The Anatomy of the Mitral Valve

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Robert H. Anderson, Shumpei Mori, Justin T. Tretter, Damian Sanchez-Quintana, and Diane E. Spicer

Introduction

As we indicated in the introduction to this book, the mitral valve is best considered in terms of a “complex.” From the outset of cardiac surgery, as pointed out in our chapter describing the history of the valve, perceptive surgeons have appreciated that all parts of the complex must work in harmony if the valve is to function properly. It was Perloff and Roberts, however, who introduced the formal notion of the valvar complex [1]. As also explained elsewhere in our book (See Chap. 3), it is now our intention to expand their approach so as to consider the complex as an atrioventricular entity (Fig. 4.1). Our account of the anatomical arrangement of the components of the complex is very much based on our own experiences. We recognise, in this respect, that controversies still abound with regard to each of its parts. There are multiple paradoxes that may well explain these ongoing disagreements and debates.

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R. H. Anderson (✉)
Biosciences Institute, Newcastle University, Newcastle-upon-Tyne, UK
e-mail: sejjran@ucl.ac.uk

S. Mori
UCLA Cardiac Arrhythmia Center, University of California Los Angeles, Los Angeles, CA, USA

J. T. Tretter
Division of Pediatric Cardiology, Cincinnati Children’s Hospital, Cincinnati, OH, USA
e-mail: Justin.tretter@cchmc.org

D. Sanchez-Quintana
Department of Anatomy and Cell Biology, Universidad di Estramadura, Badajoz, Spain

D. E. Spicer
Division of Pediatric Cardiology, University of Florida, Gainesville, FL, USA

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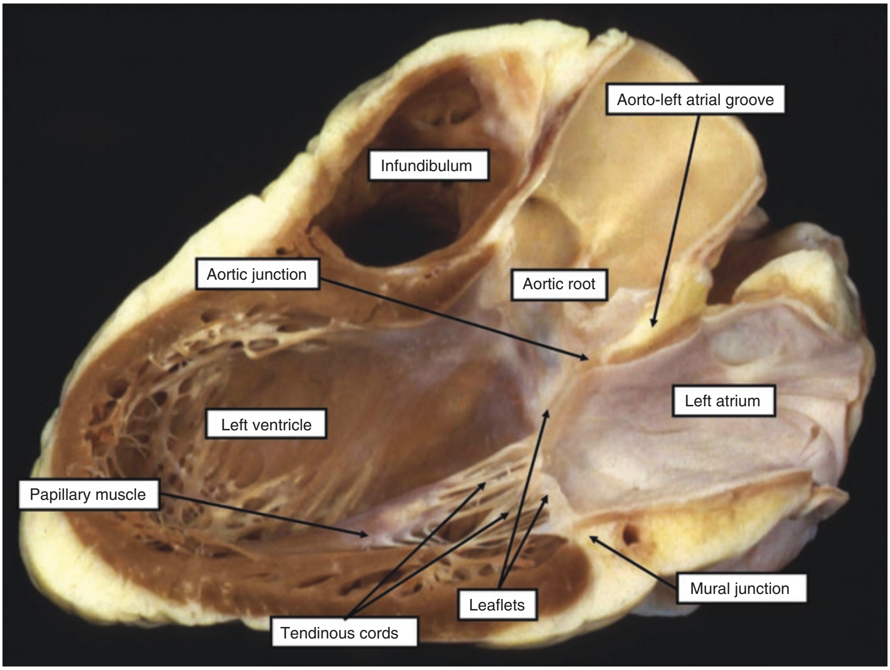

Fig. 4.1 The heart has been sectioned in its long axis so as to produce a section comparable with the parasternal long-axis view as obtained by echocardiographers. The section is photographed from its left side. The image shows the components of the left atrioventricular junctional complex, namely the left atrial walls, the aortic and mural components of the left atrioventricular junction, the valvar leaflets, their supporting tendinous cords, the papillary muscles (only the infero-septal muscle is seen in this cut) and the supporting ventricular myocardium

If the surgeon is properly to treat the abnormal valves confronting him or her in the operating room, he or she must have full information regarding the normal arrangement. This makes it important to recognise the paradoxes. The first paradox is that, while surgeons see many more mitral valves than do morphologists, the valves requiring their attention are usually abnormal rather than normal. We must extrapolate, therefore, from the normal features with which we are confronted as anatomists so as to account for the abnormal findings with which the surgeon is confronted. The second paradox is that, unlike morphologists, the surgeon has limited access to all the components of the junctional complex. From the standpoint of function, the hidden parts are likely to be of just as much significance as those that are obvious to the surgical view. We are fortunate, therefore, that the morphological details can now be shown in exquisite detail by virtual dissection of computed tomographic datasets, not only of the living heart but also autopsied specimens. Virtual dissection of the living heart has the inestimable value that the valvar components can be assessed as they are located in their normal positions within the chest. This then highlights the third paradox. As anatomists, we teach our students that all structures should be described as they are located within the body. It is surprising, therefore, that anatomists have ignored this basic rule for centuries when describing the heart in "Valentine" fashion [2]. Throughout this chapter, therefore, as with the remainder of our book, we will be describing the components of the left atrioventricular junction complex in the attitudinally appropriate fashion. As far as is possible, we will also orientate our illustrations in this way.

What Is the Mitral Valve?

The normal mitral valve guards the morphologically left atrioventricular junction. It is a well-recognised fact that the atrioventricular valves "belong" to their ventricles. In congenitally corrected transposition, for example which is characterised by the discordant arrangement of the atrioventricular connections, the mitral valve is a right-sided structure when the atrial chambers are usually arranged. The valve then guards the junction between the morphologically right atrium and the discordantly connected morphologically left ventricle. In this chapter, of course, we are concerned with the normal left-sided mitral valve. Its alternative name is the bicuspid valve. Hence, it has two components within the skirt of leaflet tissue that opens and closes within the left atrioventricular junction. We presume it was the perceived similarity of the arrangement of those two components, when viewed from the ventricular aspect, to the episcopal mitre that underscored the usual naming of the valve (Fig. 4.2).

As we emphasised in our chapter on definitions (see Chap. 3), there is a marked difference between this bifoliate pattern of normal closure and the trifoliate arrangement seen in the heart with atrioventricular septal defects in the setting of a common atrioventricular junction. That is why the left atrioventricular valve in the latter setting should not be described as being "mitral." As suggested above, we presume it was the view from the apex of the left ventricle that promoted the notion that the bifoliate valve would better be described as being mitral (Fig. 4.2). Nowadays, the valve is seen more frequently in the parasternal long-axis section as obtained by the echocardiographer. This view encapsulates the reasons why the structure is best analysed in terms of a junctional complex (Fig. 4.1). The components of the complex are the atrial vestibules, the atrioventricular junction itself, the valvar leaflets, the tendinous cords, and the papillary muscles, with the papillary muscles themselves supported by the inferior or diaphragmatic wall of the left ventricle. When viewed in the short axis of the left ventricle, the mitral valve differs from the tricuspid valve in lacking any tension apparatus directly attached to the muscular ventricular septum (Fig. 4.2). This is because an extensive infero-septal recess of the subaortic outflow tract interposes between the curtain of leaflet tissue and the endocardial surface in the inferior component of the muscular ventricular septum (Figs. 4.3 and 4.4) [3].

The presence of the recess has a marked influence on the well-recognised "off-setting" of the hinges of the leaflets of the mitral versus the tricuspid valve. This characteristic sign, used by echocardiographers to distinguish between the valves, and by inference, the ventricles supporting them, does not become visible until the transition is reached between the inferior part of the muscular ventricular septum and the parietal inferior wall of the left ventricle (Fig. 4.5). The hinge of the mural leaflet of the mitral valve then forms the leftward border of

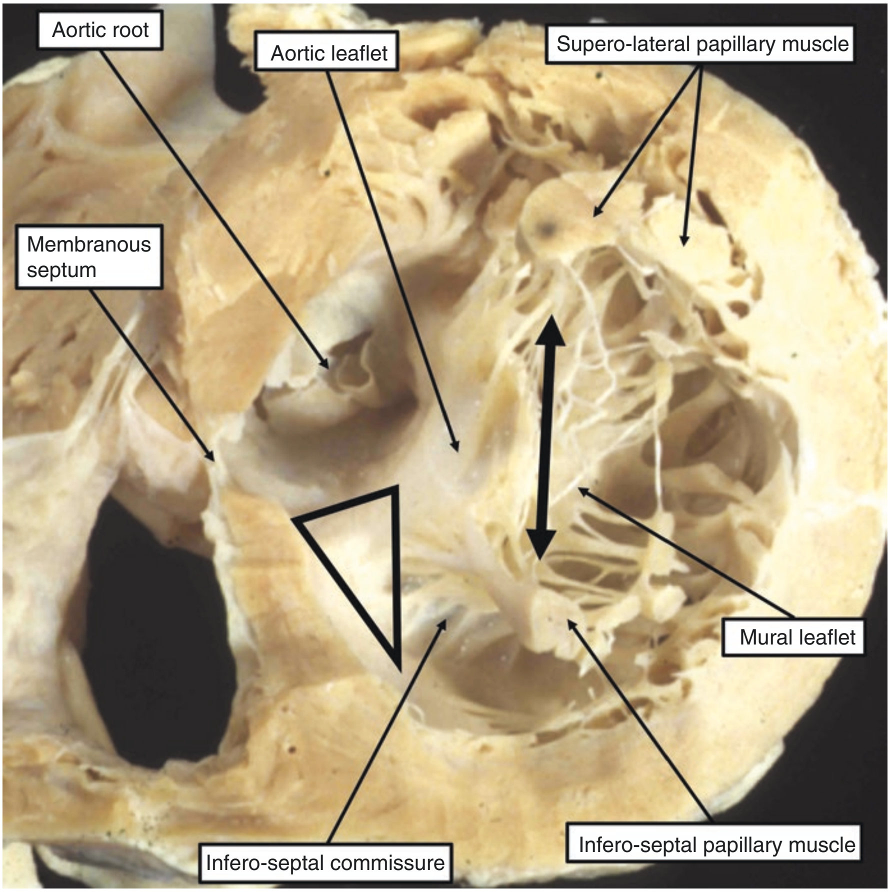

Fig. 4.2 The ventricular mass has been sectioned in its short axis, and photographed looking towards the base. The leaflets of the mitral valve come together along a solitary zone of apposition (double-headed black arrow), producing an arrangement reminiscent of the episcopal mitre. Note the extensive recess that interposes between the aortic leaflet of the valve and the left ventricular septal surface (black open triangle). This is the infero-septal recess of the aortic root. Note also that, when viewed in attitudinally appropriate fashion, as shown in this image, the ends of the zone of apposition between the leaflets, and the supporting papillary muscles, are positioned infero-septally and supero-laterally

the inferior pyramidal space. The atrioventricular node is found within the floor of the triangle of Koch at the level of the transition between the apex of the inferior pyramidal space and the inferior extent of the septal recess (Fig. 4.6). It is because of the juxtaposition of these two spaces that the penetrating component of the conduction axis, usually described as the bundle of His, has such a short course as it extends from the atrial to the ventricular components of the heart. As we have emphasised, there is marked individual variation in all

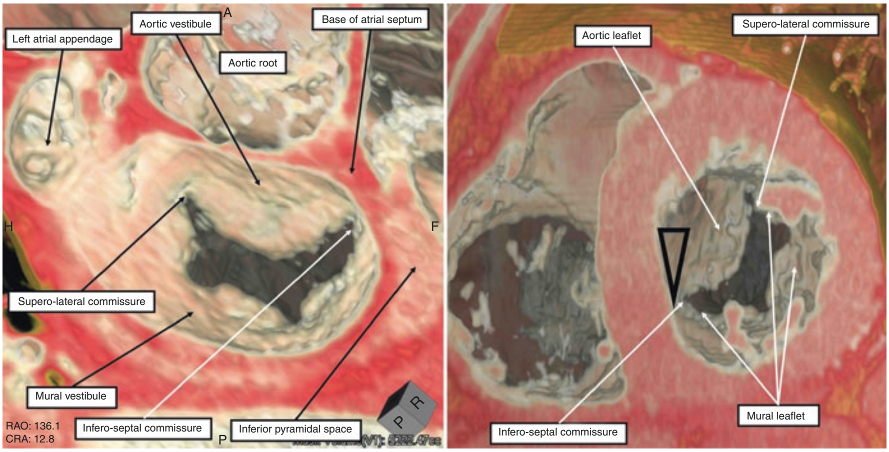

Fig. 4.3 The computed tomographic scans of the living heart reinforce the image of the valve as shown by the anatomical section shown in Fig. 4.2. The ability to section the three-dimensional dataset, however, means that it is possible to show the heart as seen from the atrial aspect (left-hand panel) and the ventricular aspect (right-hand panel). Comparing the two images shows that the infero-septal recess of the aortic root (black open triangle in right-hand image) undermines the base of the atrial septum, as shown in the left-hand image

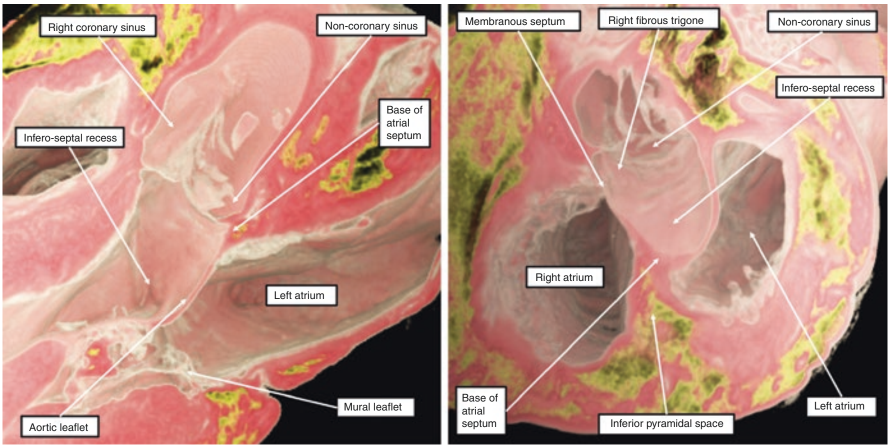

Fig. 4.4 These magnetic resonance imaging scans are made from a formalin-fixed autopsy specimen of a normal heart. They show how multiple sections can be taken to show the anatomy of features otherwise difficult to appreciate, in this instance the infero-septal recess of the subaortic outflow tract. The left-hand panel is a tilted section simulating the long-axis echocargraphic plane, while the right-hand panel is taken on the short axis of the atrioventricular junctions. The right-hand panel shows particularly well how the recess interposes between the right and left atrioventricular junctions, and undermines the base of the atrial septum. It also shows how the apex of the recess overlaps the apex of the inferior pyramidal space

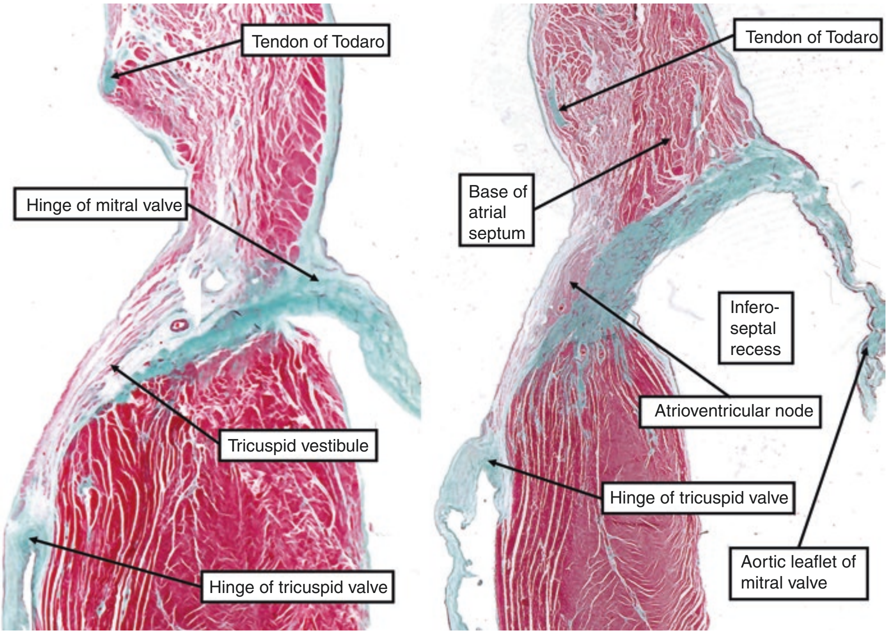

Fig. 4.5 The images, oriented in "four chamber" fashion, with the atrial chambers positioned superior to the ventricles, show two histological sections through the septal component of the atrioventricular junctions. The left-hand panel is taken at the base of the triangle of Koch, while the right-hand panel is through the middle of the triangle. The sections show how the off-setting of the hinges of the leaflets of the atrioventricular valves is found only at the base of the triangle (left-hand panel). As shown in the right-hand panel, the section taken superiorly confirms how the infero-septal recess of the aortic root undermines the base of the atrial septum, interposing between the aortic leaflet of the mitral valve and the septal surface of the left ventricle. Note the location of the atrioventricular node as seen in the right-hand panel. The node is carried on the atrial aspect of the fibrous insulating tissue, which produces continuity between the leaflets of the mitral and tricuspid valves

components of the junctional complex. We will address the extent of these variations, and their potential surgical significance, as they relate to each of the components.

The Left Atrioventricular Junction

When viewed from the atrial aspect, the left and right atrioventricular junctions, along with the aortic root, take on an obvious shamrock configuration. The diverging inferior components of the atrioventricular junctions are separated by the tissues of the inferior pyramidal space, with the artery to the atrioventricular node extending between the right atrial vestibule and the crest of the left ventricular cone in this area (Fig. 4.7). When viewed from the ventricular aspect, the orifice overlaps with the aortic root within the circular configuration of the short axis of the left

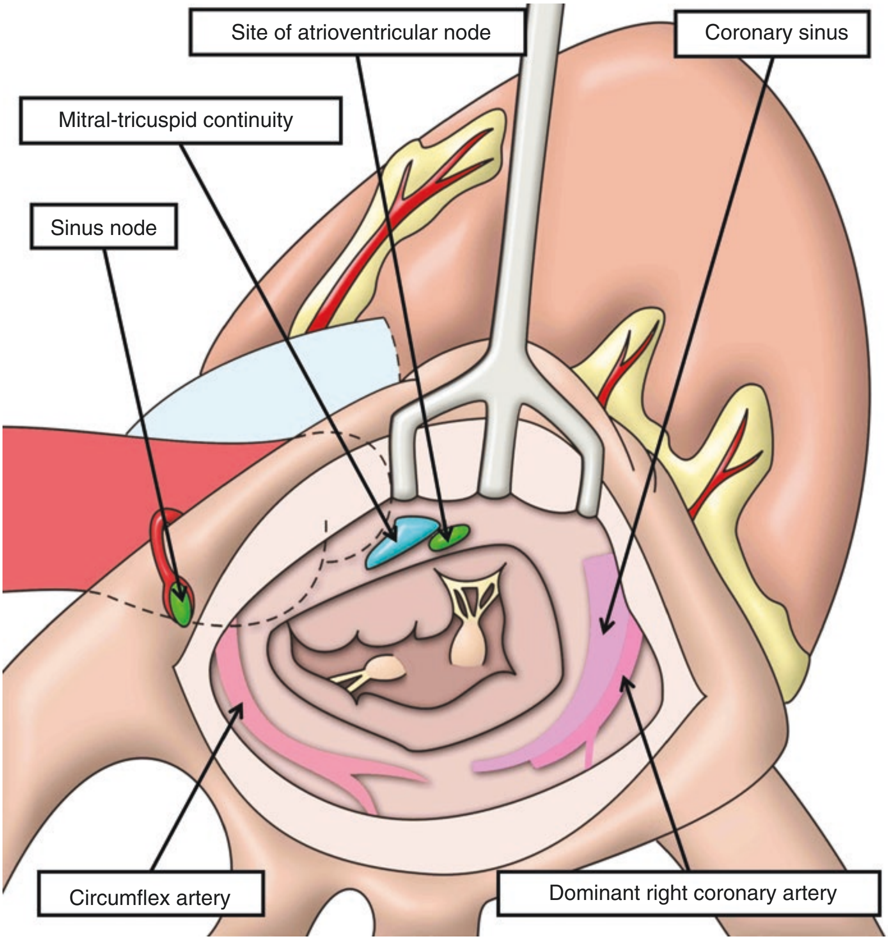

Fig. 4.6 The drawing shows the view of the mitral valvar orifice as would be seen by the surgeon. The atrioventricular node carried on the area of fibrous continuity between the leaflets of the mitral and tricuspid valves that forms the roof of the infero-septal recess (see Figs. 4.4 and 4.5), is located at the transition from the septal to the parietal components of the left atrioventricular junction

ventricular cone. This view shows well how the infero-septal recess of the aortic root extends towards the crux, separating the leaflets of the mitral valve from the septal surface of the left ventricle (Figs. 4.2, 4.3, and 4.4). When viewed from the atrial aspect, the left atrial myocardium is seen to insert into the atrioventricular junction at the margins of the ovoid orifice, forming the left atrial vestibule (Fig. 4.8). Anteriorly, the vestibular myocardium is related directly to the aortic root, with the atrial wall separated from the non-coronary aortic valvar sinus by the aorto-left atrial groove (Fig. 4.9—upper panel). Posteriorly and inferiorly, the vestibule forms the atrial part of the mural component of the junction (Fig. 4.9—lower panel). Within the mural junction, the circumflex artery and the coronary sinus are

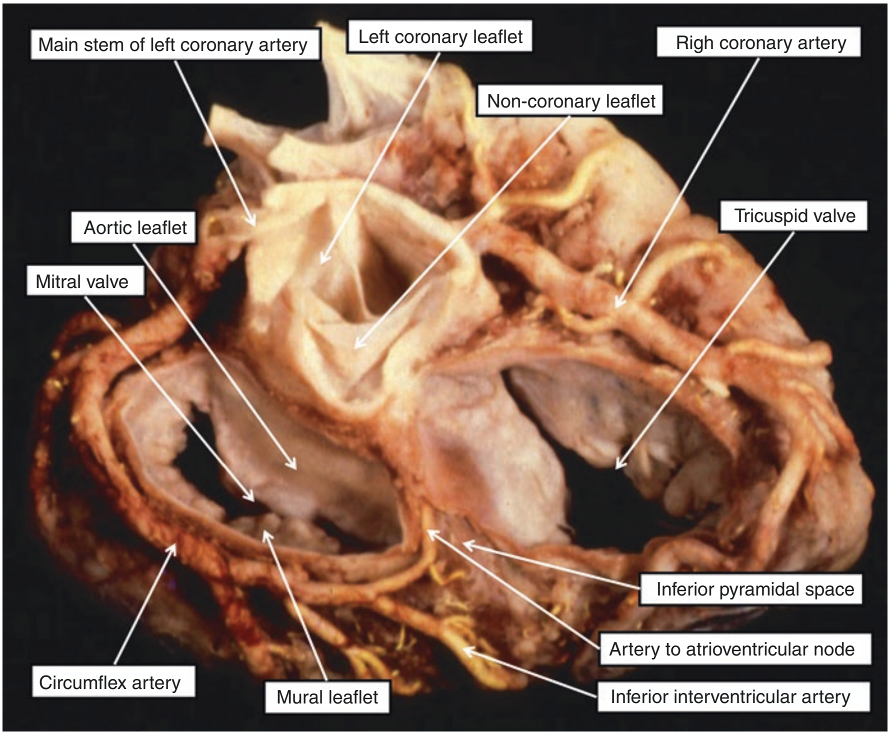

Fig. 4.7 The heart is viewed from above having removed the arterial roots down to the level of the semilunar hinges of the arterial valves, and the atrial myocardium to reveal the vestibules of the mitral and tricuspid valves. The dissection shows well the relationship between the aortic leaflet of the mitral valve and the non-coronary and left coronary leaflets of the aortic valve. In this heart, the circumflex coronary artery was dominant. Note that the artery to the atrioventricular node extends through the inferior pyramidal space, which separates the diverging inferior margins of the left and right atrioventricular junctions

surrounded by the fibro-adipose tissue that fills the left atrioventricular groove. In most individuals, who have the right coronary arterial dominance, the circumflex artery has a limited course within the junction. When the circumflex artery is dominant, a feature found in around one-tenth of the population, then it is much more closely adherent to the hinge of the mural leaflet of the valve (Fig. 4.7). The coronary arteries are usually located deeper within the groove, and closer to the endocardial surfaces, than are the venous structures (Fig. 4.10). The coronary sinus itself, nonetheless, retains an intimate relationship with the hinge of the mural leaflet of the valve (Fig. 4.9—lower panel, Fig. 4.10). Although echocardiographers typically use the so-called "off-setting" of the hinges of the leaflets of the mitral and tricuspid valves as a feature with which to distinguish them, in reality, the leaflets of the mitral valve have a very limited attachment to the left ventricular surface of the inferior part of the muscular ventricular septum.

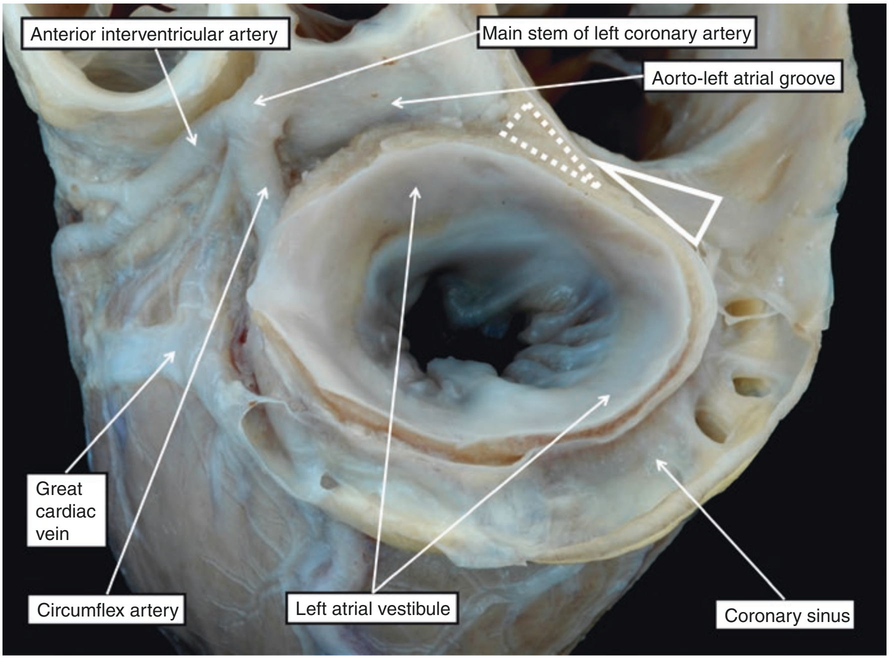

Fig. 4.8 The dissection has been made by removing the walls of the left atrium, but leaving the vestibule. The vestibular myocardium supporting the aortic leaflet of the mitral valve is separated from the aortic root by the cavity of the transverse pericardial sinus. This is best described as the aorto-left atrial groove. Note how the apex of the triangle of Koch (white triangle) overlaps the inferior extent of the infero-septal recess, shown by the white triangle with dashed lines. It is this relationship that permits the bundle of His to pass from the apex of the triangle to reach the crest of the muscular ventricular septum

As we have already emphasised, this is because of the presence of the deep infero-septal recess of the left ventricular outflow tract (Fig. 4.3). Inferior to the infero-septal end of the zone of apposition between the aortic and mural leaflets, the hinge of the mural leaflet arises from the leftward boundary of the inferior pyramidal space. This space is filled by a superior continuation of the fibro-adipose tissue of the inferior atrioventricular groove. This tissue interposes between the atrial floor of the triangle of Koch and the myocardial crest of the septal component of the ventricular cone. We used to describe this area as a muscular atrioventricular septum. We now know that because of the presence of the fibro-adipose tissue within the inferior pyramidal space, it is an open sandwich rather than a true septum (Fig. 4.11). The cavity of the infero-septal recess interposes beneath the septal component of the junction between the leaflets of the mitral valve and the left ventricular surface of the muscular ventricular septum. This subtle feature is not readily obvious to the surgeon, nor even to the anatomist, without special dissections made to show its location (Fig. 4.12). As we have shown, however, the extent of the recess is revealed by interrogation of computerised tomographic datasets (Fig. 4.4). The key

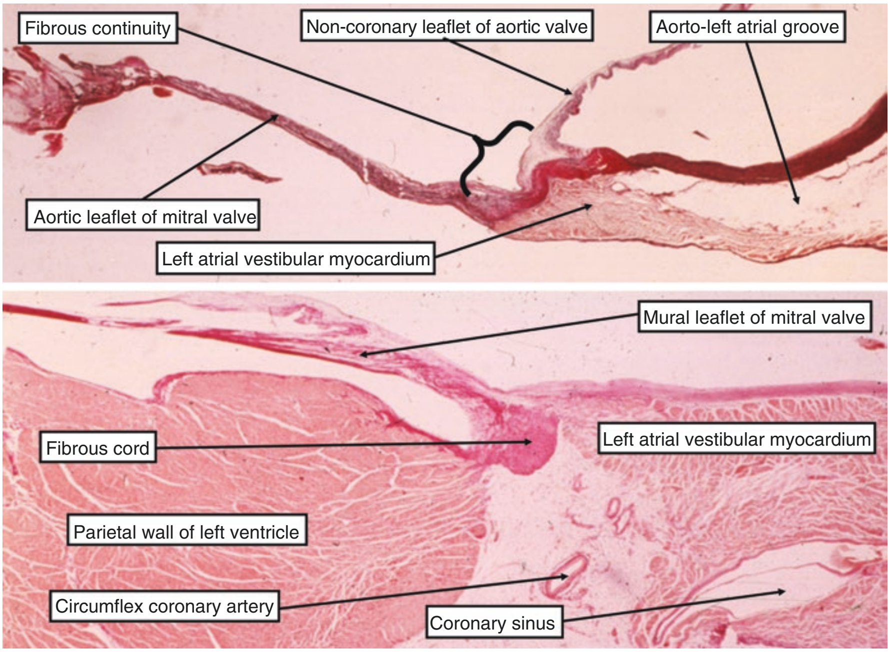

Fig. 4.9 The histological sections are taken through the vestibules of the left atrium inserting into the hinges of the aortic (upper panel) and mural (lower panel) leaflets of the mitral valve

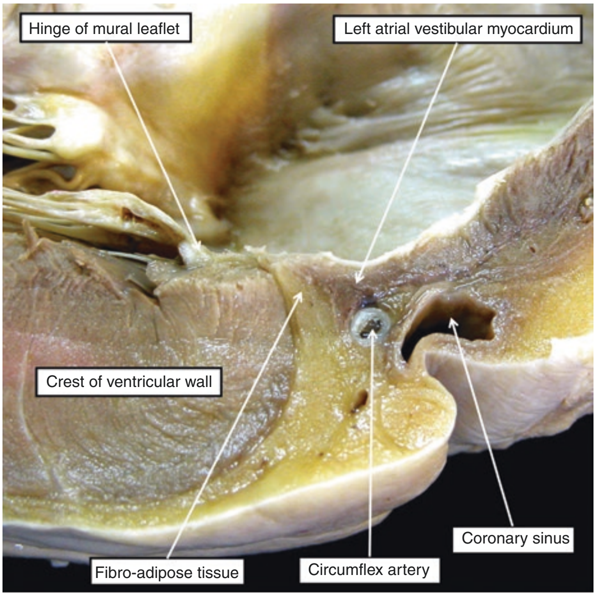

Fig. 4.10 The image shows a gross anatomical section across the mural component of the left atrioventricular junction. It is not possible to recognise any entity that corresponds to a so-called “annulus.” Insulation is provided by the fibro-adipose tissues filling the atrioventricular groove

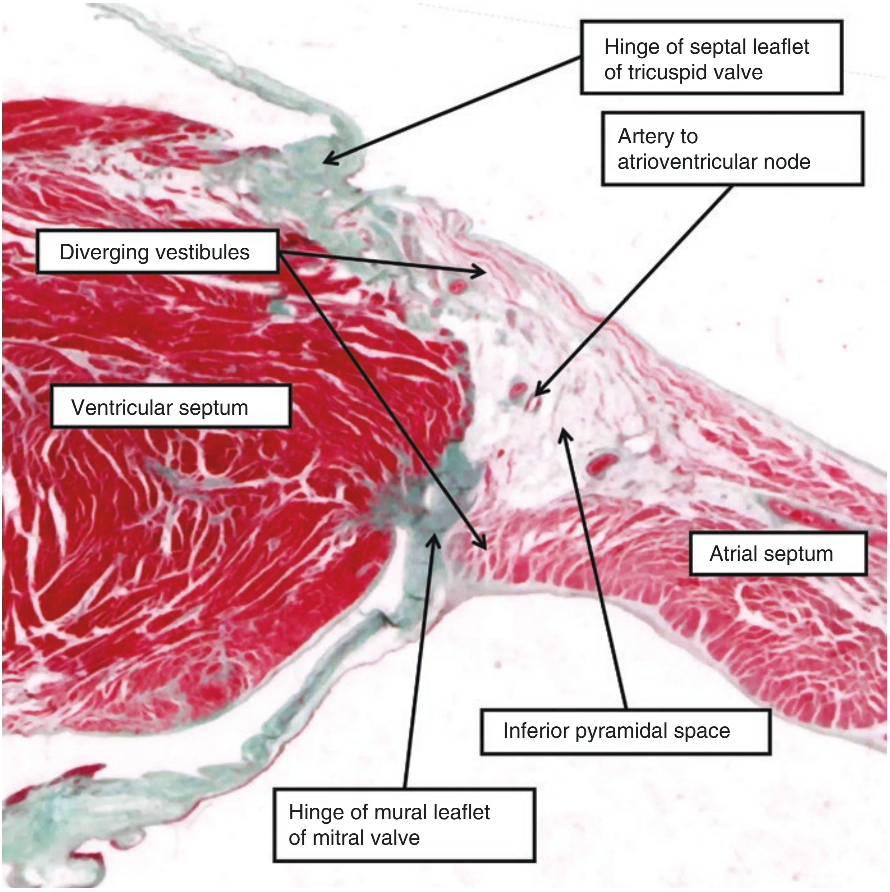

Fig. 4.11 The histological section, which is now orientated to match the arrangement seen in the parasternal long-axis section, with the cavities of the right-sided chambers shown to the top, reveals how the fibro-adipose tissues of the inferior pyramidal space interpose between the diverging vestibules of the atrioventricular junctions and the crest of the muscular ventricular septum. Note the atrioventricular nodal artery within the fibro-adipose tissues filling the space

structure to be found within the septal component of the junction is the atrioventricular node. Extensions from the node run into the parietal vestibules of both the mitral and tricuspid valves. Fortunately for the cardiac surgeon, the presence of the recess produces a distance between the node and the likely site for placement of sutures by those replacing the mitral valve. Care should be taken, nonetheless, to avoid placing sutures too deeply within the septal part of the vestibule. Respect should also be paid to the location of the circumflex artery, particularly when it is the dominant coronary artery (Figs. 4.6 and 4.7) [4].

It is often thought that a discrete fibrous “annulus” is part of the parietal component of the left atrioventricular junction. A recent editorial, for example

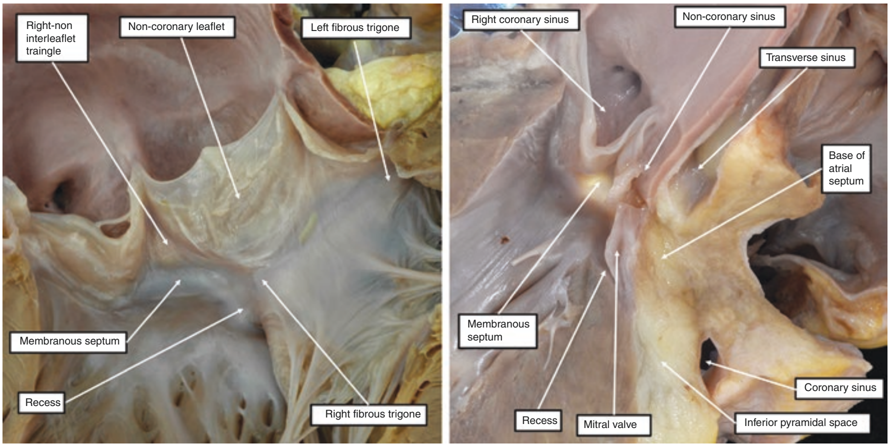

Fig. 4.12 The images show the location of the infero-septal recess of the aortic root. The left panel is a photograph of the aortic root taken from the front. It shows the recess extending towards the crux between the aortic leaflet of the mitral valve and the septal surface of the left ventricle. The right-hand panel is a section made through a different heart parallel to the septal surface and through the base of the atrial septum. The recess is seen between the leaflet of the mitral valve and the ventricular septum

suggested that the alleged entity "originates at the fibrous trigones, which sit at the junction between mitral and aortic valves and extends as an ellipse attached posteriorly to the left atrium and anteriorly to the left ventricle" [5]. This is rarely, if ever, the case [6]. The strongest part of the atrioventricular junction is the area of fibrous continuity found anteriorly between one of the leaflets of the mitral valve and the left and non-coronary leaflets of the aortic valve (Fig. 4.9—upper panel). It is because of this relationship that we name the leaflet of the mitral valve as being "aortic." The area of fibrous continuity is then thickened at its rightward and leftward ends to form the fibrous trigones. These thickenings anchor the aortic-mitral unit to the crest of the left ventricular myocardial cone (Fig. 4.12—left-hand panel). The anchorage provided by the right fibrous trigone is itself part of the roof of the infero-septal recess. This overall area of fibrous tissue then extends inferiorly as a fibrous plate at the apex of the inferior pyramidal space (Fig. 4.4). Within the mural atrioventricular junction, however, the support provided to the hinge of the mural leaflet varies markedly at different parts within the same individual. At some points, the fibrous tissue can be cord-like (Fig. 4.9—lower panel). At other points it can be shelf-like, forming a curtain between the vestibular atrial myocardium and the crest of the left ventricular wall (Fig. 4.13—upper panel). At still other parts of the junction, even in the same individual, it is possible to find areas with the absence of any fibrous tissue supporting the mural leaflet (Fig. 4.10).

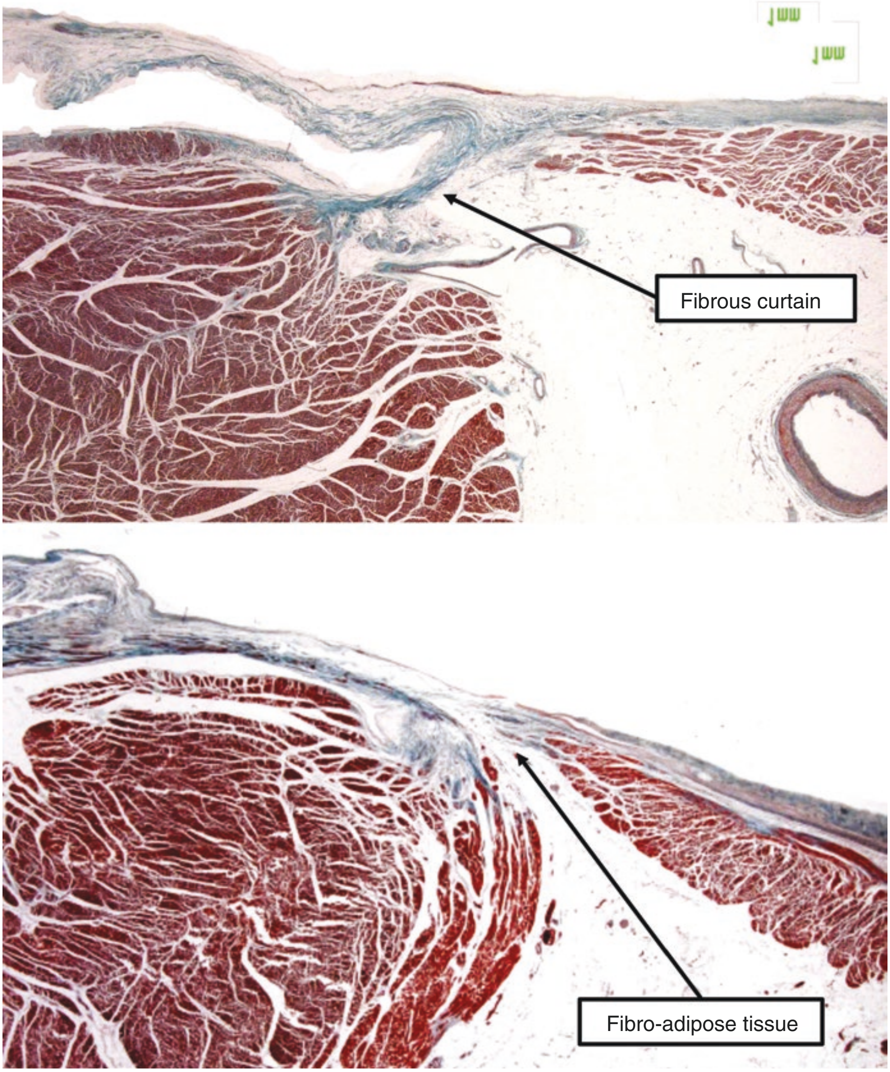

Fig. 4.13 The images are histological sections showing the different fashion in which the mural leaflet of the mitral valve can be anchored within the left atrioventricular junction. In Fig. 4.8, we have already illustrated a cord-like component anchoring the leaflet. The upper panel of this figure shows a curtain-like collar of fibrous tissue anchoring the leaflet to the base of the atrial vestibular myocardium, while the lower panel shows, as in Fig. 4.9, an absence of any fibrous tissue within the junction, the leaflet being hinged from the crest of the ventricular wall. These different arrangements can be found at different parts of the mural leaflet in the same individual

The leaflet is then hinged from the crest of the ventricular wall (Fig. 4.13—lower panel). It is the exception, therefore, rather than the rule, to find a complete fibrous structure, be it cord-like or curtain-like, which supports the hinge of the mural leaflet throughout the extent of the parietal atrioventricular junction. It is quite some time now since we demonstrated the lack of such continuous support for the hinge of the mural leaflet of the mitral valve within the left atrioventricular junction [6]. Our investigation at that time had been performed because of the suggestion that a feature termed "disjunction" might underscore prolapse of the mural leaflet [7, 8]. We found, however, that the feature described as "disjunction" was just as frequent in the normal heart as in the hearts we studied from patients with prolapsing mitral valves. We have summarised the findings from this investigation in Fig. 4.14. The fact that the variability we found in the support provided to the mural leaflet of the mitral valve was comparable in hearts obtained from normal individuals and those with prolapse now achieves new significance. This is because the notion involving so-called "disjunction" as underscoring prolapse of the mural leaflet has resurfaced, albeit with no mention made of our own previous investigation [9]. Our investigation of living datasets has confirmed, nonetheless, our previous findings using histology. The findings subsequent to the interrogation of computed tomographic datasets show that so-called "disjunction" is no more than the curtain-like support provided to the mural leaflet at different parts of the junction in most normal individuals (Figs. 4.15, 4.16, and 4.17). As yet,

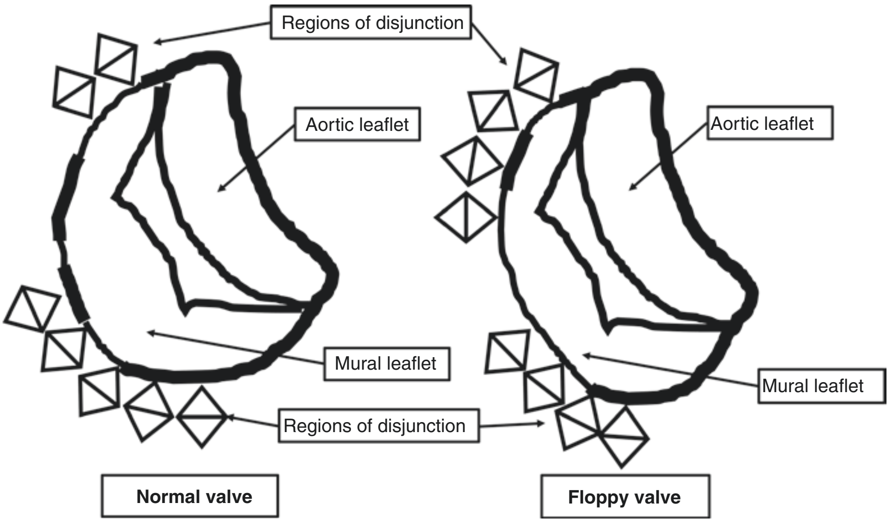

Fig. 4.14 In this figure, we summarise the findings from a previous study in which we explored the significance of so-called "disjunction." In this study [6], we compared the junctional arrangement in seven normal individuals with six hearts obtained from patients having prolapsing leaflets or so-called "floppy" mitral valves. In the drawing, we show the findings from two of the hearts, illustrating how the finding of so-called disjunction could be just as extensive in the normal hearts as in those with floppy leaflets. There was also comparable variability in the thickness of the fibrous hinges of the mural leaflets, shown by the width of the black lines

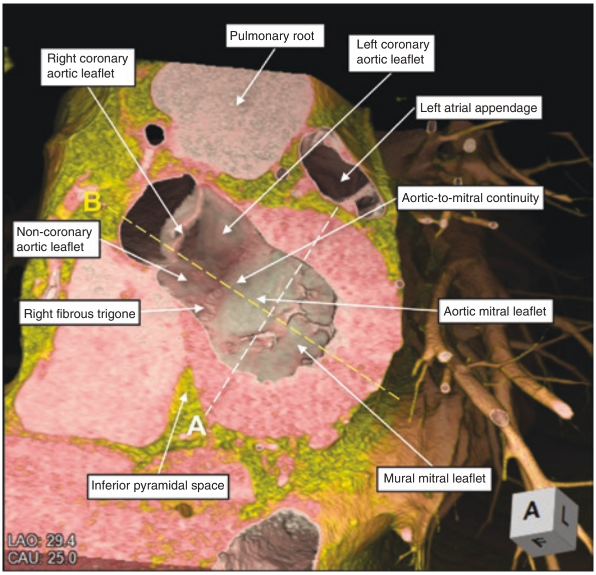

Fig. 4.15 The image is taken from a computerised tomographic dataset taken during systole in an 82-year old normal individual undergoing analysis for suspected coronary arterial disease. It shows an oblique cut through the short axis of the base of the left ventricle. Further cuts were taken along the planes A and B to show the anatomy of the hinges of components of the mural leaflet of the mitral valve

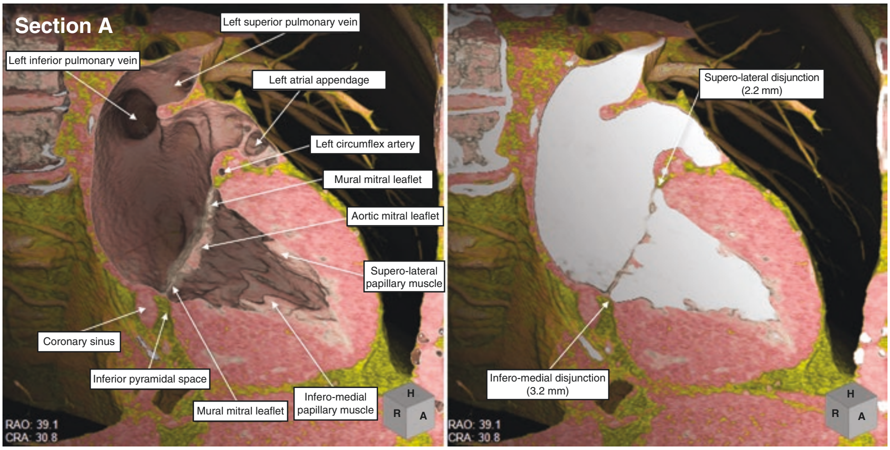

Fig. 4.16 The image shows the findings from the cut along plane A as indicated in Fig. 4.15. There is so-called "disjunction" at the two ends of the hinge of the mural leaflet of the mitral valve

therefore, there is no evidence of which we are aware positively to implicate the finding of so-called "disjunction" as the cause of mitral valvar prolapse. As was indicated by the editorialist placing emphasis on the so-called annulus [5], "new and careful physiological studies with multiple timed comprehensive measurements" will be required to resolve this issue. This will require careful comparisons with normal findings, assessing the overall hinge of the leaflet as shown in Figs. 4.15, 4.16, and 4.17.

Fig. 4.17 This image shows the findings regarding the arrangement of the hinge of the mural leaflet in its central component, with the cut taken along the plane B as indicated in Fig. 4.15. There is no "disjunction" along the support of the middle part of the mural leaflet

The Valvar Leaflets

The skirt of leaflet tissue suspended from the left atrioventricular junction closes along a solitary zone of apposition between its two components. These components are typically described as being "anterior" and "posterior." When viewed in attitudinally appropriate fashion, these adjectives are rarely completely accurate. Because of this inaccuracy, it is our preference to describe the leaflets as being aortic and mural. It is then possible, in almost all instances, to recognise the ends of the zone of apposition between these two components. For anatomists, it is the zone of apposition itself which would best be described as the "commissure." This is the area over which the moving components abut. For better or worse, conventional wisdom dictates that it is the ends of this zone of apposition that clinicians recognise as the "commissures." So as to avoid confusion, we will simply describe these areas as the ends of the zone of apposition. When viewed attitudinally, they are positioned infero-septally and supero-laterally (Figs. 4.2 and 4.3). The ends of the zone of apposition do not reach the atrioventricular junction. Between the ends of the zone of apposition and the junction itself are found the commissural components of the skirt of leaflet tissue. On occasion, these can be extensive (Fig. 4.18). This can then create problems in determining for certain which area is the zone of apposition.

In the normal heart, it is very unusual for the aortic component of the skirt of valvar tissue to be anything other than a solitary entity. On occasion, nonetheless, this part of the valve can retain the components from which it is developed. This is known as congenital "clefting", although the leaflet, in this setting, will never have been a solitary entity. In some instances, minor degrees of so-called "clefting" can be recognised in otherwise normal valves. Although the aortic leaflet of the valve is usually a solitary entity, this is never the case for the remainder of the skirt of leaflet

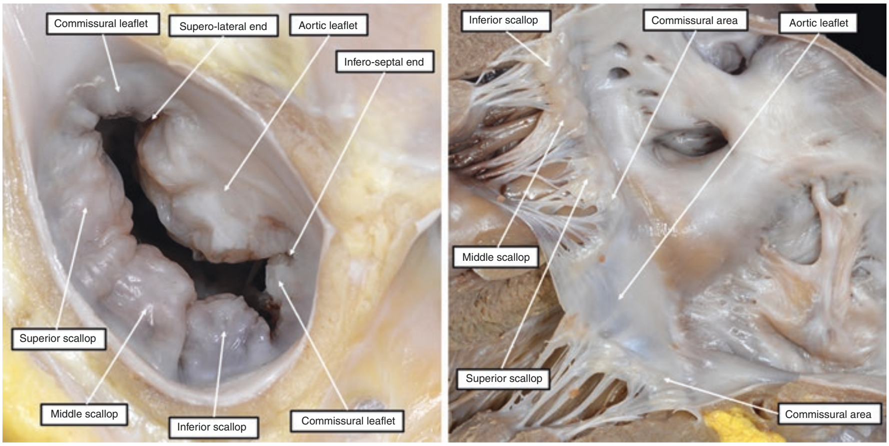

Fig. 4.18 The images show typical mitral valves as seen in the autopsy room with an intact atrioventricular junction (left-hand panel), and when opened through the inferior end of the zone of apposition between the leaflets (right-hand panel). Note the presence of an extensive commissural leaflet at the inferior end of the zone of apposition in the heart shown in the left-hand panel. This creates a potential problem in distinguishing between the end of the zone of apposition itself and the "cleft" between the commissural leaflet and the inferior scallop of the mural leaflet

tissue. The fact that the mural leaflet is never a unitary entity has spawned several approaches for describing its components. Some authorities have suggested that the mural leaflet can be considered as possessing three parts, which themselves should be considered as separate leaflets in a quadrifoliate valve [10]. More usually, these components are recognised as the valvar "scallops." It is this latter notion that provided the basis of valvar description popularised by Carpentier and his colleagues [11]. Others have pointed to the frequent presence of relatively discrete areas of leaflet tissue at the ends of the zone of apposition, promoting these parts as the commissural leaflets [12]. Victor and Nayak had commented that, in reality, there were frequently numerous slits along the mural component of the skirt. Such slits, which can be compared to pleats in a skirt or kilt, are necessary to permit the extensive mural leaflet to fit snugly against the aortic component when the valve is in its closed position [13]. Analysis of large numbers of normal hearts then shows that there is no uniform pattern [14]. The presence of three scallops in the mural leaflet, along with smaller commissural segments, is no more than the usual finding. Variations are frequent, meaning that specific description of the individual arrangement is better than procrustean classification. The area of the two leaflets, nonetheless, irrespective of the manner of division of the mural leaflet, is more-or-less the same. The aortic leaflet, which guards no more than one-third of the overall circumference of the junction, is deep, whereas the mural leaflet, guarding the remaining two-thirds, is shallow (Fig. 4.19). Irrespective of the variability in the specific arrangement of the mural leaflet, it is now conventional to describe the three scallops as representing P1, P2, and P3, with P1 being the supero-lateral scallop [11]. The opposing parts of the aortic leaflet are then typically recognised as being A1, A2, and A3 (Fig. 4.20).

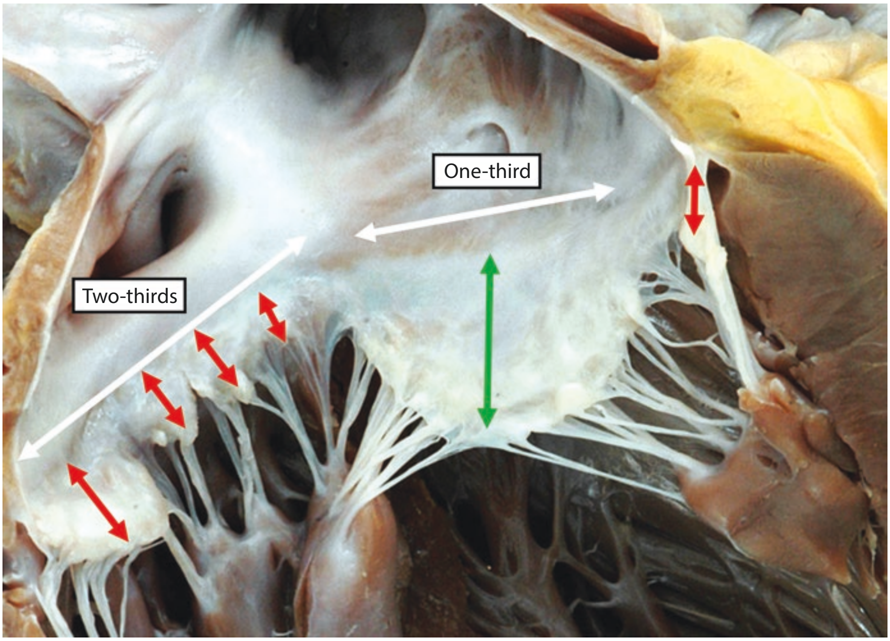

Fig. 4.19 The left atrioventricular junction has been opened by making a cut close to the inferior end of the zone of apposition between the leaflets, and the skirt of leaflet tissue opened to show the arrangement of the component parts. The aortic leaflet, which guards around one-third of the circumference of the orifice, is deep (green double-headed arrow), whereas the components making up the mural leaflet are all relatively shallow (red double-headed arrows)

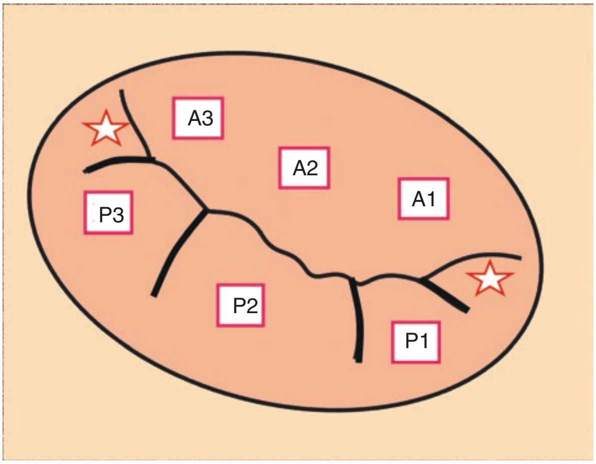

Fig. 4.20 The drawing shows the conventional approach to naming the components of the mitral valve, with P1 through P3 showing the scallops of the mural leaflet, and A1 through A3 the components of the aortic leaflet against which they abut. Note also, however, the presence of the commissural leaflets (stars)

The Tendinous Cords

Just as with the leaflets, the best way of describing the tendinous cords, or “chordae tendineae” has also proved controversial. It has long been suggested that “orders” of cords can be recognised. Others have suggested the need to differentiate between “commissural” cords and “cleft” cords [15]. As explained in our introductory chapter, we take a much simpler approach, not least because the branching of the cords makes it impossible to distinguish between the variants alleged to be “cleft” as opposed to “commissural.” We distinguish between free-edge cords, strut cords, and basal cords. The key feature of normality is that the support provided by cords attached to the free edges should be uniform for all parts of the aortic and mural leaflets (Figs. 4.18 and 4.19). It was suggested quite some time ago now that lack of such uniform support was one of the features that promoted prolapse of components of the mural leaflet [16, 17]. We see no reason to doubt this proposition. The strut cords are the force-bearing entities attached in aggregated fashion to the ventricular surface of the aortic leaflet of the valve (Fig. 4.12). They show marked individual variation, as do the basal cords attached to the ventricular aspect of the mural leaflet. Each of the basal cords is usually attached on the ventricular side to its own miniature papillary muscle.

The Papillary Muscles

The major papillary muscles of the mitral valve are positioned so as to provide greatest support to the ends of the solitary zone of apposition between the leaflets. It follows, therefore, that they are located infero-septally and supero-laterally (Fig. 4.3—right-hand panel). It is a mistake to account for the muscles as being antero-medial and postero-lateral, as continues to be the usual description of clinicians. This approach reflects the bad habit of describing the heart as if removed from the body and positioned on its apex, the so-called “Valentine” approach. Each papillary muscle receives tendinous cords from both of the leaflets. Both muscles tend to have several heads. The presence of the infero-septal recess means that, unlike the tricuspid valve, there are no papillary muscles arising directly from the muscular ventricular septum. At their bases, the muscles are then supported by a zone of trabecular myocardium, attaching them to the compact walls of the left ventricle. This presence of trabecular myocardium can be exaggerated in the presence of so-called non-compaction, which is much better described as excessive trabeculation [18]. For this reason, the bases of the papillary muscles should be avoided by those seeking to assess the thickness of the compact and trabecular components of the walls.

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