         | 42.9             | 2.6            | 38.9–48.9         | 43.0        | 2.4       | 42.9        | 3.0       | 0.860
| Width           | 1         | 52.8             | 3.4            | 45.4–56.9         | 52.2        | 3.5       | 53.4        | 3.4       | 0.070
|                | 2         | 38.4             | 1.6            | 35.1–40.4         | 38.4        | 1.8       | 39.4        | 1.7       | 0.650
| RimaPalp       | 1         | 26.0             | 2.5            | 22.2–30.5         | 25.8        | 2.6       | 26.2        | 2.6       | 0.120
|                | 2         | 27.1             | 1.8            | 24.0–31.8         | 26.6        | 1.9       | 27.6        | 1.7       | 0.030*
| SupCrus        | 1         | 13.3             | 1.6            | 10.0–15.5         | 13.2        | 1.7       | 13.6        | 1.6       | 0.007*
| InfCrus        | 1         | 13.3             | 1.8            | 9.8–16.0          | 13.2        | 1.7       | 13.4        | 2.0       | 0.560
| LatAng         | 1         | 13.7             | 2.2            | 9.5–17.0          | 13.7        | 1.9       | 13.6        | 2.5       | 0.820
|                | 2         | 16.8             | 1.2            | 14.7–19.3         | 16.8        | 1.3       | 16.8        | 1.2       | 1.000
| APLat           | 1         | 4.1              | 0.6            | 2.5–5.0          | 4.0         | 0.7       | 4.2         | 0.5       | 0.370
|                | 2         | 3.6              | 0.4            | 2.6–4.3          | 3.6         | 0.4       | 3.6         | 0.5       | 0.790
| MedCPup        | 1         | 15.1             | 1.4            | 10.1–16.7         | 15.1        | 0.7       | 15.0        | 1.9       | 0.890
|                | 3         | 15.2             | 1.6            | 12.3–18.8         | 14.9        | 1.8       | 15.5        | 1.3       | 0.054
| LatCPup        | 1         | 12.7             | 2.5            | 8.1–16.6          | 12.7        | 2.6       | 12.7        | 2.6       | 0.930
|                | 3         | 11.8             | 1.1            | 9.7–14.0          | 11.5        | 1.1       | 12.1        | 1.2       | 0.190
| VertZF         | 2         | 9.6              | 1.2            | 7.6–11.9          | 9.7         | 1.1       | 9.5         | 1.3       | 0.720
| APSphen        | 2         | 12.5             | 2.1            | 9.0–17.0          | 12.4        | 1.9       | 12.5        | 2.3       | 0.850
| ZFtoZMax       | 2         | 30.4             | 1.5            | 28.3–34.0         | 30.7        | 1.8       | 30.2        | 1.1       | 0.200
| Bizyg          | 2         | 99.8             | 3.9            | 95.5–106.8        | 99.8        | 3.9       | 99.8        | 3.9       | 0.000
| InterCre       | 2         | 18.7             | 1.6            | 16.7–20.8         | 18.7        | 1.6       | 18.7        | 1.6       | 0.000
| InterCan       | 3         | 30.5             | 2.3            | 27.9–35.1         | 30.5        | 2.3       | 30.5        | 2.3       | 0.000
| InterPup       | 3         | 60.4             | 4.3            | 54.0–67.0         | 60.4        | 4.3       | 60.4        | 4.3       | 0.000
| HW ratio       | 1         | 0.82             | 0.06           | 0.69–0.93         | 0.82        | 0.04      | 0.73        | 0.89      | 0.000
|                | 2         | 0.82             | 0.04           | 0.73–0.89         | 0.82        | 0.04      | 0.73        | 0.89      | 0.000

*p = 10 for all groups.

Significant interindividual differences were noted for all parameters except for the APLat and MedCPup. Sex differences, with lower values for females than for males, were significant for the parameters Height, Width, RimaPalp, and APLat (Table 2).

**Intercadaver Variance**

Significant interindividual differences were noted for all parameters except for the APLat and MedCPup. Sex differences, with lower values for females than for males, were significant for the parameters Height, Width, RimaPalp, and APLat (Table 2).

**Interorbital Variance**

There was no significant difference between left and right orbital measurements, when interindividual differences were taken into account, except for SupCrus (P = 0.007; see Table 1). The interorbital variance between the left and right orbits of the same cadavers was the least for the supero-inferior position of the lateral orbital insertion of the LCL (VertCor).

**Correlations**

There was a highly significant correlation among SupCrus-InfCrus-LatAng (r > 0.90, P < 0.01) and a moderate significant correlation between LatCPup-RimaPalp and Width-RimaPalp (r > 0.65, P < 0.01).

**Group 2 Measurements**

Nine measurement parameters were obtained (see Table 1). The bizygomatic, interorbital, and intersutural distances were measured to demonstrate interskull size.
Interindividual differences were significant for all parameters except APLat and VertZF. The least variable was the location of Whitnall's tubercle anteroposteriorly, which was 3.6 mm from the lateral rim. The distance between the tubercle and the ZS suture was 9.6 mm. The distance between the tubercle and the ZS suture was 12.5 mm.

**Interskull Variance**

Interindividual differences were significant for all parameters except APLat and VertZF. The least variable was the location of Whitnall's tubercle anteroposteriorly, which was 3.6 mm from the margin.

**Interorbital Variance**

No significant left-right differences were found. The interorbital differences within the same skulls were the least for the measurements of the width of the orbits and were 0.5 mm.

**Correlations**

There were significant correlations between Height-VertCor, Width-InterCre, and BiZyg-BiInterCre ($r > 0.80$, $P < 0.01$). Moderate significant correlations were found among Height-Width, BiZyg, InterCre, and ZFtoZMax; Width-BiZyg and ZFtoZMax; ZFtoZMax-InterCre; and VertCor-BiZyg and InterCre ($r > 0.65$, $P < 0.05$).

**Group 3**

**Measurements**

Five measurement parameters were obtained from the photographs of 10 anesthetized and paralyzed patients (20 orbits) (see Table 1). The rima palpebralis width measured a mean of 27.1 mm, the medial and lateral palpebral canthal distances 15.2 and 11.8 mm, respectively, and the medial intercanthal and interpupillary distances 30.5 and 60.4 mm, respectively. The position of the center of the pupil in relation to the bicanthal line and the position of the lateral canthus relative to the medial canthus were observed as well. The position of the pupil against the bicanthal line was approximately 2 mm superior to it. In two patients the pupil was laying on the bicanthal line.
Interpatient Variance

Interindividual differences were significant for all parameters except for LatCPup. There were no significant sex differences for any of the parameters.

Minor differences were noted for the lateral and medial pupillocanthal distances and the width of the rima palpebralis. The least variable was the vertical pupil position against the bicanthal line.

Interorbital Variance

A significant left-right difference was found for RimaPalp (P < 0.03; see Table 1). The least variable was the vertical position of the pupils against the bicanthal line.

Correlations

Significant correlations were found between MedCPup–InterPup and InterCan–InterPup (r > 0.80, P < 0.01), and moderately significant correlations were found between RimaPalp–MedCPup, LatCPup, and InterPup (r > 0.65, P < 0.05).

Intergroup Correlations

Comparison of the joint group 1 and 2 parameters VertCor and APLat showed significant differences for both parameters (P < 0.01), with lower mean values in group 2 than in group 1. There was no significant difference of the Height-Width ratio. In both groups the ratio was 0.82, which means that there is a good correlation between these soft-tissue and bony landmark measurements.

Comparison of the joint group 1 and 3 parameters RimaPalp, MedCPup, and LatCPup shows no significant differences with analysis of variance and two-sample t-test. This means that there is a good correlation between comparable cadaver and patient (photograph) ocular measurements.

Discussion

It is well known that one of the major factors predisposing to complications in periorbital surgery is an inadequate lateral canthal suspension [12]. The form and the position of the palpebrae and the eyelids constitute an important aesthetic factor, which is in great measure dependent on proper functioning of the palpebral ligament [28]. As Tessier emphasized, the position of the lateral canthus is a feature of the human face that is more important than usually stated [29]. Therefore, it seems appropriate, if not mandatory, to use certain strict criteria based on sound anatomical and morphological principles when dealing with surgical techniques incorporating manipulation (detachment-reattachment) of the LCL [23]. Although intra- and interindividual variations exist, as shown in this study (see Tables 1 and 2), important conclusions can be drawn that may be very useful when performing these surgical procedures.

After careful analysis of the data, it seems the most reliable dimensions are those for the APLat, the superoinferior location of the insertion of the LCL (VertCor and VertZF), and the medial and lateral pupillocanthal distances (MedCPup and LatCPup). The length of the superior and inferior crura of the ligament and the lateral angle of rima palpebralis to the lateral insertion of the ligament are quite consistent, as illustrated by the highly significant correlation for these parameters. The width of the rima palpebralis both in the cadaver and patient groups correlated very well.

Interspecimen and interpatient differences are mainly due to size and sex. There was an expected positive correlation with the general cranial measurements. Significant correlations exist among bony orbital height, width, bizygomatic, and intercrestal distance. The intersutural distance (ZFtoZMax) is significantly correlated with orbital height, width, and intercrestal distance. The soft-tissue orbital height and width dimensions showed significant intercadaver differences attributable to sex differences. Because the sex of the dry skulls is unknown, differences resulting from sex could not be determined. The orbital height-width ratio scores of the soft-tissue orbits and the bony orbits correlated well (r = 0.82). In the cadaver group, the parameters for width of the rima palpebralis and the anteroposterior distance of the insertion of the LCL showed lower values for women, whereas in the patient photograph group no sex differences were found.

Although it appears from this study that sex influenced the results in group 1, the same does not seem to be the case for group 3 (see Table 2).

A correlation was found between the soft-tissue position of the canthus superoinferiorly and the location of Whitnall’s tubercle on the dry skulls. The measurements on the cadavers were made from the superior aspect of the lateral canthal tendon or the superior border of the superior crus at its insertion to the lateral orbital wall down to the corner formed by the intersection of the lateral and the inferior orbital rims. The dry skull measurements for the inferior vector were made from the center of Whitnall’s tubercle to the same inferolateral orbital corner as on cadavers. The mean value for these measurements in the cadaver specimens was 16.8 mm; on dry skulls the mean value was 13.8 mm. The difference of 3.0 mm between these values can be explained by the fact that the LCL attaches to the superior pole of the marginal tubercle and also that the ligament is approximately 3 mm wide at its point of insertion to the lateral orbital wall.

Excellent correlation also exists between the cadaver measurements for the anteroposterior attachment of the LCL and the anteroposterior location of Whitnall’s
tubercle on dry skulls, when soft-tissue volume is taken into account.

According to our cadaver measurements, it appears that the pupil is located more laterally; the lateral canthus is closer to the pupil than the medial canthus. The pupil was located superior to a line drawn between the two canthi (the sum of the pupillocanthal distances produced more than the rima palpebralis horizontal width). However, the measurements of the pupillocanthal distances on cadavers might be somewhat unreliable because of factors such as manipulation, circumstances of death, dehydration, and excerebration of the specimens. Therefore, 1 to 1 photographs of 10 patients without ocular disease were obtained (group 3) during the deep phase of general anesthesia with complete muscle relaxation in the supine position (conditions normally existing during orbital surgery) and studied. The results showed excellent correlation between the fresh cadaver measurement values and the patient measurements (see Table 2). For example, the measurements for the medial and lateral pupillocanthal distances for cadavers and patients correlated perfectly. The width of the rima palpebralis was also quite consistent for groups 1 and 3, with mean values of 26.0 and 27.1 mm respectively, and significant correlations between rima palpebralis width and lateral pupillocanthal distance in group 1 and between rima palpebralis, medial and lateral pupillocanthal distance in group 3.

There seems to be an age correlation with the vertical position of the lateral canthi. All patients older than 50 years, except one, had their lateral canthal angles positioned inferior compared with the medial canthal angles. In the other patient, the lateral canthal corners were on the same level as the medial canthal angle.

The lateral canthal angle is closer to the pupil than the medial canthal angle. It seems also true that in the elderly, those older than 50 years, the lateral canthal angle is on or vertically below the bicanthal line. The opposite applies to the younger population.

The final results of the canthal procedures are determined more by the refinement in the soft-tissue adjustment, in particular the canthal correction, than scleral shifts or augmentations [16]. An exact anatomical approximation of the lateral canthus should be accomplished during the initial surgical intervention rather than relying on secondary corrective procedures. The LCL should be attached to the lateral osseous orbital wall (i.e., the lateral aspect of the frontal process of zygomatic bone and not the lateral periorbita). The exact repositioning of the peri-orbita is somewhat less predictable as is the estimate of the postoperative relapse. Therefore, it would be quite difficult to correct for the expected relapse by overcorrecting the lateral attachment. It should not be overemphasized that the amount of periorbital edema in trauma cases must be compensated by overcorrection of the canthal length. The level of the edema, and therefore the rate of resolution, cannot be quantitated precisely, especially in bilateral cases. On the basis of this study, the following technique of repositioning the LCL was developed.

The LCL should be repositioned using 5-0 Prolene sutures threaded through two tapered needles. Two holes should be drilled with a microdrill on the lateral orbital rim (Fig 5). The first should be positioned at approximately 9 mm below the ZF suture and 4 mm posterior to the lateral orbital margin. The second hole should be 3 mm inferior to the first one on a vertical line. The holes should be drilled from lateral to medial and the globe protected with ribbon retractors. The superior and inferior cruri of the ligament must be identified and engaged separately by vertical mattress sutures and then secured to the lateral orbital wall via the predrilled holes from medial to lateral. The sutures should be tied on the lateral-posterior surface of the lateral orbital rim. The length of the lateral palpebral ligament should be maintained at 13 to 13.5 mm.

The goal of every surgeon during orbital surgery should be a proper and precise restoration of the anatomical relations to achieve normal function and aesthetics. This study demonstrates that if the lateral canthus is reattached at 17 mm above the angle formed between margo orbitalis inferior and margo orbitalis lateralis, 4 mm behind the most anterior projection of the lateral orbital rim, and approximately 9 mm below the ZF suture (when not disrupted by fracture or osteotomy), and if the length of the LCL is maintained at 13 to 13.5 mm from its medial to its lateral attachment, a proper alignment will be achieved at prima facie. Attention should also be paid to the width of the rima palpebralis, which should be approximately 26 to 27 mm, and of course compared with the contralateral side, if not altered.
The vertical position of the lateral canthi and their relation to the pupils are also important and should be maintained at or above the bicanthal line [11] for the younger patient population and the bilateral cases or according to the contralateral side in unilateral cases. The center of the pupil should appear 1 to 2 mm above the bicanthal line and some 2 mm more to the lateral side than to the medial side, or the canthal position is likely to be altered significantly. However, a difference of 1 to 2 mm in height is often unnoticed clinically and should be an acceptable variation of normal facial symmetry [16]. The present study was carried out on adult specimens and patients. Therefore, it seems unrealistic to apply the data obtained to the pediatric population.

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